Coordinating the Internet
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Coordinating the Internet

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The front image represents the Internet in 2000, and the larger image on the back represent the Internet in 2019. They are according to scale and show all announced prefixes and autonomous systems, see Section 2.7 (page 42).

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This quote represents the complexity of the Internet. The notion of a network which supports interplanetary communication, shuffles trillions of dollars worth of financial derivatives per day, and allows for transfer of any digital data between any devices anywhere on the planet (and off the planet theoretically).

This quote also illustrates the purpose of the Internet, that is to handle any kind of need and change to meet that (coordinated) need, even if it is to infinity and beyond.
Många självklarheter i vårt digitala samhälle är beroende av Internet för att fungera. Allt från smarta dörrar för hemtjänster, till självsanningsapparaterna på ICA, till nyare bilar, moderna tillverkningsrobotar, telefoner och affärssystem. Den här licentiatavhandlingen reder ut vad Internet är, hur det styrs och vad det har för praktiska konsekvenser. Tidigare forskning finns bland annat inom telekommunikation där Internet liknas vid andra telekommunikationsjärn, så som kabel-TV eller mobiltelefoni, och inom digitalisering både inom management och informationssystem där Internet i det närmaste tas för givet som teknisk infrastruktur. Här tar jag en ansats där jag förklarar Internet ur ett kombinerat tekniskt och organisatoriskt perspektiv.

Studien är principiellt uppdelad i tre delar. Den första delen fokuserar på att begreppsmässigt hitta ett sätt att diskutera Internet utan att essentiella aspekter faller bort, såsom styrningen eller konsekvenser av den tekniska designen. Jag landar i att Internet är både ett tekniskt och ett organisatoriskt fenomen. Tekniskt i bemärkelsen att det handlar om digital paketbaserad kommunikation (dvs att olika paket kan ta olika väg och att det inte finns ett beroende på en viss specifik väg, eller ”krets”), vilket kan särskiljas från exempelvis kretskopplad kommunikation (dvs en specific väg från sändare till mottagare) eller rent analog kommunikation. I denna tekniska dimension är Internet förhållandevis likt klassisk telekommunikation såsom kabel-TV och mobiltelefoni, och förlitar sig på best-effort paketbaserad kommunikation. I den andra dimensionen, styrning och organisation, är Internet ett explicit bottom-up fenomen som styrs med andra principer och ideal än klassisk telekommunikation. Till sin utformning är denna minsta möjliga koordination som krävs för att möjliggöra koordinering av de tekniska unika identifierare som behövs för att Internet ska fungera (dvs idag DNS- och BGP-flororna av protokoll för användning av namn och nummer på Internet). Båda dimensionerna, de organisatoriska och tekniska, följer samma designprinciper, och generellt är det meningsfullt att se Internet som en ekologi av aktörer snarare än en organisation i strikt teoretiska termer (exempelvis finns ingen tydlig övergripande strategi, organisationsnummer eller löneutbetalare). Det är dessa designprinciper, som ligger väl i linje med systemarkitektursprinciper för datorsystem, som är orsaken till Internets lager-design där man (generellt) inte ska bry som om vad som händer på andra lager än sitt eget (beskrivet som ”separation of concerns” eller i dubbel negation ”high cohesion” i texten) samt att ha en minimalistisk ansats till koordinering och enbart koordinera eller skapa beroenden mellan enheter (både tekniskt och organisatoriskt) när det verkligen behövs (beskrivet som ”minimum coordination” eller ”low coupling” i texten).

Den andra delen fokuserar på hur Internet kan socialt påverkas eller förändras till något annat, eller till något med en annan funktion sett som en styrd organisation. Jag använder begreppet social robusthet, som motpol till teknisk robusthet som i hur man tekniskt kan förstöra Internet, för att diskutera dessa aspekter. Slutsatserna hår mynnar ut i att Internets explicita bottom-up och problemuppdelnings-design gör det märkbart svårt för någon att medvetet påverka Internet för att ändra dess beskaffenhet, och dessutom visar jag att även om man praktiskt lyckas ta över de formellt beslutande råden (exempelvis ICANNs och IETFs styrelser) så finns det inga formella eller praktiska hinder för att bara ignorera dem (dvs switching costs för just ICANN eller IETF är låga, om än tekniskt omständligt med att konfigurera om rötter och routing-tabeller, och betydligt enklare än att gå från IPv4 till IPv6 då utrustning kan behöva ersättas och därmed en betydligt högre switching cost). Med andra ord, det är enklare att byta ut Internets koordinerare än att byta ut Internet mot något som fungerar annorlunda. Däremot är den rådande politiska världsortningen ett hot mot Internet, eftersom den regelstyrd och koordinerade världsortningen inte längre är lika självklar som den varit tidigare.
Den tredje och sista studien fokuserar på nätneutralitet, dvs rätten nätverksoperatörer har att fånga värde i andra dimensioner än trafikmängd, som en praktiskt effekt av hur Internet styrs och fungerar. Det primära praktiska bidraget är att nätneutralitet inte får ses som enbart en reglerings och lagstiftningsfråga utan det är mer relevant att prata om i termen av nätneutralitet i praktiken. I den bemärkelsen är lagstiftningens vara eller inte vara mindre intressant än praktisk nätneutralitets vara eller inte vara och en tyngdpunktscjutning i den offentliga debatten hade fört diskussionen närmare hur Internet fungerar. Sammanfattningvis ger Internets designprinciper att marknadskrafter, och ej direkt reglering, ska möjliggöra nätneutralitet. För att förtydliga, tanken är att det ska finnas konkurrens inom de flesta nivåer eller lager, och att det är av vikt att det finns konkurrens rakt igenom så att en kundvilja för paketneutralitet på tjänstennivå även påverkar nätagar- och infrastrukturturnivå, så att det är användarnas efterfrågan som leder till nätneutralitet (om den användarviljan finns). Dock kan det mycket väl vara så att man som användare inte är intresserad av nätneutralitet och då ska tjänsteleverantörer inte heller tvingas vara neutrala genom lagstiftning då det går stick i stäv med designprinciperna. Inte heller ska en grupp s tillval kring nätneutralitet påverka andra möjligheter att välja.

Genomgående identifierar jag två kolliderande världsbilder, den distribuerade regelstyrd och koordinerade ordningen i sitt perspektiv med sina förkämpar, och den mer integrerande och suveräna världen med sitt perspektiv och sina förkämpar. Rent praktiskt uppfyller Internet en önskad funktion i den tidigare men ej i den senare, då Internet designmässigt är byggt för att tillåta snarare än kontrollera och bestämma. Exempelvis finns det inte inbyggda (tekniska) mekanismer i Internet för att till exempel möjliggöra statlig övervakning eller kontroll av material som finns tillgängligt, och då ligger det mer i statens intresse att ha kontrollerade telekommunikationstjänster, såsom kabel-TV, mobiltelefoni och liknande lösningar där man inte helt enkelt kan lägga på ett “extra lager” för att uppnå kryptering, anonymitet eller tillgång till andra tjänster.

I texten använder jag perspektiven tillsammans med teknologi, marknader och byråkrati för att fånga upp dynamiken och strömningarna i Internet-ekologin och jämför med tekniska samhällsförändringar, som exempelvis järnvägssätt, postverk och finansiella marknader. Jag konstaterar att Internet har varit styrty av teknologiskt baserade värderingar, till skillnad från de andra exempel som i huvudsak har utformats av dynamiken mellan byråkrati och marknad. I denna mån föreligger det att teknologi kan användas som strömning och motperspektiv till den klassiska uppställningen med byråkrati och marknad för att beskriva fenomen i digitaliseringsens tidsalder.

Avhandlingen sätter även pågående tendenser i ett bredare perspektiv mot både organisation och teknik, och trycker på vikten av att förstå delarna var för sig och tillsammans för att på ett rikare sätt måla upp helheten.
The modern society is to a large extent Internet-dependent. Today we rely on the Internet to handle communication for smart doors, self-scanning convenience stores, connected cars, production robots, telephones and ERP-systems. The purpose of this thesis is to unbundle the Internet, its technology, its coordination, and practical and theoretical consequences. Earlier research has, in telecommunications, focused on the Internet as one of many potential telecommunications services, such as cellphones or cable-TV, and the management and information systems field has by and large treated the Internet as black-boxable infrastructure. This thesis explains the Internet from the combined perspectives of technology and coordination.

This text contains three empirical studies. The first is focused on conceptualizing and discussing the Internet in a meaningful way using both technology and coordination frameworks. I unceremoniously conclude that the Internet is both a technological and a coordination phenomenon and neither of these aspects can be ignored. The Internet is technological in that it concerns digital packet switched digital communication (as opposed to circuit switched) or purely analog communications. The technological dimension of the Internet is similar in its constituency to classical telecommunications networks, and has best-effort mechanisms for packet delivery. In the other dimension, coordination, the Internet is an explicit bottom-up phenomenon minimally coordinated (or governed) by other ideals than classical telecommunications networks and systems. At its core this least necessary coordination concerns technical unique identifiers necessary for inter-network communication (in practice today manifested as naming with the DNS protocol suite, and numbering with the BGP protocol suite). Both dimensions follow similar design characteristics; the design of the technical Internet is similar to the design of the coordination of the Internet. These design principles, which are well aligned with software design principles, is the cause of the Internet’s layered design (“separation of concerns” in practice) and minimal view of coordination (the “least coordinated Internet”). In general terms it is fruitful to view the Internet and involved actors as an ecology, rather than one organization or entity in need of governance or control.

The second study looks at the social resilience of the Internet. That is, is it possible through social means to change what the Internet is or can be viewed as. I use social resilience as a counterpart to technical resilience, i.e. resilience to technical interference. In essence, the bottom-up and separations of concerns design of the coordination aspect of the Internet minimizes possible influence of actors intent on mission disruption. I also practically show that even a take-over of the central councils have little effect the constituency of the Internet, since these councils are not invested with formal powers of enforcement. This thesis suggests that the cost of switching from ICANN and IETF to another set of organizations is quite low due to the nature of the coordination of the Internet, compared to for example, switching all equipment to IPv6 capable equipment. However, the current political situation is a threat to the current Internet regime, since an international and rule-based world order is no longer on all states’ agendas.

The final empirical study focus on the practical and theoretical implications of the Internet on the case of net neutrality. The primary contribution is that de facto and de jure net neutrality differ in practice, and as such de facto net neutrality deserves more attention. Also, I suggest that any regulation, either for or against net neutrality, is problematic, since such regulation would interfere with the inherent coordination mechanisms of the Internet. As such regulation should focus on providing the necessary markets for Internet function given the coordination and design of the Internet. As a net neutrality example, net
neutral Internet access options should exist as part of a natural service offering if wanted by customers, not due to direct regulation.

Throughout the thesis I identify two colliding world orders, both in terms of digital communication networks and terms of organizing society in general: the rule-based and coordinating order with its champions, and the integrated or sovereign order with its champions. In practical terms, the Internet can be considered a want in the former (the distributed perspective), but not the later (the integrative perspective), since the Internet lacks inherent (technical) controls for surveillance and content control which are necessary in a world order where borders are important. Regardless of if that importance stems from state oversight or intellectual property rights legislation.

I use these perspectives together with technology, markets and bureaucracy to catch the dynamics of the Internet ecology. I then compare these dynamics with other technological and societal phenomena, such as railway networks, postal services and financial markets. And conclude that the Internet (as conceptualized in this thesis) can best be explained by technological values, in opposite to the other examples which can best be explained by the dynamics of markets and bureaucracies without any real influence of the values of technology. As such, I suggest that the classical frame of markets and bureaucracy can fruitfully be expanded with technology to better explain the Internet and similar digitization phenomena.

This thesis puts current trends in a broader perspective based on technology and organization, where the two perspectives together better can draw the full picture in a rich fashion.
Preface

In Economic Information Systems, our main focus is where management and IT meet, not least the new, fast-growing, IT-intensive organisations. More specifically, we deal with how information is transferred from, between and to people, and with the potential in and consequences of digitisation. The area includes research on business development, management control, and knowledge and competence development, especially in organisations where use of IT plays an important role.

We study the roles that strategies and information systems play in the collaboration between people in organisations in different sectors (public, private and non-profit), networks and coalitions, and the interaction with the surrounding ecologies. Perspectives management – perceiving and handling the perspectives of different stakeholders – is an important part in the striving for a deeper and more nuanced understanding of the phenomena we study.

Our PhD students also participate in the Swedish Research School of Management and Information Technology, a collaboration between a dozen Swedish universities and university colleges. In line with its name, the research school organises courses, PhD conferences and supports PhD candidates within management and IT, thus providing a wide network.

The present thesis, Coordinating the Internet, is written by Fredrik Lindeberg. He presents it as his licentiate thesis in Economic Information Systems at the Department of Management and Engineering, Linköping University.

Linköping in December 2019

Alf Westelius
Professor
Economic Information Systems
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To my family, Sabrina and Benjamin, for being there, and not complaining too much when your partner and father was working late or traveling somewhere. I could not have done this without you.

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University management, faculty management and student unions; putting PhD students back on the agenda has been an interesting but tough trip. Being part of the university board, research councils, the national PhD student council and student union boards taught me more about practical organizing than any PhD course.

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Linköping, November 2019
Fredrik Lindeberg
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1 Introduction

The Internet is but a brief craze [translated]
— (supposedly) Ines Uusmann, former Swedish secretary of communications and IT

1.1 The Internet

Let us start with a question. Who controls the Internet? Now, let that one sink in a bit. And again, who controls the Internet? And what is the Internet?

This thesis looks at the Internet for the broad aim of supporting discussions of its role in society, and how it may be developed. In order to do so, I have used literature, discussions and interviews with practitioners and data from the Internet itself to understand the peculiar intersection of technology and coordination that has evolved over the past decades. Given how the Internet is coordinated and works, I suggest further research and practical implications for organization, society and Internet coordination itself.

It is possible to argue that the Internet is a collection of technical standards or protocols for digital communication, but the Internet is more than that. It is an idea of a network controlled by Everyone, which means that No-one rather than Someone is in charge. Explicitly not Someone as in the case of many formal governance situations, such as national policy.
I argue that the Internet should be defined as (in the shortest possible form): “a set of protocols for digital end-to-end communication affected by its users”, where “its users” can be seen as Everyone interested. As such the epistemic community, that is the individuals with opinion and ideas about future development, sets its own agenda and lobbies onto itself. This is different from the international telecommunications regime (cf. Cowhey, 1990), in which epistemic communities influence organizations such as the International Telecommunications Union (ITU), the United Nations (UN) and national regulatory authorities to set the agenda for international digital communications.

As it turns out not Everyone has equal impact on influencing the Internet, and the complex ecology contains various Someones and Everyones who together in effect coordinate that which we consider to be the Internet.

Let us start with a visualization of the technical Internet in Figure 1.1. It depicts the world of millions of interconnected actors which can be described as partaking in an ecology, an ecology where having Everyone and No-one in charge is the norm rather than having that particular Someone in charge.
1.2 Framing

Reading instructions

If you are only going to read a few parts, I suggest you should read Section 8.7 where the Internet design principles for both technology and coordination of the Internet are compared and contrasted, and Section 9.1 with a hands-on of the two prevalent views of the Internet and digital communication technologies in general today, and compare with contemporary ideas and technologies. The general themes of this thesis are shown in Table 1.2 which are further elaborated on throughout the thesis and have their own concluding remarks in Chapter 11.

As a reader service, there is a substantial glossary at the end with Internet-specific vocabulary. When read on printed paper, it is necessary to go to the glossary by hand (at page 323 for glossary and 341 for acronyms). When read in a PDF-reader, all terms are “clickable”, and the first time they appear in a chapter they are shown in red, and abbreviations printed fully (when printed on paper all terms are black, as long as the PDF-standard is followed. Following a standard is not always the case, as this thesis shows in the case of the Internet).

Before clicking on the examples in the next paragraph, familiarize yourself with the back- and forward-buttons in your PDF-reader (on macOS probably \( \text{cmd} + [ \text{backspace} ] \) and \( \text{cmd} + [ \text{enter} ] \) (i.e. \( \text{cmd} + \text{Alt} + [8] \) etc), and on Windows \( \text{Alt} + [ \text{backspace} ] \) and \( \text{Alt} + [ \text{enter} ] \).

As an example, the first time Internet Protocol (IP) (expanded, clickable and colored) is seen in a chapter it is written out and in red, while all further appearances in the chapter look like: IP (clickable but not colored). The same is true for terms as well as abbreviations, such as the Internet (clickable and colored) and when repeated as the Internet (clickable but not colored).

If the “clickability” is annoying, I refer to the documentation of the PDF-reader, which should have a setting for (hyper-) links (disable them).

1.2 Framing

Previous academic literature, such as Raustiala (2016), DeNardis (2012) and van Eeten and Mueller (2012), tend do focus on the Internet from the lens of policy as a means of governance or technology, whereas this thesis sees the Internet as the interplay of two dimensions, coordination and technology. Here a dimension is a way of understanding or framing a phenomenon. For example, Figure 1.1 shows the technical Internet. The Internet itself is the main object of study and the empirical setting for this thesis. The later parts, in particular Section 9.1 and Chapter 9 in general, reason outside this empirical setting into other areas where coordination mixes with continuous technological change (which can both be positive development and negative change).
1. Introduction

Figure 1.1 is an example of one perspective of the technical Internet. Figure 1.1 shows all routable entities (prefixes (collections of IP addresses) and networks (Autonomous Systems (AS)), not devices) visible by Border Gateway Protocol (BGP) (technical details in Chapter 3) in September 2019, as seen from RIPE NCC in Amsterdam. This figure, Figure 1.1, is one way of illustrating the technology dimension of the Internet consisting of approximately one million vertices (managed networks and prefixes. An Internet Service Provider (ISP) usually has several) and one million edges (connections between different networks), which also has a coordination dimension in how, for example, standards and unique identifiers are handled and decided. In Figure 1.1, centrality, in a sense how important a node is, sets color; the most central nodes are blue, and as the nodes lose importance, they turn greenish and finally tints of yellow and tone out into white. The white nodes are that which is considered the edge of the Internet. If printed on paper, the nodes are too small to be distinguished individually, and the white nodes can be thought of being the edge or border between the figure and the white background.

This thesis is a study of the Internet viewed as an ecology, or an ecosystem, of both coordination and technology actors, which is referred to as the Internet-ecology in the text. I use ecologies in the sense of Olve, Cöster, Iveroth, Petri, and Westelius (2013) and Westelius and Lindh (2016), that is more of a nuanced tool to describe a relevant context than a full fledged theory for describing all interaction. Nuanced in the sense that ecologies can be constructed (cf. Olve et al., 2013) to include informal relationships which more formal network models can miss (cf. Johanson & Vahlne, 2009).

In other words, the ecology perspective is used to study the Internet’s stakeholders more broadly, in effect including a larger set of actors than is the norm in policy literature, such as public opinion (see the net neutrality debate) and norms and standards (see for example Internet Engineering Task Force (IETF) mantras and Internet Corporation for Assigned Names and Number (ICANN) policies). Even important individuals influence the processes and outcomes, as such it is not only organizations involved in the ecology. Ecologies illustrate systems of actors, not necessarily systems of actors where all actors are equal.

To put ecologies in perspective, it makes sense to start with the extreme points or framing edges. The most formal ecologies (in essence a formalized network) have strict hierarchical structures as those in regulation, such as the field of Law, where there is a sovereign who has the last say, for example the supreme court, as illustrated in Figure 1.2b. The policy field has studied regulation in general and regulation in particular with regard to the Internet (cf. Raustiala, 2016; van Eeten & Mueller, 2012, although conceptualized differently). These structures are in general top-down, and the actual decisions tend to be complex (out of necessity, since one decision has to be valid in a multitude of contexts, a general precondition, as argued in Cohen, March, & Olsen, 1972). Note that Figure 1.2 is void of directions on the connections.
For most implementations the connections would be directed, i.e. power or pressure going in one direction, except centralization (Figure 1.2a) which per definition controls the other nodes more or less directly.

There are ecologies and perspectives in which there are no central or top actors, where the power in the “who-is-right” or “what-is-right” debate is distributed (but does not have to be equally distributed), illustrated in Figure 1.2c. These ecologies are different in that decisions are localized and separated due to lack of formality and that actors in the ecology can have their own solutions for internal problems rather than synchronizing with a central actor (although a central actor with absolute power would, probably, consider a centralized system simpler). Mintzberg (1993) describes such a constellation as an *adhocracy*, whilst texts such as Burt (2004) argue that the structural holes\(^1\) are evenly distributed since there is no formal concentration of power to clusters.

The middle ground is an ecology where actors are central only in certain perspectives or lenses (such as standards setting or legislative bodies). A simple example is a standardization entity; that entity would have large power over the standardization processes but for other matters would not necessarily be central. Another example is the supreme court, which only exercises power in its certain area, but can not govern in others. These ecologies would contain traits from all of the Figures 1.2a to 1.2c.

Figures 1.2a to 1.2c are also used to illustrate technical protocols and standards. For example, Domain Name System (DNS) (“the Internet’s phone-book”) works according to Figure 1.2b while BGP (routing) works according to Figure 1.2c (in particular Figure 1.1 shows nodes and edges relevant for 

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\(^1\)In Burt (2004) structural holes are important since they show actors which are not central but still powerful due to being the only link or one of the only links between larger clusters.
1. Introduction

Routing. Many non-Internet technologies work according to Figure 1.2a, such as Facebook, Twitter and Google who act as sovereign in their own worlds. Many Internet firms have governance models significantly different from the Internet itself.

Another way of framing the Internet for an actor external to the Internet and its coordination is through digitization, as one conveyor of digital information between localized contexts. The Internet is vital for many kinds of digital use today, even though there are digital applications which do not rely on the Internet. The set of Internet-dependent applications includes smartphones, smart locks, firmware updates and remote controls for modern cars, digital libraries, the entire web, email, and so forth.

Important here is that digitization is rapidly changing and evolving, both in how it is used but also what it does, which has real and extensive implications for users of the Internet who consume the content provided by the coordinated technical infrastructures.

For example, DNS used to behave similarly regardless of position on the Internet, but today it is common that ISPs, other actors or open-source do-it-yourself solutions such as Pi-hole\(^2\) filter DNS queries, and in practice dictate the content reachable by users under the auspices of protecting them from malware.

As an example of Internet use, deepfakes are becoming more common. That is real time faked video, for example by swapping out the expressions on a face or changing what (the video of) the face says. The repository (i.e. the code) needed for this is freely available\(^3\) but requires some technical knowledge, and it is today possible to fake a news report, a presidential state of the union without state level resources (i.e. a small group of technically skilled individuals could do it reasonably well with smartphone cameras, laptop levels of computing power and time\(^4\)). Deep-faking is available due to the Internet, but it is unclear which responsibility or role the Internet as an entity or ecology has. Or if the Internet as an entity can be responsible in any way, given the way the Internet is coordinated and built.

As an example of responsibility, Article 15 and 17 of the EU copyright directive\(^5\) (written by legislators lobbied by epistemic communities in a thought collective\(^6\) where digital communications is a service rather than a provision of infrastructure) puts responsibility on the Internet access provider, even though

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2See [https://pi-hole.net](https://pi-hole.net), a community driven DNS-based “black hole” for advertisements.

3See [https://github.com/deepfakes/faceswap](https://github.com/deepfakes/faceswap), requires familiarity with python and commandline, but not knowledge of neural networks or similar.

4As an example, the upcoming version of iOS will use similar technology to change focus of eyes in video calls to avoid the “look into screen or look into camera”-issue. See iOS 13 public beta changelog.

5The numbering of these directive have changed several times during the last years, I here refer to the “link-tax” and the “meme-ban”.

6I use epistemic community and thought collective as Adler and Haas (1992) suggests. That is, a thought collective is a group of individuals framing the world in a similar manner,
the technical nature of the Internet is designed on the notion of separation of concerns in which the network is not responsible for what is transferred over the network (except in rare circumstances such as preventing harm to the network itself). In such a legislative ecology the ISPs are given responsibility for what happens “on the Internet” even though that goes against the technical design (and coordination design as I argue in this thesis).

Another consequence of the Internet as an open platform (see, as examples, de Reuver, Sørensen, & Basole, 2017; Hanseth & Lyttinen, 2010, for Internet as a (information) platform reasoning) usable by all services and ideas, such as blockchains and the dark net. From a news article on the arrest of a dark net drug millionaire:

A Frenchman who was arrested in August 2017 after arriving in the United States to attend a beard competition in Austin, Texas has now admitted to being “OxyMonster”, a well-known drug vendor on the Dream Market underground online marketplace. (Farivar, 2018)

This particular case is both a fun quote of a modern day Al Capone or Pablo Escobar, and an effective illustration of a new breed of “netizen”. That is, someone who does not particularly identify with one culture or origin in particular, and in this case also becomes a dollar millionaire on illicit drug trade based on cryptocurrency payments, possible due to the Internet. The Internet is used by many legal and legitimate purposes, but it is also used for less legal or legitimate purposes. And it should be noted that drug dealing can be considered legitimate on the dark net and on the Internet, whilst it in many jurisdictions is illegal (and in some illegitimate).

This is part of the setting in which I look at the Internet, not only as a “web of web-pages” (cf. texts not differentiating the Internet and the web) or streaming-platform used by humans (cf. net neutrality literature), but as a fully fledged digital communications idea used by all manners of living and non-living things for communication of all manner of digital information, which might be web-pages but most certainly does not have to be. And naturally that network might be used for morally despicable causes, or illegal causes, or both.

This is relevant since viewing the Internet as a technology phenomenon is easy and ultimately a fallacy, most computer engineers probably think they understand it completely due to understanding of IPv4 and DNS, just as I once did. The complex part is when coordination and use is introduced. The same is true from the other direction, the policy perspective also becomes have a shared notion of facts or assumptions, and an epistemic community is the part of a thought collective trying to change the world in line with their understanding of the world. Thought collectives can be the actors in scientific fields, but also other groups with a common understanding of a particular set of issues.
1. Introduction

complicated when taking the technical design of the Internet (and the coordination of it) into account. One purpose of this thesis is to explain the Internet outside a single thought collective.

1.3 Research questions

As alluded to, this thesis introduces more questions than it answers, however, as is common research practice still proposes a research direction. And as in most research, the final formulation of these questions are much of an after-the-fact construction rather than the initial inquiry, which rather was along the line of “what is going on here?”. Figure 1.3 ties the questions together with the approach, where the questions make sense of the approach.

RQ 1 How can the Internet meaningfully be described and conceptualized using coordination and technology dimensions?

The Internet is typically defined in terms of its technical infrastructure and the means for transmitting information across this infrastructure, but as I have shown, the infrastructure cannot be understood in isolation. As such, I propose an ecology perspective to complement the framing of the Internet’s technical dimension. Because the ecology perspective focuses on actors and their collective action, “coordination” is a key dimension of an ecology view. Although these perspectives have been discussed, to various degrees, in previous academic literature, they have not been combined into one conceptualization, even though I find this to be a core requirement for understanding the interplay of influences and technologies that make up the Internet. This research question addresses this shortcoming by proposing a description of the Internet which combines the coordination and technology dimensions into one cohesive conceptualization. I use this conceptualization as the basis for discussing implications of the ecology view from the perspective of the role of actors and the nature of coordination.

Practically, to answer this question I read up on standards (such as Requests for Comments (RFCs) and Best Current Practice (BCP) suggestions), refreshed my practical knowledge on routing and domain name resolution and set out to interview those who presumably knew more. I present an answer to this question in Chapter 5. Both Chapter 6 and Chapter 7 are framed in the conceptualization construed in Chapter 5. The discussion is summarized in Chapter 8, and of particular interest are the design principles behind the Internet since they succinctly explain and define the initial intentions with the Internet; and in a less succinct but still applicable manner describe the development since. My suggested design principles differ from the suggested design rules in Hanseth and Lytyinen (2010), both in scope (Hanseth & Lytyinen, 2010, includes activities on the (technical) Internet in the Internet-concept,
1.3. Research questions

but does not mention its coordination and actual rules. In the perspective of this thesis, texts such as Hanseth and Lyttinen (2010), DeNardis and Raymond (2013) and Liu (1999) are too including in what they consider the Internet, and the more parsimonious conceptualization of this thesis explicitly puts use of the Internet outside the Internet Coordination arena for the Internet.

In addition to my Internet conceptualization, Chapter 5 also goes through and presents the most important Internet actor influencers (who in extension affect the ecology as a whole), who in essence shape the Internet, both from a coordination and technology point of view. Chapter 10 summarizes the discussion.

RQ 2 How is the Internet, as conceptualized, here, coordinated?

Just as academic agreement on the constituency of the Internet is nonexistent, so are the agreements on how the Internet is coordinated or governed. Existing literature (for example DeNardis & Raymond, 2013; Liu, 1999; van Eeten & Mueller, 2012) puts almost the entirety of the digitization concept into the Internet concept as such, and end up with perspectives of an Internet in need of governance. By using an ecology-view of the Internet actors and technical understanding (which, for example, de Reuver et al., 2017; Hanseth & Lyttinen, 2010, do not explicitly show) I present a more nuanced view of the technology and coordination which constitutes the Internet.

I set out to find out how the Internet as envisioned (i.e. Chapter 5) is governed (or coordinated), by interviews and reading policy, statutes, bylaws and similar documents with regard to the Internet and telecommunications. Chapter 5 suggests one perspective of Internet Coordination and Chapter 6 goes deeper into the social questions of this coordination (primarily from a social resilience point of view). Section 8.5 makes the case that the Internet is coordinated on the same principles as it is technically designed (as such aligning technology and coordination, which is often mentioned or assumed, but seldom defined, cf. Askenäs & Westelius, 2003; Groth, 1999; Lapointe & Rivard, 2007; Leonardi & Barley, 2010; Zuboff, 1988). Chapter 8 ties together the discussion and Chapter 10 summarizes it.

RQ 3 Which are the prevalent perspectives of how to coordinate, design and run digital communications networks?

Prior research and practice suggest different ways of conducting digital communication networks and use, and I contribute to the notion of digital communication networks and services by synthesizing two perspectives on digital communications networks.
I suggest two perspectives, in some aspects disparate, containing guidelines and rules for designing and coordinating digital communications networks and services. These perspectives are called the distributed perspective and the integrative perspective, and follow different logics, principles and values both in technical design and coordination and organization.

In essence, I make the argument that there is a difference in coordination modes between classical telecommunications and the Internet. I elaborate more on these differences and their practical consequences with regard to net neutrality in Chapter 7, discuss design consequences in Section 8.7, throw an even wider net in Chapter 9 (digitization and organization) and end with a wider discussion of implications and contributions of this thesis in Chapter 11.

Given that the aim of this thesis is to support discussions about the Internet based on a broader understanding of who is involved in coordinating it, and what the main mechanisms and challenges of coordination are, I conclude the discussion of this question with an in-depth reflection on implications for uses of the Internet and actors who make up the Internet.

My intention is to not get caught in minutiae of protocol specifications or bylaw wording, and rather go for the greater scope of the Internet and its implications. I unavoidably think of an old paper I read which has a look at make (or Makefiles, a way of automating software builds) and says quite illustratively:

Most of us are too caught up in the minutiae of just getting the rotten build to work that we don’t have time to spare for the big picture. (Miller, 1998, p. 92)

This quote illustrates life all too well. Miller (1998) was here referring to the larger issue of whether the software did the right thing when all developers were stuck in details.

In addition, this thesis contributes to doing research on digital technology issues, and the somewhat somber conclusion is that understanding is needed due to the rapid change (I make the philosophical case of a paradigm shift every seven years is in Section 3.11). As an example, this thesis’ different notion of the Internet compared to many other suggestions, is that this thesis approached the concept of the Internet from multiple directions rather than trying to frame the Internet from one viewpoint or thought collective. The same is true for most matters both organizational and technical, as argued in Section 9.1, and to draw meaningful conclusions with regard to organization and technology, an understanding of both is needed.

As such, I take my conclusions from my empirical setting (the Internet setting), and apply them on a broader set of cases of a dual nature, i.e. organizations using technology and the larger setting of society and technology, and suggest different ways of understanding the Internet and similar phenomena in the larger setting.
1.4. Approach

In particular Section 9.8 concerns organizing and the perspectives, while Section 9.9 goes further and compares the Internet to contemporary technical infrastructure in society, such as the postal system, railway networks and financial services. I suggest that the Internet has developed farther from monolithic institutions than either postal services, railway networks or financial services, due to lower infrastructure costs (i.e. barriers of entry), distributed coordination, shorter investment cycles and shorter service times (i.e. bank transfers, post service and railway transportation usually measure in days, and hours at their shortest, while Internet packet delivery measure in ms).

This thesis also suggests that the Internet is meaningfully seen as a platform or infrastructure for society, similarly money\textsuperscript{7} can be seen as central to how we conduct ourselves and how organizations interact in society. However, it should be noted, as Sassen and Henry (2014) does, that international finance and the Internet are tightly intertwined, so comparing them requires careful investigation, and I suggest a starting point of such an inquiry rather than present the entire inquiry.

1.4 Approach

My approach in this thesis is largely based on interaction with practitioners in the Internet sphere as the initial frame. Chapter 5 and Chapter 6 are driven by semi-structured interviews whilst the later chapters also include leads and thoughts from more informal discussions. My interaction with practitioners bear traits of engagement rather than the passive observer, as described by Van de Ven (2007) and Greenwood and Levin (2006), in that I challenge my interviewees with ideas or thoughts I picked up in the process. Figure 1.3 shows an overview of the approach (Section 2.6 goes through the idea in detail). The original research direction “the Internet” span off into two directions, illustrated by the two arrows (rather than three) in Figure 1.3 from the “Research directions” node. The first two directions are intertwined, and are rather a construction after the fact, and build on the initial “what is the Internet, really?” approach. Figure 1.3 describes what I did in which order, while the research directions are how they are presented in this thesis.

The short version, expanded on in Chapter 2, is that I set out to find out about the Internet, and while doing so discovered that the Internet can meaningfully (in the perspectives I use) be described by a combination of a technical perspective (as an example as in Figure 1.1) and a coordination perspective (as an example as constellations of Figure 1.2). After that I set out to frame actual use based on my understanding of the Internet, and found

\textsuperscript{7}Or debt, credit, coinage, etc. This is briefly problematized as the concept of money and its relationship to markets, and this footnote is used to point out awareness of the conflicting theories of money (in particular the credit theory of money and the commodity theory of money), and argue that the use of money and monetary markets and systems today in society can serve as a meaningful comparison to the Internet in society.
1. Introduction

The Internet

- Research directions
- The Internet is divided into two perspectives, the technical Internet and the actors and coordination of the Internet.
- What is the Internet and what defines and describes it? Chapter 5 raises and answers this question by going through actors involved in setting the frames for what the Internet is.
- How can the Internet be changed and by whom? Chapter 6 investigates the Internet’s social resilience.
- How does the constitution and definition of the Internet affect the use of the Internet? Examplified through the net neutrality debate in Chapter 7 and firm perspectives on the same topic in Section 7.13.

I also use academic literature as well as online information sources such as IETF standards (i.e. Internet Standards and RFC documents) or the bylaws of ICANN, which both remain relatively untouched in academic literature. This is interesting considering that some Requests for Comments are specifically geared towards the coordination of the Internet, such as RFC-2028 The Organizations Involved in the IETF Standards Process (Hovey & Bradner, 1996), which go through all organizations involved in Internet Coordination (according to IETF). Some fields have their own take on the Internet, for example the field of law and regulation: the Internet as unruly and non-functional because there is no traditional state or nation level oversight (see earlier model comparison and Mueller & Chango, 2008; WGIG, 2005, as examples of the Internet being something in need of governance), even though there are exceptions such as Raustiala (2016) and Mansell (2017) which reason that there might be limitations for the traditional law approach to handle Internet Coordination (which I agree with).
1.5 Results

And the most interesting aspect of studying the Internet today is that it is all around us all the time. It is possible to touch and feel it (given that you consider your digital fingers as real as your physical ones), wherever and whenever. As such I have used information of the Internet as well, such as routing, naming and numbering.

As a management scholar I am part of the perspectives sciences, this since my research is not dependent solely on objective measurements but also interpretation and reasoning. My main task is to make sense of my interactions, and to present them in an as coherent and believable way as possible.

Also important, is that not even scientific fact creation processes can be considered objective, but rather contain social elements and take place in what Ludwik Fleck calls thought collectives (see Fleck, 1935, for argument). As an example different fields use different limits for creation of scientific fact from quantitative data; social sciences use 2σ cutoff for sampling randomness, while physicists use 5σ. And both has issues, as shown with Samuel Reich (2011) which “proved” that neutrinos are faster than the speed of causality (i.e. speed of light in perfect vacuum) with a margin lower than 6σ, and was later shown inaccurate (due to instrument error).

The same is true for qualitative and other approaches as well, the contextual thought collective can limit and decide fact and theory.

Mixing management sciences with an engineering understanding of technology is not the easiest of tasks, especially since there are different notions (in these two thought collectives) of what is scientific fact. As I argue further, in Chapter 2, engineering sciences often concern themselves with stating measurable effects (often instrumentally), and do not elaborate on the meaning of such effects, while management sciences can focus on perceptions of events and structures (which can be perceived rather than, in an engineering thought collective, measured).

1.5 Results

On a conceptual level I show that the Internet can be seen as a phenomenon consisting of both coordination (governance) and technology (technical) aspects (as briefly shown in Table 1.1) by logically showing and explaining current and historic events. This perspective of the Internet (i.e. both technology and coordination) gives us a lens in which we can view most digitization-related advances, such as the today common buzzwords of blockchains and artificial intelligence (AI).

I frame the Internet in a distributed perspective, the notion of a bottom-up-governed digital network, which is explicit on a separation of concerns strategy (a software engineering concept, see Section 4.11 for detail) where individual entities are supposed to do one thing and one thing only. Real world examples include Internet subscription in many Swedish cities, where
1. Introduction

Table 1.1: Suggested dimensions of the Internet

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination</td>
<td>Explicitly loose bottom up with focus on empirically motivated decisions.</td>
</tr>
<tr>
<td>Technology</td>
<td>End-to-end best effort digital communication.</td>
</tr>
</tbody>
</table>

different actors provide different layers of the Internet service, i.e. one might sell you the Internet service, one might own the optic fiber, and you buy content from another actor (such as Netflix, HBO or YouTube).

Also included in the distributed perspective view of the Internet, is that the Internet is a best-effort digital communications network, and as that it is prudent that the infrastructure and network operators should not concern themselves with what is sent over it or issues such as intellectual-property rights and network security. The reason for this is that coordinating these additional tasks both violate current design layers, and add additional overhead for coordination so the minimum necessary coordination would be more complex than just coordination of unique identifiers (as the case is today with the Internet Assigned Numbers Authority (IANA) function).

Contrary to the distributed perspective framing stands the integrative perspective, which is focused on optimization of business logic (for example revenue or profit, rather than change in the distributed perspective). The integrative perspective is in some sense the natural behavior of large firms according to economic theory and reasoning (see texts such as Coase, 1937; Taylor, 1914, for earlier thoughts and context on organizing and economic rationality), where logics concern planning of work (where the nature of the work itself, implicitly, can be known ex-ante).

These perspectives are extremes and many real world examples lie in between the two extremes, and the perspectives are concepts rather than real world applications. These perspectives are discussed and presented in Chapter 9.

In practical Internet matters, the long-term power balance in the Internet ecology is changing. One example, ICANN is slowly changing into a more formal governance actor, which can be seen in the recent changes in the bylaws where ICANN gives itself formal power to negotiate on behalf of the Internet. Even though my interviews show that changes are neither readily known nor accepted they still mark measurable difference to the earlier almost universally accepted “Tao” of the IETF: “We reject kings, presidents and voting. We believe in rough consensus and running code” (IETF, 2012).

On a more general level, this thesis shows an example of an ecology which function quite well without a clear governor or leader under these conditions, such as a separation of concerns design. This ecology applies “minimum coor-
Table 1.2: Major themes and threads in this thesis and also the red threads.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Relevant parts</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet</td>
<td>Chapter 3, Chapter 5, Chapter 6, Chapter 7 and Chapter 8</td>
<td>These parts concern the empirical Internet, i.e. the empirical underpinnings of this thesis.</td>
</tr>
<tr>
<td>Technology</td>
<td>Chapter 3, Section 4.11, Section 4.13, Chapter 5, Chapter 7, Section 8.7 and Section 9.1</td>
<td>The technical Internet, focuses on what standards say and their actual implementations. Used to provide a grounded discussion on the coordination of the Internet.</td>
</tr>
<tr>
<td>Coordination</td>
<td>Section 3.3, Section 3.4, Chapter 4, Chapter 5, Chapter 6, Chapter 7, Chapter 8, Section 9.1 and Section 9.7</td>
<td>The coordination part of the Internet and its generalization into digitization grounded in technology.</td>
</tr>
<tr>
<td>Design and values</td>
<td>Section 3.12, Section 4.11, Section 4.12, Section 4.13, Chapter 7, Section 8.7 and Section 9.1</td>
<td>The Internet as a design problem, designed by individuals with values and ideas, which ties together the technology and coordination perspectives on the Internet.</td>
</tr>
<tr>
<td>Telecommunications and policy</td>
<td>Chapter 5, Chapter 7, Section 9.1</td>
<td>The Internet compared and contrasted to telecommunications and telecommunications policies and differentiating the perspectives (i.e. distributed perspective and integrative perspective).</td>
</tr>
<tr>
<td>Society</td>
<td>Chapter 7, Section 9.1, Section 9.8 and Section 9.9</td>
<td>The Internet as an empirical case of technology in society. A generalization outside of the specific empirical context of this thesis.</td>
</tr>
</tbody>
</table>
1. Introduction

dination” by only coordinating unique identifiers (called Least Common Internet in this thesis). Organizational literature in general, for example Alvesson and Spicer (2012), Cohen et al. (1972), Mintzberg (1993), indirectly agree that the complexity of planning and decisions makes centralization difficult, and software design literature explicitly agrees by promoting the SOLID\textsuperscript{8} mentality in particular and texts such as Gamma et al. (1996) in general. Internet coordination and governance mechanisms are organized as suggested by mid nineties software design theories (which are relevant today). Which here match since both coordination and technology structure follows the same design principles and can therefore be said to be aligned. Chapter 7 goes deeper into the mismatch between Internet Coordination structures and the policy enforcement structures in place today for telecommunications with the case of net neutrality, an example of a mismatch of different coordination systems or ideas.

1.6 Contribution of studies

Table 1.3 shows how the studies (or chapters) map to the larger contribution of this thesis. Chapter 5, Chapter 6 and Chapter 7 have all been presented as (working) papers at conferences and are turned into chapters for the purpose of this thesis. Chapter 8 ties the Internet context together and suggests design patterns which leads to the coordination and technology dimensions present today. Chapter 9 goes outside the Internet context and suggests two major design philosophies, or perspectives, to make sense of all manner of digital technologies; I call these the distributed perspective and the integrative perspective.

1.7 Design of thesis

This thesis is primarily written for the reader with an interest in Internet Coordination as well as matters arising from Internet Coordination as digitalization with high-tech in general. The thesis starts off by demarcating the Internet from the general concept of digital communication and then shows the consequences due to these demarcations. A management scholar might consider the management implications shallow, the same way an Internet or technology expert might consider the technological discussion shallow, but neither is my sole focus. My intention is to clarify the consequences of the Internet being both the concept of technical infrastructure and standards and a particular view of coordination and governance.

\textsuperscript{8}SOLID is a set of design principles for object oriented software design. These principles together with principles in Gamma, Helm, Johnson, and Vlissides (1996) provide the foundations for finding the Internet design principles.
1.7. Design of thesis

Table 1.3: Contributions of studies to thesis

<table>
<thead>
<tr>
<th>Study</th>
<th>Subjects</th>
<th>Design</th>
<th>Key contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 5</td>
<td>Internet, coordination, definitions</td>
<td>Qualitative exploratory study</td>
<td>A conceptualization of the Internet, and an empirical mapping of important Internet actors and relationships.</td>
</tr>
<tr>
<td>Chapter 6</td>
<td>Internet, coordination, social resilience, take-overs</td>
<td>Qualitative exploratory study</td>
<td>Shows external political pressure as the most significant threat to current Internet regime by an overview of current Internet coordination systems.</td>
</tr>
<tr>
<td>Chapter 7</td>
<td>Internet, net neutrality, policy</td>
<td>Empirical survey of Internet service</td>
<td>Conceptualization of net neutrality and suggests a matrix for mapping digital communications and net neutrality regimes.</td>
</tr>
</tbody>
</table>

This text assumes that the reader is familiar with the Internet on a conceptual level, i.e. knowing that neither Netflix nor Facebook function without the Internet, but not knowing how at a technical level. Chapter 3 goes through the necessary technical underpinnings for the results to be meaningful, even to encourage all readers to strive for a deeper understanding in how the core Internet protocols and Internet Standards function to appreciate the match between coordination and technology fully.

At a broad level, this chapter (Chapter 1) serves as an introduction to the topic, and is directly answered by the conclusions (Chapter 10). In between these two demarcating chapters lies the main empirical contributions (i.e. Chapter 5, Chapter 6 and Chapter 7), which is introduced by two chapters, one on technical matters (Chapter 3) and one on coordination matters (Chapter 4), and summarized into context in one chapter (Chapter 8). This summary is then applied to related contexts (in Chapter 9) before the concluding chapter (Chapter 10) and suggestions for further research (Chapter 11).
2 Reflection on process and approach

I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail.

— Abraham Maslow

The purpose of this chapter is to go through what I have done and how I have reasoned doing it. This chapter comes ahead of the frames of reference since the frame of reference is heavily dependent on the method, rather than the other way around. In general terms, this is a mixed method thesis. I use interviews (qualitative); written sources such as Internet Standards, Requests for Comments (RFCs), bylaws and academic literature (qualitative); website data (quantitative, i.e. a sample of the web); and Internet routing data (the entire Internet).

2.1 Background and agenda of the researcher

Writing a thesis is different from writing a paper, which is a short text usually aimed at answering one or two well formulated research questions.

A thesis is a long text concerning more than just a narrow question. It involves growing and learning as a researcher. Questioning not only what you do, but yourself.

Therefore, it is prudent to spend a paragraph or two to introduce myself and how I affected the process and potentially the results.
In essence this thesis is based on interviews, what can be observed on the Internet itself and written or otherwise accessible sources. Of these, both interviewing and reading texts, both academic and non-academic, are susceptible to interpretation.

I came to the topic of Internet Governance sliding in on a banana peel. In essence, I was writing a course paper in management where I wanted to compare management systems/frameworks/principles. I wanted to compare the notion of collegiality as a management principle in universities to the governance and coordination mechanisms of the Internet. To my surprise there was no academic consensus of what the Internet is or how it is governed. This insight fueled my calling, since who would be better equipped than me, a computer engineer working at a management information systems division to unravel the mysteries of Internet Governance (or rather Internet Coordination)\

Hubris aside, as an engineer with software development experience in integrating various systems over the Internet I had a decent understanding of the technical side of the Internet. And on the governance and coordination side I was active as a PhD representative in several boards and committees, in essence I was starting to think more critically of how organizations really work and spin.

Armed with technical understanding and growing thoughts on management and governance I set out to explain the Internet. I also want to be explicit that my safe corner (prior to writing this thesis) is (was?) computer engineering, mathematics and finance; and they are the perspectives in which I use(d) to describe the (my?) world (i.e. my thought style). In essence, I was trained to tell upper management at classic production firms that they are now software and IT firms instead and need to rethink how things are done in the age of digitization. Although I have, as of writing this, in my professional life so far spent more time on pricing currency and money market related derivatives\(^1\), integrating financial platforms and systems\(^2\) or getting into the details of day count conventions\(^3\), as well as being part of the interesting pro-

\(^1\)Such as cross currency interest rate swaps, forward rate agreements, currency options, or any exotic combination of any related instrument.

\(^2\)Such as automating hedge trades based on subsidiary currency risk exposure, often with the help of the Internet rather than proprietary networks (as are, or at least were, offered by Bloomberg and Reuters among others).

\(^3\)There are about ten widely used methods of counting days in finance (i.e. how many days of interest should I get in the interval 2009-02-01 till 2049-02-01?), as well as about (depending on how you count and what counts as a different method) three ways to calculate spot/settlement dates based on tenor (for example 3 months or 40 years) or instruments with two settlements in different time-zones (as happens when Western markets are closed Saturdays and Sundays, while Middle Eastern markets Fridays and Saturdays, prompting Friday (Western) — Sunday (Middle East) settlement combinations to avoid having only four market days per week rather than the customary five days).
cess of automating treasury functions to a degree which obsoleted the project manager and treasury staff\footnote{The interaction I had with well paid treasury staff with the intention of automating their work processes taught me a lot; nobody wants to be replaced by \textit{automation}.} than I have on this thesis.

With this I want to make explicit that I might have more of a penchant for technical details than the normal thesis in a non computer-science IT field (such as business studies), which leads me in different directions than most literature I have read. In my \textit{thought style} I try to draw conclusion from the whole of all matters Internet (including both technology and coordination), rather than trying to black box the technology and focus on the social as seems to be the trend in organization or business studies (broadly speaking). I also want to be explicit on that I set out to explain the Internet meaningfully to most (curious) people, I did not set out to explain the Internet within the thought collective of business studies, marketing or similar (which undoubtedly might have been easier, as I argue in Section 2.3, or any other well-defined thought collective).

2.2 Philosophy of science

Where do I belong? How do I think? Instead of stating that I belong in a particular box of philosophy of science, I would say that it matters what I am doing and who I am doing it for.

In essence, I do not believe in absolute objective creation of scientific fact as long as people are involved in the fact creation. I can appreciate the instrumentalism of particle physics (“science is only that which we can observe”) as well as post-modernism (“science is a social construct”) or critical realism (“science is an ongoing process to improve understanding”).

I think Fleck (1935) (a note is suitable here, he wrote the original work in 1935 in German and Polish, I have read and refer to the English translation published in 1979, ergo Fleck (1935) is a precursor to Kuhn (1962) by several decades) to a large extent capture how I see the world.

Both Fleck (1935) and Kuhn (1962) promote similar ideas in different wraps. The much more known \textit{The Structure of Scientific Revolutions} by Kuhn explains scientific evolution in terms of paradigm shifts, in effect when there is enough evidence to support a new theory or understanding the norm for what is right changes. Kuhn (1962) avoids the concept of truth in a way Fleck (1935) does not, and Fleck (1935) merely uses it similarly to fact. But what is fact and theory then?

Let us start from a quote by Freeman Dyson (theoretical physicist, also the Dyson in “Dyson sphere”\footnote{A bit off-topic, for the curious reader; the theoretical notion that advanced civilizations want to gather all the energy of their sun with a sphere of what amounts to advanced solar panels. This is one of the theoretical means of harnessing the energy needed for interstellar travel in human meaningful time spans.}):
Science consists of facts and theories. Facts and theories are born in different ways and are judged by different standards. Facts are supposed to be true or false. They are discovered by observers or experimenters. A scientist who claims to have discovered a fact that turns out to be wrong is judged harshly. One wrong fact is enough to ruin a career.

Theories have an entirely different status. They are free creations of the human mind, intended to describe our understanding of nature. Since our understanding is incomplete, theories are provisional. Theories are tools of understanding, and a tool does not need to be precisely true in order to be useful. Theories are supposed to be more-or-less true, with plenty of room for disagreement. A scientist who invents a theory that turns out to be wrong is judged leniently. Mistakes are tolerated, so long as the culprit is willing to correct them when nature proves them wrong. (Dyson, 2014)

So in the view of Dyson facts are absolute and always true or false, while theories can be descriptions of ideas of how the world works. And fact is “harder” and more right than theory in this perspective.

The perspective of Dyson is comparable to the perspective I experience in my research environment, i.e. that facts are absolute and cannot change. Theory on the other hand is led by empirical evidence but has not been proven true for every scenario. During a scientific argument I pressed for the difference between fact and theory, and got in response that the Newtonian laws are fact, while for example most economic theories are just that, theories. This confused me, since the Newtonian laws are simplifications of mechanical understanding of medium-sized objects moving at medium velocities and acceleration (in essence, objects big enough to be seen by eye but smaller than planets, and objects slow enough not to dilate time, i.e. a falling rock or a fast airplane), and not at all close to being useful at higher velocities or scales, i.e. at best useful simplifications or theories for explaining how objects we can see and measure interact (in an instrumental sense). As an example GPS takes into consideration that time is relative, ergo even the most basic of rules or scientific laws we learn in elementary school are subject to interpretation and are in essence simplifications of representations of reality (and in some context thought collectives referred to as “models”).

Going back to Fleck (1935), the text argues that a fact is partly a social construction, and that thought collectives have developed methods and context for creating fact (cf. paradigm in Kuhn, 1962), and that these facts are

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*The current regime in astrophysics is Newtonian dynamics modified with general relativity (i.e. Einstein, 1915), although this regime is challenged by other theories aiming to explain gravity at both quantum and cosmological scales. Newtonian dynamics does not explain gravity at quantum scales and have issues with observations at cosmological scales.*
often incommensurable between thought collectives, i.e. scientific fields. As my previous example states, for someone not in physics the Newtonian laws might very well be fact, even though they are objectively not fact in that they are not true in every perspective or thought collective (or velocity or acceleration for that matter). A main difference between Fleck (1935) and Kuhn (1962) is that Fleck (1935) does not assume that changes in thought collective leads towards a “better” thought collective whilst Kuhn (1962) assumes improvement with paradigm shifts (i.e. Fleck is not a stranger to the idea that science might devolve due to communal or social processes).

It is possible to say, a bit boldly, that thought collectives do not consider that which they do not understand (or are interested in) important. As the Maslow quote in the epigraph states, it is always tempting to frame the world in ways you understand rather than change your perspectives.

Another interesting input on the topic of science and truth is Eddington (1934) who quite thoughtfully said: 

But are we sure of our observational facts? Scientific men are rather fond of saying pontifically that one ought to be quite sure of observational facts before embarking on theory. Fortunately those who give us this advice do not practice what they preach. Observation and theory get on best when they are mixed together, both helping one another in the pursuit of truth. It is a good rule not to put overmuch confidence in a theory until it has been confirmed by observation. I hope I shall not shock the experimental physicists if I add that it is also a good rule not to put overmuch confidence in the observational results that are put forward until they have been confirmed by theory. (Eddington, 1934, p. 211)

Of which the last sentence is often misquoted as “I won’t believe the experiment until it is confirmed by theory!” as, among others, is done in, Hestenes (2009), but Eddington obviously thought deeper than that and is in line with the reasoning in Kovács and Spens (2005) in that a combination of theory (i.e. explanation) and observation (i.e. something measured) provides the best research, or the most believable research.

For avoidance of doubt, I do not fully agree with Dyson (2014) but I can accept that facts are seen that way in the thought collective of physicists.

To quickly touch on theory, Fleck (1935) argues that theory is not reality in itself but rather ways to explain the world in a thought collective, much like facts but less dogmatic. A view which is shared by DiMaggio (in DiMaggio, 1995) in his comment on Sutton and Staw (1995), “What Theory is Not”. To further elaborate on this, theory should explain not only what happens, but why it happens. The argument in Weick (1995) goes further than Sutton and Staw (1995) and says that it is important not to forget theorizing, the process of creating theory, and that journals in their hunt for theory-rich
papers should not be quick to reject work contributing to theorizing rather than theory. This is the view on theorizing I have in this thesis, I do not aim to objectively explain everything in the world but rather focus on reasoning on empirical observations (such as interviews, literature or Internet observations) in order to suggest reasons why what I term the Internet ecology is developing the way it does today. And also, explicitly, contribute to the notion of how it is possible to theorize with regard to the Internet (and digitization in general).

Here it should also be noted that I follow the belief in Fleck (1935) and Kuhn (1962) that science is not only cumulative in its accumulation of fact and theory, and that shifts in thought collectives or paradigms happen and need to happen to understand events in changing contexts. For example, new instruments allowed for more precise measurements of heavenly bodies and ushered (several) paradigm shifts in cosmology and astronomy. Or the example of the phlogiston theory of combustion, which was not improved on but discarded as it had gotten fundamental axioms and assumptions wrong. In the light of this thesis, there are several thought collectives which rely on the existence of money for market function (which is reasonable if money is only given out by states and under some form of conservative governance), but certainly something is bound to happen if firms with for-profit interests starts printing (digital? crypto?) monies. Or the Internet, if assumed as a best-effort black box (as is the case in business and information systems research), how would a non-best-effort (for example a service layer digital network) change or discard earlier theories on the use of the Internet in those thought collectives.

Also, I consider the notion of Sutton and Staw (1995) that referencing is not theory, and that referencing is done too easily and that it is often unclear which part of a referenced idea the author is referring to, which I explicitly aim to avoid in this thesis.

Another aspect of science is its generalizability, a topic touched on in Lee and Baskerville (2003), a text sometimes considered canon in the thought collective I work (and partially do my research), which is only touched indirectly in Fleck (1935). One might argue that the purpose of science is to create generalizable theories, but how then might we generalize and still consider the generalization scientific? I see the answer to this in a qualitative context that as long as it is possible to logically explain and reason why something happens or is connected, it can be considered scientific.

In essence my approach can be seen as an abductive (or “hypothesis”, cf. Kovács & Spens, 2005; Pierce, 1878) use of grounded theory (i.e. where empirics rather than theory lead the original inquiry). That is, I used both previous literature, all of theory, opinion and empirical information, and my own empirical data to create a working understanding, or theory in the definition of Sutton and Staw (1995), of how the Internet works and is coordinated. I mean abductive in the sense of Kovács and Spens (2005) (i.e. “hypothesis” in Pierce, 1878), i.e. with focus on using intuition and creativity along with
2.3. Positioning

Table 2.1: Traditional modes of inference in Pierce (1878)

<table>
<thead>
<tr>
<th>Mode of inference</th>
<th>Deduction</th>
<th>Induction</th>
<th>Abduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic</td>
<td>Rule + Case $\Rightarrow$ Result</td>
<td>Case + Result $\Rightarrow$ Rule</td>
<td>Rule + Result $\Rightarrow$ Case</td>
</tr>
<tr>
<td>Description</td>
<td>“Top-down logic”, inference to the result from the rule and case</td>
<td>“Bottom-up logic”, inference to the rule from the case(s)</td>
<td>Inference to the best explanation (among many)</td>
</tr>
</tbody>
</table>

literature and empirical data, and go back and forth between literature and empirical data, to create new understanding or theory. Or as encountered in philosophy of science contexts; abduction is “inference to the best explanation” (i.e. close to the Hilary Putnam argument of “science works because it is reasonably close to truth”, see Table 2.1 for an overview of inference paradigms as described in Pierce, 1878).

I did not actively choose “abductive grounded theory”, but it is rather where I ended up when explaining what I encountered to the mixed academic community.

2.3 Positioning

As a PhD-candidate in a cross-disciplinary environment it was natural to frame the problem at hand (Internet Coordination) without a strong delimitation to a particular academic field. Therefore the results of this thesis would have been different if I had set out to frame the Internet in a pre-existing literature stream (such as telecommunications policy where the Internet often is a service, or business studies where the Internet is often black-boxed technology).

An example might be prudent here; if you are to study business models in organizations, should you set out to study what you consider to be business models or should you study what the organizations (or their top management? or their mid level management?) consider to be business models?

I did the latter, I set out to find out what the Internet is according to those using and coordinating it (since I let the empirical setting guide my inquiry it would have been counterproductive to use my own prior conceptualization of the Internet as a measuring stick). My prior bias with regard to the Internet was technical rather than one of governance or coordination. Even though I tried to avoid my own bias, I was looking for hints and traces of how the
2. Reflection on process and approach

Internet in a technical sense was and is governed or coordinated. As an example, I knew how Internet Protocol (IP) and Domain Name System (DNS) worked, but I did not really know how they came to be the accepted standards. Nor the norms in charge of keeping the network as such functioning.

This would have been an easier and straighter journey if I had followed the norms and thought style of a field. But, as I argue in this thesis, the results would not have been interesting nor useful outside that context.

To further explain this standpoint, I believe that “standing on the shoulders of giants” is meaningful in that you do not have to empirically redo what has already been done (except when that is the explicit purpose, such as replication studies) but not in the sense of using what has already been done without a deeper understanding (cf. Sutton & Staw, 1995, which argues that referencing is not theory). This is a comment on how I have been schooled as PhD-candidate, and review processes with comments such as “why did you not reference X or Y?”, that I perceive a focus on referencing rather than using or understanding that which is referenced.

Worrying to me, is the notion that you as a non-tenured academic should not stray far from theory, as can be seen in, among other, Van de Ven (2016) which argues that it is detrimental to science that we stay too close to accepted theory in an effort to improve that which is known instead of creating new ways of understanding (i.e. new thought styles in the Fleckian sense). Recently there was an explicit case in astronomy concerning ‘Oumuamua, the first known interstellar object to pass through our solar system7, where distinguished astrophysicists argued that it is not possible to reject the theory that it is a solar sail (see Bialy & Loeb, 2018, for the initial paper), implying that we cannot reject that it is the first sign of alien civilization due to the stationary nature of the object relative the local rotation of the Milky Way, the origins and the unusual dimensions of the object (see Reid, 2018, for a pop-science summary). The paper, Bialy and Loeb (2018), has been ridiculed for being unscientific and potentially wrong (even though the math checks out) due to mentioning extraterrestrial life. Loeb (the more senior of the researchers, also connected to the previously mentioned Freeman Dyson by professional setting) responded to this in an interview with ArsTechnica as follows:

> [on why some are “angry” at the use of extraterrestrials as a potential source for ‘Oumuamua]

Quantum mechanics was discovered as a result of experiments. Einstein had this emotional reaction to it, he didn’t like that theory, he thought that something is wrong with it. He wrote papers

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7Technically an interstellar object is (roughly) an object with enough momentum to not be bound by the gravitational well of our sun, implying that the object originated well outside our solar system.
about it, but Einstein was wrong. So, Einstein made mistakes and the reason I point this out is that anyone can make mistakes. Therefore, one should remain humble. The academic community has this concept of tenure, where someone has faculty position for life, you’re irrespective of what happens, okay? As long as that person doesn’t commit a crime. That is a great privilege. It’s a privilege to follow ideas to where they lead you without worrying about what other people think.

However, many practitioners in academia do not use that privilege. Once they get to the position of tenure, they worry about their image and about not being wrong. By doing so, they betray the purpose of their profession.

(Loeb in the transcript of Reid & Loeb, 2018)

This ties back into texts such as Van de Ven (2016) and the purpose of research and the incentives in research today. As a research student representative with experience from department, faculty, university and national level boards and similar constellations ranging from university governance to national research policy I am also worried and see the trends described in Van de Ven (2016) and Loeb (in Reid & Loeb, 2018), that we are incentivized to stay close to “the wall” rather than letting go to find new explanations and ways to make sense of the world. As argued in Fleck (1935), research is a social process fraught with conflicting ideas and ideologies, and we should not stop to create new ways to make sense of the world just because we might make someone angry.

These thoughts have affected how I thought and what I did during the process. I have striven to be honest with myself and this text about what I see and encounter, even though it at times would have been easier to shave the empirical setting to better fit theoretical notions on how international governance and markets are supposed to work.

I have tried to write a text that carries meaning for a wider audience and not only myself. It has been a long and arduous journey.

2.4 Motivation for bundling thought collectives

This section aims to, briefly, explain reasons for using concepts commonly available in disparate thought collectives, such as interviews and inspecting raw Border Gateway Protocol (BGP) data, when investigating a phenomenon. Also important, is the notion that multiple thought collectives can make sense of the same phenomenon (in their own worlds), i.e. it is possible to make sense of the same events or empirical setting in different ways. See for example the example of syphilis in Fleck (1935) (well worth a read) as either a virus or bacterial infection, or as a punishment from God.
2. Reflection on process and approach

I make the argument that to understand the Internet, an understanding of both technology and coordination is needed. For example, Section 3.10 makes the case of a technical only Internet as nonsense (i.e. not fact\textsuperscript{8}), and Section 3.4 argues that the Internet without fully understanding its technological constituency is nonsense.

Table 2.2: Using two thought collectives to distill theory.

<table>
<thead>
<tr>
<th>Thought collective B</th>
<th>Thought collective A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fact</td>
<td>Fact</td>
</tr>
<tr>
<td>Nonsense</td>
<td>Nonsense</td>
</tr>
<tr>
<td></td>
<td>Combined thought collective</td>
</tr>
</tbody>
</table>

As illustrated in Table 2.2, the notion is that each additional thought collective, or way of making sense of the world, adds to the power of the theories or theorizing done in regard to a setting. For example, using quantitative frequentist\textsuperscript{9} nomenclature, each additional thought collective can reject additional hypothesis, and possibly the null hypothesis as well.

As such, the notion is that by using multiple ideas of creation of theory and fact (i.e. thought collectives) I can distill a crisper, more detailed and still (in those thought collectives) meaningful conceptualization of the Internet and consequences of that conceptualization.

It should also be noted that not only can combined thought collectives filter out meaning in complex settings, but that meaning might also be harder to find. As such, adding additional thought collectives might conclude a certain theory or fact as nonsense, even though said theory or fact already carries meaning in multiple thought collectives, much like multiplying any magnitude with zero equals zero. Therefore, thought collectives should be used with care, and it is possible to turn the conclusions of this thesis into nonsense by adding additional thought collectives to the context at hand.

For example, March and Simon (1958) argue (conceptually) for the need of hierarchical structures and managers to efficiently organize organizations, while Billinger and Rosenbaum (2019) limits the context in which such assumptions are true. In the context of this thesis, net neutrality literature, such as Economides and Hermalin (2012) and Cheng, Bandyopadhyay, and

\textsuperscript{8}The notion that everything not “fact” is nonsense is quite harsh, and only used to draw a full picture based on inter-thought collective interactions, that is that the amount of fact in two thought collectives is less than the amount of fact in either of the thought collectives.

\textsuperscript{9}As opposed to other quantitative thought collectives, such as Bayesian or neural networks.
Guo (2011), often use technical assumptions from cable-TV-like infrastructure, which is different from the networks of interconnected networks that is the Internet, to draw economic and policy conclusions in a policy / economy thought collective. An addition of a technical thought collective would have discarded such conclusions based on inaccuracies of assumptions (as I do in Chapter 7). Here it should be noted that from a critical perspective it is possible to use fields or thought collectives as hermeneutic or epistemic tricks knowingly to avoid paradigm shifts (cf. Kuhn, 1962) or enforce a thought collective (cf. Fleck, 1935) by avoiding settings or empirical data which said field or thought collective cannot (or does not want to) explain.

As an example, it is possible to argue that Cheng et al. (2011) is written with assumptions, abstractions and models which do not pass a technical litmus test, knowingly to in the larger setting indirectly make the argument that the fields of economics and policy are relevant when discussing the Internet and Internet-access. I am here not suggesting that it is the case, merely suggesting that it is possible to misuse science in a social way to further agendas, much as Latour and Woolgar (1979), Fleck (1935) and Kuhn (1962) argue with varying degrees of explicitness. And to be frank, the Internet concerns trillions of US dollars and most digital information flows, so it is to be expected that there are a multitude of interests from both for-profit organizations and nation states vying for different degrees of control.

In the light of this thesis, ecology texts (such as Olve et al., 2013; Westelius & Lindh, 2016) are used in conjunction with notion of managing (such as Malmi & Brown, 2008; Simons, 1995), organizing (such as DiMaggio & Powell, 1983; Groth, 1999; Meyer & Rowan, 1977; Mintzberg, 1993; Okhuysen & Bechky, 2009; Simon, 1997) and technical systems design (such as thoughts in Dijkstra, 1982; Gamma et al., 1996; Martin, Rabaey, Chandrakasan, & Nikolic, 2003) to illustrate a meaningful ecology perspective of the Internet. As such I mix, to a certain extent, different philosophies of science to make sense of the object at hand, the Internet (cf. argument in Van de Ven, 2016, on whether theory or observation should guide the scientific inquiry, and what the pitfalls of each are).

In essence, I try to use a combination of theories to explain the Internet, as for example cosmology does when explaining the universe and in particular the issue of gravity (see, for example, the philosophy of science approach to cosmology in Massimi & Peacock, 2015). In short, there is no agreement on how gravity works in quantum and cosmological context (i.e. very very small and very very large contexts). As such there are several theories on what gravity is (a fundamental force? an emergent property?), including but not limited to Newtonian general relativity (as formulated in Einstein, 1915, and based on Newtonian principles), MOND (MØdified Newtonian Dynamics, see for example Milgrom, 1983a, 1983b), TeVeS (MOND with general relativity, see Bekenstein, 2004), entropic gravity (or emergent gravity, i.e. gravity is not a force, rather a consequence of quantum fields, see Verlinde, 2011) or
2. Reflection on process and approach

quantized inertia (gravity and inertia is the result of quantum fields, Unruh radiation and Rindler horizons, see McCulloch, 200710. All these theories intend to explain gravity.

The point here is that thought collectives in astrophysics and cosmology do not understand gravity, even if an observer external to these thought collectives might believe we do. We can approximate the behavior of gravity in most contexts, but we have not agreed on how it actually works (opposed to, for example, the strong and weak (nuclear) forces and electromagnetism). But only by having scientific discussions can we go forward. My intent here is to challenge the concept of the Internet in multiple thought collectives and to that extent contribute to theorizing (or scientizing) of the Internet specifically and digitization in general. Discussing and theorizing is needed, not adherence to thought collectives.

The last paragraph can also be framed as too much theory build in a different context hampers observations and reasoning with regards to different contexts. Using Kuhnian terms, this is rather a push for a paradigm shift than an exercise of normal science, and a push for a wider paradigm where assumptions are given less credence than interpretation of observations (of any kind).

This thesis uses thought collectives as an efficient means of gaining resolution of proposed theorizing, rather than going deep in one thought collective, instead paint a landscape or overview of the Internet and its ecology in a way meaningful in multiple thought collectives if disregarding axiomatic assumptions, abstractions and idealizations in said thought collectives.

2.5 Writing process

It might also be prudent with a short word on the (technical) writing process and the final layout and ordering of this thesis. From the start I aimed for a compilation thesis with three papers; one on the general coordination of the Internet introducing and defining concepts such as the Internet and Internet Coordination, one on social resilience (i.e. given what the Internet is and is coordinated, how can it be disrupted by non-technical means?) and one paper discusses consequences of this conceptualization and view of the Internet on broader society through the lens of net neutrality.

Quite late in the process the two first papers, which are available as conference papers, were filled out to a more proper paper size in terms of scope and converted to chapters (i.e. Chapter 5 for overview and conceptualizations and Chapter 6 for social resilience). This meant that I also converted

10A bit simplified, traditional physics started with the Newtonian model of mass causing gravity and switched to the general relativity model of mass bending space-time which we interpret as gravity. Emergent gravity theories go further and often suggest that both mass and gravity are consequences of quantum field interactions (in different forms).
the third (working-) paper into a chapter (i.e. Chapter 7 and net neutrality). Ergo, the chapters have clear remnants of paper character, such as their own method and literature sections, and are written in a telecommunications-policy thought collective rather than a more business studies or management thought collective as the rest of the thesis (or rather, written to be accepted by such a thought collective than actually written in it).

This thesis is written in Emacs and typeset with LuaTEX based on the liuthesis-template\textsuperscript{11}. Due to my developer background I also continuously built my thesis and I have all my version history in a git-repository. This might seem like overkill but has helped me diff (i.e. look for changes structurally) versions of the thesis and easily jump through different versions without the risk of ever loosing any text written. As an example this version is named (i.e. has the hash) f28cdfe and was committed by Fredrik Lindeberg (flindeberg@gmail.com) on 2019-12-06 (this sentence is automated).

The downside of using LuaTEX is that in the end my thesis compiled in roughly five minutes from clean on my working laptop, which at times was infuriating when I had reformatted the glossary or similar “breaking changes” in LuaTEX. This long compilation time stems from my liberal use of figures and multi-page tables (which T\TeX, i.e. the typesetter, has issues doing efficiently). Minor modifications required shorter compilation times, measured in seconds rather than minutes (if tables did not have to be moved). The entire compilation process is controlled by \texttt{make} and several \texttt{Makefiles} to be able to parallelize the process (I mention \texttt{make} here to show that I am proficient with such tools, as I later in Chapter 4 give quite hard critique to theorizing which oversees, what in their thought collective, are just technical details).

Most figures are generated by the TikZ and PGF libraries, in particular the mindmap library for figures such as Figure 2.1 and Figure 4.1. There are some figures, such as Figure 1.1 and Figure 3.5, which are generated by a mix of tools for graph generation, and some additional changes in my own fork\textsuperscript{12}. Other figures, such as Figure 7.2 and Figure 7.3 are generated by a different graph-tool I wrote\textsuperscript{13}. The implementation details and notions are discussed in Section 2.7.

The process of generating this thesis can be roughly compared to the “Engineering vs Office” approaches as described in Healy (2019). This thesis being in the engineering end, and frankly outside of the scale in Healy (2019) as Healy does not build nor write his own tools.

The first words of this thesis were written some years ago (which I can see by looking at git-history), so the entire writing process in essence is spread over multiple years, which means that for such a politically interesting and

\textsuperscript{11}Available at https://gitlab.ida.liu.se/olale55/liuthesis, I forked and modified it slightly to better suit my needs. I have not (yet) made pull requests for my changes.

\textsuperscript{12}Graphing code available at https://github.com/flindeberg/LGL

\textsuperscript{13}Website tracer and graphing code available at https://github.com/flindeberg/internet-tools
current issue as the Internet (and especially net neutrality) many reports and articles have been published during the process. Many newer texts have been incorporated into the text of the thesis naturally, but for example Chapter 5 and Chapter 6 are at the defense of this thesis more than two years old in content (although reformatted and modified into chapters) and Chapter 7 more than one year. Due to being on parental leave the first half of 2019 and focusing on the administration of printing and getting a defense set up in the second half, I have not been up to date to all literature and reports published on the subject. Some have come to my attention though, one particular such example is the Swedish Internet access definition report (see Netnod, 2019) which was released the spring of 2019 and is included as a revisit to the Internet-definition in Chapter 5, rather than, if the entire thesis was written in one day, as one of the major sources from which I could have grounded my definition. Another interesting report is the Royal Swedish Academy of Engineering Sciences report on digitization (see IVA, 2019), roughly titled “digitization for increased competitiveness [of Sweden]”, which covers the role and coordination of digitization in Sweden.

Tying back my writing style into the thesis, previously in my professional life I focused on the what, rather than the how and the why (i.e. the meaning of the what) which is the norm in interpretative fields. See for example the very technical Schaik et al. (2019), Minkin et al. (2019), Lipp et al. (2018) or Kocher et al. (2018), who all describe different (but interconnected) vulnerabilities for computer processors (a what), and also show how to use them (another what), and do not go further and reason to the larger meaning or problem with these vulnerabilities. That is how I used to write, changing style into discussing how and why took more effort than I initially expected, and I assume that any reader of this text will realize the valiant efforts of an engineer trying to communicate with the larger academic setting and society.

2.6 Research approach

In general my approach was abductive (in the sense of Kovács & Spens, 2005), and I iterated between talking to people, reading technical specifications, reading academic articles, mapping my own Internet use and writing and using network related scripts and programs to figure out what the Internet is and how the Internet works. In essence the research process can be divided into three steps related to the research questions (and illustrated in Figure 2.1): find the actors responsible for creating and running the Internet to figure out what the Internet is through interviews, literature and other documents such as bylaws and memorandums of understanding (Chapter 5); figure out what could change what the Internet is in a social sense through interviews and reading through bylaws, statutes and academic texts on all manner of (sometimes hostile) take-overs (Chapter 6); and finally, in what way does it matter
that the Internet is as defined in Chapter 5 with limitations in Chapter 6 (shown through the example of net neutrality in Chapter 7 based on mapping the resources needed for a large selection of websites and economic and policy literature on net neutrality).

The final step is generalizing from the results in Chapter 5, Chapter 6 and Chapter 7 and apply to different fields and areas. Specifically I show that the design principles behind the Internet are present also in many other areas.

Also important, is that in this approach the Internet is not only technical or only coordination, but assumed to be some collection of technical infrastructure, standards and their implementations, organizations and people.

### 2.7 Collecting data

I have collected data from three conceptually different sources. At a general level I have a heuristic approach (in that I cast a wide net to find texts, and interpreted them in the context they were written in) to texts, such as academic texts, statutes and news articles. The critical approach to interviews in that I routinely challenged the views of my interviewees with my own views and the
view of other interviewees (as long as they could be kept anonymous). A positivist approach to collecting data, such as traceroutes and website resources, of the Internet itself.

I have talked to people in the effort of getting their view of what they consider to be the Internet and how it is managed, coordinated, controlled or governed (if applicable). I have taken into account that many of my interviewees are employed by organizations who (in the way organizations can have an opinion) might have plans for the Internet.

In addition, I used texts of different kinds, such as academic literature, bylaws, process-documents, standards and so forth, which represent both previous academic understanding of the subject at hand (the academic literature, mainly economics and policy on the topic of international communications regarding the Internet, and also organization and business literature on the more general concept of organizing and coordinating) and of the formal documents in charge of coordinating the Internet.

In a sense the closest I have come to asking the Internet itself what it is, is querying hosts and servers across the Internet, as well the large data sampling for websites I did for Chapter 7 which taught me quite a bit about current website design and resource use. Also, on the Internet itself is the generation of graphs (such as Figure 1.1), which is based on actual historic routing data, and as such a representation of the technical routing reality of the Internet.

Of these three, quite broad, categories of data none in itself is unique. I am not the first one to talk to people to get their understanding or guidance in understanding the Internet, neither am I the first one to read academic literature or bylaws to understand coordination phenomena, or the first one to use data collected from the Internet to show how the Internet is used in practice. But I might be among the first who use all three to describe the Internet and its coordination coherently.

In the upcoming sections I go through each of these sources in the order written sources, interviews and the Internet itself.

**Academic literature and other written sources**

Internet Governance and the Internet itself are both problematic terms, as argued in van Eeten and Mueller (2012), and many fields use different names or terms to describe similar but sometimes different things. This is in line with the reasoning of Fleck (1935) on thought collectives.

Therefore, my process of finding relevant literature consisted not only of searching for keywords such as Internet or Internet Governance but also browsing through journals and text collections for literature concerning Internet Governance, but potentially using a different vocabulary.

Also problematic, is the term governance, which in many areas pertain to the concept of a sovereign power governing something. Both the sovereign
2.7. Collecting data

power and the concept of something needing governance is problematic in an Internet Governance lens.

In a quasi-sensitizing manner I set out to find literature before doing interviews (as a step to appear more knowledgeable during interviews), and soon after doing the first interviews I realized that much of what I had read was irrelevant. Mainly literature assumed that the Internet was more governed than it is and went from there, for example assuming that Internet Corporation for Assigned Names and Number (ICANN) has fundamental regulatory power over the Internet rather than one of several coordinating actors.

My interviews led me into economics, policy and law literature which is focused on providing recommendations for public governance such as policies, and literature which in general is quite incommensurable with both technical literature on the Internet and business studies literature. Incommensurable because different aspects are considered important and worth reporting on, even though the same aspects were described differently (is the Internet market based or an international telecommunications regime?). For example Sutton and Staw (1995) argues that it is important to follow the empirical situation and not hold on to previous literature forever (i.e. let empirics lead where reasonable), while for example net neutrality literature in economics focus on applying economic models such as two-sided markets to the Internet (i.e. lead by theory) even though the assumptions necessary for two-sided market theory are not present in the technical nature of the network (see Table 3.6 for growth and size of the Internet).

I read through those Requests for Comments (Internet Engineering Task Force (IETF) published documents) related to the standards-setting processes, of particular interest is RFC-2026 The Internet Standards Process – Revision 3 (Bradner, 1996), describing the Internet standards process and serves as a guideline for what the Internet can be seen as, and RFC-2028 The Organizations Involved in the IETF Standards Process (Hovey & Bradner, 1996), which describe the (back then) actors involved in the coordination process.

I also went through most official documents of ICANN and their Empowered Community (EC) hierarchy, such as bylaws and statutes, voting procedures, missions and mandates and so forth (which I compared to opinions of interviewees, i.e. I did not assume that the documents describe the actual process, and neither did I assume that the interviews described the actual process with full accuracy).

At a broader level the information in the IETF and ICANN related documents is more congruent with the Internet operation and function I encountered in my interviews than previous academic literature on the subject. Also, the Electronic Frontier Foundation (EFF), a non-profit pro-open-Internet organization, is worth a mention as a source of (argumentative) texts on the Internet and its function, and is responsible for the publication of documents such as Markus (2006), part of Hepting v. AT&T a class action lawsuit against
2. Reflection on process and approach

AT&T for spying on their customers (on behalf of the government). Everyone interested in the Internet should read Markus (2006) and its description of “Room 641A”. It succinctly explains why and how the Internet infrastructure should and should not be trusted (Hepting v. AT&T was ultimately dismissed in 2009 since the FISA Amendments Act of 2008 was passed, which in essence grants telecommunications companies immunity for cooperation with authorities, i.e. spying on behalf of the National Security Agency (NSA)).

Chapter 3 and Chapter 4 are more critical of Internet Governance literature than what can be considered the norm in a licentiate thesis. Primarily due to assumptions and grounding which is, technically speaking, inaccurate for policy and economics literature (such as assuming that Internet use can meaningfully be modeled as a two-sided market), and technical literature which wholeheartedly ignores coordination or market issues which might arise from a certain solution (such as concentrating all power to one actor).

Interviews and discussions

One of the main data collection strategies I had was talking to people. And challenging people on their ideas. I assumed that it would be easy to find people willing to talk about the Internet and its coordination, but it turned out to be harder than I thought (at least to get it on the record). One early interview highlighted a reason for this;

Interviewee — [T]hey [everyone except Internet people] are usually not interested in these matters [Internet coordination issues], and you [i.e. I, the interviewer] are going to have a hard time to get them to talk to you.

Interviewer — Why?

Interviewee — It’s not that it doesn’t concern them, it’s that they don’t know it concerns them. (Translated from Swedish)

When I started to look for interviewees I was initially looking for Internet people, at that stage the people I gave credit of both understanding the technical Internet and its governance, and they almost all agreed to talk to me in one form or another.

Initially I contacted internationally senior people in Internet central organizations, in many cases previously known to me since I have been technically interested in the Internet and its inner workings for a long time, and went from there. A word on “senior” might be prudent as well; since I could almost only find contact information to senior people publicly I assumed that the junior people just were not publicly reachable in the same manner, but it turned out that is many cases there were no junior people (and as I discuss in Chapter 5 several interviewees consider it to be an issue to get new blood in organizations such as ICANN and the IETF).
A majority of those I formally asked in the Internet setting agreed to formal interviews (i.e. controlled setting, such as recording the interview in a room) and due to my time prioritization not everyone who agreed to talk to me has been interviewed formally. This prioritization consisted of that interviews in a certain setting or role had started to repeat themselves, and I would then rather interview (or rather spend time trying to get into an interview situation) people with a different perspective on the Internet and its governance. I consider that I exhausted the Internet-people perspective in the context of this thesis.

Potential interviewees in other areas than directly connected to the Internet were in general very restrictive. Surprisingly, only one Internet Service Provider (ISP) agreed to do a formal interview with me. At the time I did not reflect on it, and even explained it with “they are probably just too busy to talk to me”, but at the finalization of this thesis my thoughts were rather “why should an ISP talk to me?” since my investigation led me in the direction that triple-play and similar should not be offered by one actor (i.e. from an Internet perspective, one who sells Internet access should not also sell TV or phone services due to separation of concerns constraints or layer violation concerns, which I later on understood the ISPs are aware of. And therefore would not want to be present in a recording defending triple-play and no-net neutrality regimes).

For initial contact I used cold emails and references (I tried cold calling but no contact initiated by phone ended up in an interview). The initial email contact was usually positive and the potential interviewee asked for some example issues I wanted to discuss. The Internet people response to my example issues were generally very positive, and as an example I got a response, which I consider positive:

Interviewee in email — Could we move the interview to [another date and time]? I think we should have more time than I do at [original date and time] (Translated from Swedish)

Other potential interviewees were negative with regard to talking to me in a formal setting, an example comment:

Potential interviewee in email — I cannot talk on behalf of [the entire organization] on these issues, and I couldn’t find anyone else who could [could / had authority / wanted to, direct translation “is able to” but nuanced towards want and need] discuss your topic, but I think we have a very general “the Internet should be open” policy (Translated from Swedish).

This particular example is from a “very large cloud firm”, and a person I had met previously who at the time of meeting initially thought he / she could talk to me on matters of Internet Coordination and specifically how
2. Reflection on process and approach

“the firm” sees the Internet and its development, but who later retracted the offer over several emails. I had not at the time, and I assume neither had the person, understood the sensitivity of some Internet issues, such as net neutrality in the US, which is what I thought is behind the retraction of the interview offer.

Even though I did not get any formal interviews with software and cloud firms, every firm I got in touch with used an expression in line with the above quote, that the Internet should be open in the sense that ISPs should not be able to discriminate which services they could sell to which customers. In general, a clear majority of interviewees who agreed to be recorded were or could be considered part of the “Internet community” (that is either are or have been closely connected to ICANN (and subgroups), IETF (and subgroups) and / or national regulator for telecommunications).

As alluded to above, I also informally talked to or interviewed people in different organizations on different levels to find out who I should talk to. Since I do not have their formal consent as I do with the formal interviews I do not quote or refer to these throughout the thesis in any identifiable manner. They were solely used to find someone I could interview or to write off potential interviews.

The interviews themselves were semi-structured, which for me means that I used a fixed question battery to start the interview, and then dig deeper into issues which had come up during the formal part or I knew the interviewee had special competence in. Practically, I used two rounds of interviews; one round to sensitize and make sense of what the Internet even is, and one later round with focus on particular issues (such as net neutrality or a specific coordination process in the IETF or ITU Plenipotentiary (ITU PP)).

I opened every semi-structured sensitizing interview (i.e. first round of interviews) in the same manner, as described and illustrated in Table 2.3. I also ended these interviews in the same manner, asking the questions in Table 2.4.

I conducted all the interviews and wrote all the summaries.

In between my fixed questions I aimed for an open discussion where I asked for opinions and examples of all the issues we discussed. Here my technical knowledge worked to my advantage; as an example one interview went into the peculiarities of power transfer in DNS vs DNSSEC\textsuperscript{14}, which opened up the interview and the interviewee did no longer hold back from being technically accurate. But as alluded to earlier, my technical knowledge also seemed to put off potential interviewees. This happened to such an extent that I seriously considered “playing stupid”\textsuperscript{15} but chose not to due to ethical considerations. As an example of this; I had at a conference met a high level

\textsuperscript{14}Domain Name System Security Extensions (DNSSEC) is the secure version of DNS, the protocol used for resolving hostnames such as www.dn.se. Chapter 3 mentions the differences briefly.

\textsuperscript{15}In the sense of not appearing technically knowledgeable.
Table 2.3: Questions asked at the start of interviews

<table>
<thead>
<tr>
<th>Question</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A short presentation of me and my research</td>
<td>Answering what am I going to use this interview for. I.e. research, not journalism, etc.</td>
</tr>
<tr>
<td>Explain that I am looking for the opinion of my interviewee</td>
<td>It is important to make it clear, especially when interviewing on issues which are semi-technical, that I am not looking for the penultimate truth but rather their perspective on it. I also made clear that they are welcome to elaborate as much as they want to.</td>
</tr>
<tr>
<td>What is the Internet in one sentence or less?</td>
<td>Prior to conducting my first interview this question felt odd, but I wanted to make sure I did not miss their view of the Internet. In the end it turned out to be the most important question.</td>
</tr>
<tr>
<td>Shortly, how is the Internet governed today?</td>
<td>As the previous question, turned out to be more important than I thought. Gave me insight into the different meanings of governance, control and coordination in the Internet sphere. As an example answer; “The Internet is not governed, it is coordinated”.</td>
</tr>
<tr>
<td>Who are you and which formal bodies are you a part of?</td>
<td>Almost all interviewees were or are part of formal governing or consulting bodies either at a national or international level. This question was used to check for potential bias, such as overly emphasizing the goodness in the view of their financier / employer.</td>
</tr>
</tbody>
</table>
2. Reflection on process and approach

Table 2.4: Questions asked at the end of interviews

<table>
<thead>
<tr>
<th>Question Motivation</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the most significant threat to the Internet today?</td>
<td></td>
</tr>
<tr>
<td>In the typical interview we discussed this already, but I wanted to ensure everyone was</td>
<td></td>
</tr>
<tr>
<td>asked this question.</td>
<td></td>
</tr>
<tr>
<td>Since my approach was based on snowballing and grounded theory, an important</td>
<td></td>
</tr>
<tr>
<td>aspect was to allow the interview to continue further.</td>
<td></td>
</tr>
<tr>
<td>A simple measure to avoid one dissenting voice in an organization.</td>
<td></td>
</tr>
<tr>
<td>That all least some of the discussions gave food for thought.</td>
<td></td>
</tr>
<tr>
<td>Is there something you expected me to ask about today which I did not know when we</td>
<td></td>
</tr>
<tr>
<td>expect this interview?</td>
<td></td>
</tr>
<tr>
<td>Did you have any other questions?</td>
<td></td>
</tr>
<tr>
<td>I went in with the assumption that I did not know everything.</td>
<td></td>
</tr>
<tr>
<td>Who and why?</td>
<td></td>
</tr>
<tr>
<td>In the typical interview we discussed this already, but I wanted to ensure everyone was</td>
<td></td>
</tr>
<tr>
<td>asked this question.</td>
<td></td>
</tr>
<tr>
<td>Do you know (of) anyone who would disagree with what you told me today?</td>
<td></td>
</tr>
<tr>
<td>Would everyone in your organization agree with what you told me today?</td>
<td></td>
</tr>
<tr>
<td>If no, who and why?</td>
<td></td>
</tr>
<tr>
<td>Is there something you expected me to ask about today which I did not know when we</td>
<td></td>
</tr>
<tr>
<td>expect this interview?</td>
<td></td>
</tr>
<tr>
<td>What is the most significant threat to the Internet today?</td>
<td></td>
</tr>
</tbody>
</table>
officer (just below the CxOs) at a large telecommunications company who had given preliminary consent to talk to me in a controlled environment (i.e. not in the public at the conference location), but who during lunch where we sat at the same table noticed that I knew the technical particulars of routing and congestion avoidance and after that avoided me (this kind of behavior is one of the reasons I started on Chapter 7, which is a technically meaningful discussion on net neutrality in a Western setting).

My previous experience related to interviews, mostly from my Master’s thesis, was the formal interview in a conference room with someone in a suit and tie or comparable. This time around the situation was usually different, clothing was less formal, and I was often invited into the interviewees’ office where we sat on quite equal ground.

Often the interviewee also had a laptop, and we had an informal discussion on all things Internet and Internet Coordination in their area of expertise, usually with the interviewee pausing to answer an email or phone call now and then. Examples of settings include offices, conference rooms, cafeterias, lunch restaurants and even on one occasion the living-room of an interviewee. My perception is that calm environments with access to white-boards led to better discussions, and in contrast the interviews done in cafes or restaurants were more formal and held back.

All semi-structured interviews were recorded using OneNote on a MacBook Pro using the built in microphone, which worked well except for one sentence in one interview which got garbled due to my fans spinning up (which I rectified by contacting the interviewee again).

After the interviews I listened to the interview two or three times and then summarized it down to a couple of pages worth of readable text. Most interviewees said that they wanted to look at my summary, so I sent it over. The comments I got on my summaries were either minor or of a very detailed (often technical) character, so in essence I either understood what they meant, or I was so far off what they meant they had no interest in correcting my interpretation of what they said. My interpretation is that I understood their perspective on the matters we discussed.

The interviews themselves can broadly be divided into two categories, sensitizing “early interviews” by using the questions in Table 2.3 and Table 2.4, and later stage “sanity checks” where I put more emphasis on pitting perspectives against each other in the interview setting. In a snowballing fashion (cf. Goodman, 1961) I reached saturation in that no new perspectives surfaced and I could for the most part predict responses. As alluded to earlier, I believe I reached actual saturation on Internet community perspectives, but I

16 This was an exceptional case, and my interpretation of the situation is that the interviewee appreciated our discussion since it had both technical and coordination depth, and when the public space we occupied at the beginning of the interview got too crowded for further recorded discussion we moved there.

17 Model “MacBookPro12,1” for those interested.
2. Reflection on process and approach

do believe there are categories of people with other perspectives which I have not talked to who would have added more insight to the study. A bit simply, I have through interviews captured what the Internet is and how it works, but not why it should not be that or not work like that.

The Internet itself

All data collected from the Internet itself, such as name resolutions and traceroutes are based on what I can see at the edge of the Internet, i.e. a user. One issue, or one central tenet of the Internet, is that there is virtually no centrality on the Internet, no keeper of truths.

This can be considered problematic in the perspective of repeatability, since repeating the tracing in Chapter 7 unavoidably would give a different picture since the Internet is very different depending on where (and when) you are standing and looking at a particular thing. For example looking at something quite static, such as publicly available routing tables, gives you the technical standards and policy of the Internet, but not how it is used.

To make matters even more confusing, the Internet in a way assumes best-effort through all layers, which mean that the Internet cannot and should not be trusted at a technical level. Do note that with “not trust” I refer to not trusting delivery, not “not trust” as in that nefarious things will be done to all packets sent.

I took time to go through current standards and learn those that were new to me, as an example I have had experience on setting up and running DNS servers, but I had never worked with DNSSEC so I took the time to set up and configure a DNSSEC-speaking DNS server properly. The same can be said for many more “modern” protocols such as DMARC, IPsec, SPF, DKIM among others. Doing this provided me with the knowledge to discuss technical matters in interviews, read standards and improve my own methods for collecting data on the Internet itself.

All in all, it is important to understand that with regard to the Internet data shown and used for reasoning is that that data itself was only valid then and there, the Internet would unavoidably look different in a different place or a different time. In that sense much of that which is on the Internet is fluid and dynamic, but that which stays the same is the working or the function of the Internet as a black-boxable means of accessing distributed data. As such I cannot draw generalized conclusions on the specifics of the use I captured, but rather on the patterns of how the Internet is used.

As an example, if I can show that a website uses between 500 and 1000 external resources spread over ten or more networks when I fetched it, from that I can draw the conclusion there are services (i.e. the web) on the Internet which uses the Internet’s distributed nature. And if I can repeat that experiment for most websites in the Alexa-ranking I should be able to say that it
2.7. Collecting data
does not make sense to look at the Internet as just a service to deliver packets between two points (this is the essential content of Chapter 7).

Also, important to note is that in Chapter 7, I use the web (a service on the Internet) to draw conclusion on how the Internet is used in practice.

As in Chapter 7, I leave the specific technical details for a collection of tools I put on GitHub\textsuperscript{18} rather than to fill out several paragraphs and chapters with technical details. These details anyhow require extensive technical knowledge of how the Internet works so there is no reason to write it in text rather than provide well commented code with an architectural overview. In essence Chapter 7 is empirically based on the same approach as Section 3.7, except more emphasis is put on the distributed nature of website content rather than the website itself. The process itself is automated and divided into two steps; the first is based on a headless\textsuperscript{19} instance of Chrome visiting websites and storing all the Hypertext Transfer Protocol (HTTP)-requests and answers locally, the second on iterating through all HTTP-requests and answers and tracing their origin and mapping all nodes to networks (i.e. Autonomous Systems (AS) and in practice ISPs). The first step is done by publicly available tools (such as Chrome headless and functionality for storing har-files) and the second step is by a python script written specifically for that purpose since available tracing tools are not parallellized enough.

As a ballpark figure, the data set I used in Chapter 7 consists of 1.5 TiB of data\textsuperscript{20}. Which in Internet-terms is not that much data, but gives a good indication of the nature of the websites I explored in Chapter 7.

The graphs in this thesis (such as Figure 1.1 and Figure 2.2) are generated by code I keep public on Github\textsuperscript{21}, which in turn depend on notions in Broido and Claffy (2001) for using BGP data, notions in Adai, Date, Wieland, and Marcotte (2004) for graph generation and code (the LGL codebase), and Tange (2018) for parallel data yoga in shell-scripts. These graphs contain millions of entities and represent the entire routable Internet. As an example, Figure 1.1 represents the Internet as of September 2019 and took roughly 28 h of CPU-time to process. The original LGL codebase did not work (originally written in 2002) so I had to fix it, for example updating boost-dependencies, and change scripts for generating images since I was interested in generating multiple correct graphs based on Internet routing data rather than one nice graph for a certain set of proteins (as the LGL library was intended for, see Adai et al., 2004).

I acquired bgpdumps from RIPE, specifically their rrc00 node\textsuperscript{22} collecting routing data in Amsterdam, which can be considered to contain routing data

\begin{footnotesize}
\footnote{\textsuperscript{18}See https://github.com/flindeberg/internet-tools for actual implementation.}
\footnote{\textsuperscript{19}Fancy way of saying automated instance.}
\footnote{\textsuperscript{20}The equivalent of 1500 GiB of website data (i.e. resources).}
\footnote{\textsuperscript{21}See https://github.com/flindeberg/LGL for run-down of technical details.}
\footnote{\textsuperscript{22}See http://data.ris.ripe.net/rrc00/ for raw data. Rrc00 is the longest serving collection node, and has data from the end of 1999, although in a different (non-bgpdump) format.}
\end{footnotesize}
from the entire public **Internet**. In short, the local network have to know where the prefix is situated (i.e. in which **AS**) to route the packet, and as such I use the routable **Internet** as visible in Amsterdam as a proxy for the entire technical **Internet**.

I also had to convert the bgpdump-format (as routing data commonly is available as) into something usable by LGL, as such I extracted **AS** paths and prefixes from the bgpdump and built a file containing all edges and their inverse weights. I inverted the weights since, graphically, it made more sense to put important vertices apart, else all important vertices and edges ended up in the middle of the graph. Color range from dark blue (very central vertices and edges), going past dark cyan and green until almost white at the furthermost and least connected vertices. The white edges can serve as a
2.8. Generalizability of results

meaningful conceptualization of the concept of the edge of the Internet. All images are publicly available\(^\text{23}\).

The problem with this technical side of the Internet is that those readers who cannot verify the technical methods are left to trust me, in essence a leap of faith. And important to remember is that this technical side combined with its coordination is what leads me to different conclusions than most other literature. The duality of the Internet cannot be ignored, even if it would be more convenient to see the Internet as either only coordination or only technology.

And for avoidance of doubt, I use www.dn.se repeatedly in this thesis to explain certain mechanics of phenomena of the Internet, but I am not affiliated with www.dn.se, they just happen to have a good and illustrative setup of their domain names, including that www.dn.se and dn.se are different hosts which make them suitable for certain examples, as we will see later on.

2.8 Generalizability of results

Research as such is often concerned with generalizability, that is how is it possible to draw conclusions based on a study in a different context. For the purpose of this text I agree with a definition such as “to form general notions by abstraction from particular instances” (Lee & Baskerville, 2003, p. 232).

In Chapter 7 I discuss, briefly, how organizations might be affected by changes in what the Internet is. This could be seen as generalizing, using the typology in Lee and Baskerville (2003), from data to description (EE) or generalizing from description to theory (ET) depending on definition of theory.

In a strict technical sense, for example as shown in Figure 2.2, I use the entire Internet as my sample, as such generalization from the sample to the population is not possible (since, mathematically, \( n = p \)), which is an interesting contrast to interviews on the nature of the coordination of the Internet.

The main part of this thesis, in my perspective, is explaining the coordination mechanisms of the Internet. In which way can those be generalized? There are not that many global digital communications networks that generalization would be viable for, and given that I have low variability on some aspects due to the Internet being the only global digital communications network it is not a meaningful exercise. Rather, I chose to generalize from my description and definition of the Internet to what that means for organizations, firms, governments, civil-society, the public and everyone else. In essence generalizing within the case or generalizing from description to theory (ET) for those using the Internet.

\(^{23}\)At https://github.com/flindeberg/LGL/tree/master/resources/images/latests. If using them or the codebase reference this thesis and Adai et al. (2004).
2. Reflection on process and approach

Although, in Section 9.8 and Section 9.9 I venture outside the Internet and on loose theoretical grounding compare the Internet as a general phenomenon of technology in society. I there argue that the Internet is unique in its technology and coordination dimensions and show that most comparisons to earlier innovations, such as the postal systems, railroads, and so on, are only feasible at a very high level, and the ownership, coordination, financing, and development velocity (see Section 3.11) of the Internet is different to anything society as a whole has seen previously.

2.9 Ethical considerations

Ethical considerations can take many shapes and forms, but mostly concern issues with third party information. This thesis is mainly concerned with these issues through interviews and handling of that data.

No one outside my immediate research environment has seen my research data pertaining to people (i.e. the raw interviews) and even though I have informed consent for all interviews I have anonymized the interviews. Since I present some thoughts which can be considered controversial, I have taken extra care not to disclose personal information. At the start of my interview process I did not think that my results would be as controversial as they are, i.e. I thought there would be consensus on what the Internet is and how it works, but there are agendas pushing in all kinds of directions. As can be illustrated by the net neutrality-debate in the US, comments during interviews such as “[in response to statement read from my notes] What? Someone told you that? Here [i.e. Western context]? That’s crazy” and behind-the-scenes activities as those explained in Markus (2006) (i.e. the nation-wide spying program orchestrated by the NSA). What the Internet is and how it is coordinated is not an uncontroversial topic.

I have not in any way during interviews or in discussion with potential interviewees pretended to be someone else or representing something else. I have always presented myself as a PhD-candidate with a technical skill-set investigating the Internet and its coordination, even though that proved detrimental at times.

Neither have I directly referenced or used material I have gotten access to without explicit permission. I have used such material for sensitizing purposes. Examples of such material include conversations in social settings and presentations which “were not supposed to be public”\(^\text{24}\).

Also, research can be susceptible to unethical use. This could be considered problematic if for example I had devised a new method for controlling the Internet, could I then disclose that method without harming anyone? In

\(^{24}\)As a practical example, web archiving services such as the Wayback Machine contains such documents and has provided me with documents which are not supposed to be available. Only used for sensitizing purposes.
my case I have in Chapter 6 discussed in detail how to socially disrupt the Internet, is this moral? Potentially not since I on the one hand conclude that it is possible to take over central Internet organizations, but on the other hand I conclude that the Internet itself is resilient to tampering by said organizations, so I do not consider that ethically problematic.

I, me and myself as a researcher has surely affected the outcome of this thesis. For example, as previously mentioned, my technical knowledge led discussions and interviews in directions and to nuances which would be hard if not impossible to catch without a technical understanding. But I also carry agendas and beliefs, which I might have hidden from myself, which I have tried to keep away from influencing this thesis by clearly stating my train of thought and indicating when I have done leaps of faith which someone of different training might have done differently.

As an example, as I have technical training I can see the technical nature of the Internet, but might it also be so that I would rather like to see the separation of concerns side of the Internet since that was part of my engineering schooling? Also, being Swedish gives certain presuppositions on what the Internet is, most definitely when it comes to price and access but also on the role of digitization in society; and the commonplace of texts such as “Dnr: 15-7200 Remissvar” (2018) which publicly criticizes the Swedish national regulatory authority (in terms of understanding the Swedish Internet situation), and broad initiatives and texts such as IVA (2019) which discusses the role Internet and telecommunications in an increasingly digitized society. Such initiatives are not, at least anecdotally when asking interviewees, commonplace outside of Sweden.
3 Technological frame of reference

Any sufficiently advanced technology is indistinguishable from magic.

— Arthur C. Clarke

This chapter will start off with definitions of the Internet, after that we will venture through previous literature and end with a discussion on the Internet Assigned Numbers Authority (IANA) function. In this chapter we go from not understanding what the Internet is to having a working understanding of how the Internet conceptually can be seen. This chapter is the first of two “frame of reference” chapters, where this focuses on the Internet as such, and the latter uses the terminology of this chapter to properly discuss coordination and governance concepts in light of the Internet.

Keep in mind, the Internet would not be the Internet (as defined, i.e. as it functions today) if either its coordination or its technology were different conceptually.

Also, the purpose of this chapter is to explain the fundamentals of the Internet in a generic and understandable fashion. In essence this chapter is the equivalent of explaining that the most common vehicle on a road is the car which normally has four wheels and is powered by a combustion engine to someone who has never seen a car nor a road.
3. Technological frame of reference

3.1 The Internet and the web

In non-academic contexts it is quite common to use the Internet and the web interchangeably. I am using both terms explicitly. On the one hand this thesis is more or less in its entirety defining the Internet. On the other hand the web is much easier to define, those parts of the Internet you can visit, see or experience through a web-browser. The web is a service on the Internet. The web concerns protocols and standards such as javascript and html, and organizations such as World Wide Web Consortium (W3C). The web is in essence a service layer, not an infrastructure layer\(^1\) as the Internet. See Section 4.11 for a more nuanced and deeper view into that which is commonly known as layer violation.

For example, when using a browser to read the news you are using the web on top of the Internet.

But when you run a traceroute to diagnose routing issues you are only using the Internet, or when your laptop is using NTP\(^2\) to synchronize its time with the company servers it is only using the Internet (or even the local network).

However, even Internet specific texts have issues demarcating the Internet and the web, see for example World Wide Web Foundation (2019) which uses the web in the title (Contract for the Web) but describes the Internet in contents (for example “Ensure everyone can connect to the internet”, “Keep all of the internet available, all of the time”, “So that no one is denied their right to full internet access”, “So everyone can use the internet freely, safely, and without fear” and “Make the internet affordable and accessible to everyone”). These are problematic terms.

Going forward, the Internet refers to the Internet as infrastructure (and concept) and explicitly not the web. And the web is used as a service on top of or with the Internet.

3.2 The Internet

I see the Internet as a phenomenon of both coordination and technology, which is contentious and not an accepted truth in most fields. In Table 3.1 I show how a selection of literature and actors relate to the concept of the Internet.

Table 3.1 should be read as Chapter 5 suggests that the Internet is also (explicitly) coordination. The ITU and the UN on the other hand are explicit in that the Internet is only technical, and are explicit in saying it; further they argue that any coordination related issues concerning the (technical) Internet

\(^1\)I use infrastructure a bit freely here, since the web could be seen as an infrastructure layer to something else, such as an application, above it, and that the Internet is more than just physical and technical infrastructure, as I spend this thesis arguing.

\(^2\)A method to synchronize time across devices.
3.3. Internet coordination

To make any scientific field viable, definitions are needed. I am therefore proposing that Internet Coordination should be defined as all practices which influence how an end-user might view and interact with the Internet. Which includes what an end-user might do with the web, even those that usage only in exceptional cases should affect the Internet itself. This is not in line with the common use of a similar term, Internet Governance, where an actor with authority dispenses governance or control over other actors (as used in policy fields, whereas management fields have a broader view of governance). My broader definition also encompasses practices which are not intended to be of governing or coordinating nature, but happen to be so in some way.

For example the protocols for naming and numbering (i.e. Domain Name System (DNS) and Border Gateway Protocol (BGP)) are mostly technical in their formulations but have consequences for how numbers and names can be coordinated.

In comparison with the Management Control (MC) field the distinction is similar to that between a Management Control Package (MCP) and Management Control System (MCS), where MCP includes all MC-practices, independently designed, but an MCS is limited to a conscious set of MC-practices designed interdependently (as argued in Grabner & Moers, 2013), i.e. differentiating between coordinating the part and coordinating the whole. Greenstein (2015), Mathew (2016), van Eeten and Mueller (2012), Zittrain (2008) among other texts argue that Internet to a very large extent grew organically and

<table>
<thead>
<tr>
<th>Coordination</th>
<th>Explicit</th>
<th>No</th>
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<tr>
<td>Yes</td>
<td>Chapter 5</td>
<td>Zittrain (2008), DeNardis (2012), and van Eeten and Mueller (2012)</td>
</tr>
<tr>
<td>No</td>
<td>The ITU and the UN</td>
<td>Economides and Hermalin (2012) and Cheng, Bandyopadhyay, and Guo (2011)</td>
</tr>
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</table>
3. Technological frame of reference

without planning (central or otherwise) and consciousness, which implies that limiting Internet Governance to only the conscious or intended management or governance practices would make Internet Governance a weak construct (although I argue in this text that the Internet grew organically but intentionally organically, i.e. that the unplanned growth was influenced by plans made or enacted, by a thought collective or epistemic community).

Another argument is that there is no single entity controlling the Internet, but rather a multitude of instances tasked with different aspects of the Internet. An example is the Internet Engineering Task Force (IETF) who coordinate most Internet-standards in use today, even though they are not officially tasked with doing so.

On the topic of naming and defining the term Internet itself, it is practice, among but not limited to Internet Corporation for Assigned Names and Number (ICANN), W3C and IETF, to treat Internet as a proper noun in the English language and therefore use a capital “i” whenever referring to the global internet. When referring to an internet on the other hand, i.e. the concept of a network-of-networks, the “i” is not capitalized. The Internet is an internet, but not all internets are the Internet. A small working example of a non-Internet internet is two connected home-networks, i.e. two interconnected networks.

On the topic of use, I earlier wrote that the Internet Governance construct is more meaningful in practical terms when not limiting it to intentional and conscious governance both in MC and organization studies, where the object of research often is an organization. Contemporary Internet Governance studies are often looking at one or a small set of institutions. Van Eeten and Mueller (2012) even goes as far as to say that there is a valid reason for this focus, because it is easier to gather empirical data in ICANN and Internet Governance Forum (IGF) meetings rather than to actually map out some view of the Internet and quite bluntly states:

For empirical work, studying a centralized institution is a lot more convenient than having to identify and study a wealth of disjointed, messy and globally distributed processes that together produce governance. (van Eeten & Mueller, 2012, p. 729)

Their argument is that even though it would be difficult, it is suggested to be worth it to attack this disjointed mess, and argument which texts such as Frau-Meigs (2012) agrees with.

I argue that the “disjointed, messy and globally distributed processes” produce coordination rather than governance. To be a bit tough on van Eeten and Mueller (2012), the text does not take the technology dimension fully in account (i.e. study the Internet based on understanding of what the Internet

3The IETF is more of a "them" than an "it", an important distinction to the grammar-aware reader. The same is true for most of the upcoming groups in this chapter.
3.4 Previous literature

I argue that my description of the Internet is valid in most contexts, and that there is a need for looking at the Internet through a wider lens than just governance. But what does the rest of the literature say in regard to the Internet and Internet Coordination? (or Internet Governance?)

The short answer is that many actors do not pursue a discourse using the term Internet Governance but rather look at particular parts of the Internet through a lens from another scientific field. The term Internet Coordination is used in literature, but not well-defined (as in “Internet Coordination is [something distinguishable]”), although texts such as Liu (1999) and DeNardis and Raymond (2013) mention the term.

Liu (1999) notes that Internet Coordination is largely de facto (i.e. “as is” rather than de jure) and in a reflection on it says “[... all of the computers on the Internet could [theoretically] have decided, and could today decide, to accept as authoritative the version of the root directory held by another party and point their browsers or other software programs to an alternate server],” showing the disconnect between legal authority and actual Internet function. In terms of coordination and governance, Liu (1999) does not distinguish explicitly but gives hints throughout the text that coordination is the general term and governance is when a central legitimate (legal?) actor coordinates, although the text sometimes uses them interchangeably.

Another text which utilizes both is DeNardis and Raymond (2013), in which governance is used similarly to Liu (1999), as central and legitimate, except in the case of Internet Governance which (in my reading) is used interchangeably with Internet Coordination. As an example from DeNardis and Raymond (2013), “Cybersecurity governance” vs “Interconnection coordination” even though the same kinds of mechanisms are described. As a quick note, DeNardis and Raymond (2013) uses a wider concept of Internet Governance (or Internet Coordination) than this thesis does by including surrounding concepts such as the web, image- and video-standards, cybersecurity and intellectual property rights which are explicitly not part of the Internet and Internet Coordination (as argued by this thesis later on).

Van Eeten and Mueller (2012) identified four common terms used in discussion of different aspects of Internet Governance. The article does not define Internet Governance, but states that the common definition is too narrow, focuses too much on the IGF, ICANN and country code top-level domains (ccTLD) in their discourse and miss issues such as how Internet Service Providers (ISP) wage their wars against botnets and spam (van Eeten
3. Technological frame of reference

& Mueller, 2012). Here follows my summary of the four views on Internet Governance identified in van Eeten and Mueller (2012):

Internet governance
A term used in fields such as Economics and Computer science and deals with issues pertaining directly to entities such as ICANN, IGF, World Summit on the Information Society (WSIS), Working Group on Internet Governance (WGIG) and IETF. In effect focusing on a well-defined core set of Internet-organizations.

Telecommunications policy
A term used in fields such as Communication and Economics and deals with issues such as regulation of telecommunications, Internet, broadcasting and cable TV, interconnection agreements, net neutrality, competing policy and radio spectrum allocation.

Information security economics
A term used in Political sciences and Computer science when dealing with network and information security, cybercrime, botnets, cyberwarefare and infrastructure threats. Concerns the economics of information security rather than information security itself.

Cyberlaw
A term used mainly in Law and its subfields and deals with privacy, jurisdiction in cyberspace, surveillance, copyrights, patents, trademarks and censorship. All of this related to applying law as we know it on Internet phenomena.

Van Eeten and Mueller (2012) goes as far as to state that there is a misunderstanding in many academic and policy debates that ICANN govern the Internet (a statement which most of the interviews back up, most explicitly as “There is a very general and broad misunderstanding that ICANN govern the Internet [...] and I consider it dangerous that ICANN have not done more to dispel this notion” (senior representative in both ICANN and IETF groups)). An example of this is Kleinwachter (2000) where general speculation is being made on the grounds that ICANN have a central governing role. Yet another example is Weber (2009) who from assuming that ICANN govern the Internet concludes that there is a need for another governor for the Internet-of-Things (IoT). For avoidance of doubt, Chapter 5 is firmly in the same corner as van Eeten and Mueller (2012) here, i.e. that there is something missing in the Internet Governance discourse, which I call Internet Coordination, aimed to capture coordinating actions outside of policy and regulation.

A text quite aptly named “Conducting Research on the Internet and its Governance” ends in the following manner:
The Internet itself impacts the way research is being conducted, and how to use its tools and affordances also weighs on the direction of its governance. Future research will need to focus on network theories such as Actor-Network Theory or Social Network Analysis, as sustained by big data analytics. Academia, as one of the multi-stakeholders, will also need to engage in the design and interpretation of data, and evaluate current models and myths on governance (the “hands off” approach in particular), to ensure that Internet depends less on code and telecommunication infrastructures and more on principles of openness and accountability, conducive to the creation of more democratic and more inclusive normative instruments. (Frau-Meigs, 2012, p. 16)

Frau-Meigs could be read as suggesting that research should take a turn towards a deeper understanding of the Internet (cf. Orlikowski & Iacono, 2001, and the call for a deeper understanding of the material in sociomateriality). However, there are apparent problems with defining what more democratic and more inclusive actually means, since more inclusive might imply closed and controlled if that was the will of the additionally included.

Both Zittrain (2008) and van Eeten and Mueller (2012) agree on that there is no single entity controlling the Internet, but that it is a rather complex organization or ecology lacking a central actor. In its infancy the Internet was designed against central control but rather focusing on redundancy of both maintenance and control (Zittrain, 2008), one example being that BGP4 was created as a distributed solution not dependent on a single working entity, which differentiates it from how the DNS works (see Mathew, 2016, for this particular example).

There are published texts which on some level assume, if not governance, then at least a form of leadership, that ICANN control the Internet. The scholarly texts DeNardis and Hackl (2015), Mueller and McKnight (2004), Weber (2009) are all examples of articles presenting a problem which they presume ICANN should solve and asks how ICANN can solve it, rather than having a discourse about whom (or selection of whom) should solve the problem. The Economist is a prime example of a non-academic outlet also having a quite explicit view of ICANN as prime governor (see The Economist, 2014, 2016a, among others), as well as the news media flooding with articles about “the internet not being under democratic control” when ICANN was released from the Department of Commerce and their Memorandum of Understanding (MoU) during the fall of 2016.

4In this thesis I am using BGP broadly to incorporate all standards and implementations related to the original BGP, including eBGP and iBGP, and as an example do not particularly go into the differences between BGP typologies and physical typologies. The technically interested reader might start with Request for Comments (RFC)-8212 (Mauch, Snijders, & Hankins, 2017) and work backwards.
This view of ICANN governing, or controlling, the Internet would require ICANN to be more powerful than they are today. For example the current naming-power they possess is based rather on active ISP choice to use their root-zone, which is not a requirement to be part of Internet the same way BGP-compliance is (Mathew, 2016). This can be compared to a road network with cars (BGP and routing) and road-signs (DNS and naming); to drive on a road you need a car but you do not need to understand the signs, even though understanding the signs would help.

Although, practically, an ISP would have a hard time selling Internet-access if they used another root-zone (which might, for example, not include Facebook and Netflix), it is not a technical issue.

If we turn to management control again, there is no literature stating it explains how the Internet works, but based on the works of Zittrain (2008) and van Eeten and Mueller (2012), it seems likely that there is no unified strategy in place implemented through one MCS, using the terminology in Grabner and Moers (2013). Prior to doing this study I believed there was more coherence in Internet Coordination thoughts than I found.

Going further back from Internet-specific literature into telecommunications policy in general it is prudent with a bit of history. Prior to the Internet, international telecommunications was in general run by governments (Cowhey, 1990, contains a summarized history), such as telegraphs and the first telephony operators (sometimes through state owned firms). Cowhey (1990) notes a shift when private companies entered the telecommunications market and the first anti-trust cases were brought against veritable monopolies on telephony.

Cowhey (1990) describes this shift through epistemic communities, that is thought collectives with an agenda to influence those in power to change something (in this case the telecommunications regime) to create a market where firms could compete (rather than the previous state monopolies). Adler and Haas (1992) and Haas (1992) further elaborate on the epistemic communities concept and introduce several examples of when epistemic communities have changed the current regulation or regime through lobbying towards those in power. According to Haas (1992) sometimes as few as 35 (!) individuals (i.e. an epistemic community) set the international agenda on important issues.

An epistemic community is by nature close to a thought collective, but with the distinction made in Haas (1992) that epistemic communities are set on influencing and changing something. In that manner, most epistemic communities are the active smaller part of a larger thought collective.

The notion is that for many areas, there is an epistemic community who promotes the main view or perspective, an epistemic community which might be academic or scientific but does not have to be, and usually consists of a couple of dozen people. The epistemic community might or might not itself be in charge of setting the agenda; Adler and Haas (1992) gives examples of both.
3.5 The United Nations and the International Telecommunications Union

The purpose of the following paragraphs is to introduce the concept or idea that in some thought collectives (or epistemic communities) neither the UN nor the ITU are organized and represented in such a way that they would be the proper place for Internet Coordination as described in this thesis. This is a contentious issue, since World Conference on International Telecommunications (WCIT) went in the direction of putting the Internet under ITU control, and other organizations, such as the Electronic Frontier Foundation (EFF) are against it (I have interviewed people on both sides).

In short both the UN and the ITU are member organizations where members are states recognized by the UN. In practice, although not officially, the ITU acts as the telecommunications arm of the UN (i.e. same members, different representatives). The system is democratic to the extent that the members might be considered democratic, and to the extent different voter-weights might be considered democratic (i.e. Brunei has greater votes-per-citizen-ratio than does China). Neither are perfect representations, although creating a perfect representation is nigh impossible.

ITU is today the international telephone coordinator (international prefixes, frequency spectrum allocations, etc) and has historically done (and is doing) the same for radio and telegraphs. In these cases there is one standard (which might consist of smaller standards) or rule-book describing how these networks should work, both at a technical and a governance level. In a historical sense, presumably, states were the only entities large and powerful enough to be interested in coordinating these matters on behalf of (at least in principle) the citizens. But also some matters should be coordinated by states, even from an Internet perspective, such as telephone numbers since they have geopolitical bearings (which for example Internet Protocol (IP) addresses do not but domain names can do (especially ccTLDs)).

The Internet is not intended to be democratic (in either direct or representational sense, according to interviews and standards documents), but rather meritocratic in the sense that those interested should be able to affect the Internet. Also, those interested might be firms, non-profits, individuals, or other grouping in society and as such it was necessary to create a coordination system outside of the ITU-ecology for the Internet (from the perspective of the Internet epistemic community). In epistemic community terms, the Internet seems to be (and is as I argue) particular on the notion that the epistemic community should be in charge of the Internet (standards) directly, rather than working through lobbying on international organization such as the ITU.

These perspectives (or thought collectives, or epistemic communities) clash in this thesis, and in particular Chapter 5 and Chapter 8 go further.
3.6 A short history of the Internet

I previously jumped quickly into the Internet and quite abruptly defined it. Here I go through the background in a bit greater detail, which is useful to understand the context of the thesis.

Internet and the idea of a global network of networks stems back from Defence Advanced Research Projects Agency (DARPA) and when they created ARPANET, which is a direct precursor to Internet, during the end of the sixties (1960s). Note the military character of DARPA and the need for a packet rather than circuit switched network (i.e. more resilient in case of attack) which resulted in ARPANET. Back then some corporations already had private networks, i.e. their own cables between offices, on which they could communicate internally so the idea of long distance digital communication was in place, but for ARPANET the governance- and infrastructure was different. Instead of being used by a corporation with a specific internal goal, ARPANET was global and institutions allowed to join at their own leisure after DARPA had turned over the reigns to the National Science Foundation around 1986 (Zittrain, 2008).

Internet as a term started being used more frequently in the mid nineties, and around 1995 the term Internet was established as a name for a particular internet, the global internet which allowed usage by all types of actors, private consumers, research institutions, government entities, military etc. Around this time Internet was also starting to structure itself formally with the creation of organizations such as ICANN (1998-ish) and IETF (1993-ish).

Using the terms in Mintzberg (1980) for coordination mechanisms, the Internet had gone from being coordinated by mutual adjustment by interested parties (military, academia and a little corporate interest) in the 1980s to more standardized coordination in the late 1990s (through ICANN and IETF). Although the primary coordination mechanism was still mutual coordination and management was done according to “running code and rough consensus”, in effect long term planning prior to rollout was at most implicit and no single organization controlled a large part of the Internet in any way (see Zittrain, 2008, for extensive history).

There are several suggested ways of labeling and looking at Internet Governance, one of them shown in Figure 3.1, and the common attribute of the labels I have encountered is that they do not explain the power and coordination relationships.

Going back to Figure 3.1, a vast majority of Internet-actors are shown, but only a subset of them are labeled as governing, “internet governing arenas” in the figure, whilst I, and van Eeten and Mueller (2012) and DeNardis and Raymond (2013), would argue that more actors would belong in that category in some way (even though I would use coordinating rather than governing). Also, noteworthy is that no relationships are shown, and Figure 3.1 is rather a table in image format rather than an illustration of the complex connections.
3.6. A short history of the Internet

During the 1990s it is important to note that the precursor to ICANN (back then a one-man-show by Jon Postel who did the naming-function in what can best be described as a spreadsheet) started rolling out ccTLDs such as dot-se and dot-no and in effect creating a need for local naming-governance (Weber, 2009). Today most ccTLDs are run locally in their respective countries, but under different organizational forms (Zittrain, 2008). For example the dot-se-top-domain is operated by the non-profit IIS in Sweden on the basis of a MoU with ICANN (see Aerts (2007) and Twomey (2007) for the exchange of letters) whilst the Ukrainian ccTLD has a stricter contract, called Accountability Framework (see Oleg and Chahadé (2015) for actual agreement), with ICANN.

An other type of organization was created as well, the Regional Internet Registry (RIR), for example RIPE, which handle allocation and registration of Internet number resources such as IPv4 and IPv6 addresses as well as Autonomous System Numbers (ASN) in Europe, a requirement for all ISPs.

![A brief overview of some Internet Governance actors.](image)

**Figure 3.1:** A brief overview of some Internet Governance actors. Used with permission, see Chapter 12.
3. Technological frame of reference

This in contrast to ICANN and named resources (i.e. the DNS-system, a hierarchical system, see Figure 3.7b).

In Figure 3.2, Figure 3.3 and Figure 3.4, I show how the world is roughly divided between the RIRs, and when the introduction of additional RIRs took place.

As can be seen in Figures 3.2 to 3.4 the RIRs are today matched to Europe, North America, South America, Africa and Asia + Oceania.

Technically the Internet has grown ten times bigger in the last twenty years, an approximate growth of about 10% per year. Upcoming Table 3.6 shows the routable edges and nodes of the Internet since the year 2000, numbers based on public routing information and graphing codebase\(^7\). Figure 3.5 illustrates the differences graphically. Data on the Internet prior to 2000 is

\(^7\)See https://github.com/flindeberg/LGL for code and technical considerations.
3.6. A short history of the Internet

Figure 3.4: RIR distributions after 2005 and valid at least at the start of 2017

hard to find, and Figure 3.6 depicts the Nordic Internet in 1990, that is prior to the current BGP standard, when all Nordic countries together consisted of just 3 (!) Autonomous Systems (AS). Note here that this is prior to wide BGP acceptance and commercialization of the Internet, such services started to pop up (on a ballpark average) in 1993 and 1994 depending on location.

As an example, the last Internet preventing monopoly in Sweden by Telereverket (the Swedish state agency for telecommunications) ended in 1992 and ISPs become quite common after that. Worth noting is that Sweden had “open-access” regulation in the sense that ISPs might sell Internet access services on top of infrastructure owned by someone else.

If we go back again to the creation of ICANN it is important to note that it was not a straight and easy process to create ICANN. A competing organization WSIS (and later the working group WGIG) was created by the UN organ on telecommunications, the ITU. According to Weber (2009), among others, ICANN was (also) created as a protest to a UN/ITU run committee with naming rights, i.e. the right to control naming on the Internet. Universities and corporations in general supported ICANN over WSIS. In both Chapter 6 and Chapter 7 I go back to naming and numbering and the discussion of their coordination. As, for example, the UN want naming and numbering under their control (due to the UN being the organization for international collaboration) but I argue that the current system is inherently more aligned to the actual design of the Internet (see Section 8.7 specifically).

8This monopoly did not concern the Internet per se, but rather ownership and maintenance of wired connections.
3. Technological frame of reference

(a) 2000

(b) 2019

Figure 3.5: The technical Internet over the years.

3.7 The Internet in practice

In Chapter 5 I broadly state the three missions of the IANA function: coordinating Internet naming (i.e. domain-names), coordinating Internet numbering (i.e. IP-addresses) and coordinating necessary protocol numbers (i.e. DNS at port 53).

The purpose of this section is to prepare the reader for these terms since they are of utmost importance to differentiate the Internet itself from services and issues on-top of the Internet (such as the web, cybersecurity and video-standards, just as cars are separate from roads, and services delivering pizzas in cars driving on roads are separate from roads).

In essence BGP and DNS can be seen as two ways of solving Zooko’s triangle, that you can only chose two of security, decentralization and meaningful names (see Wilcox-O’Hearn, 2001, which will be discussed in further details later on), where BGP focus on decentralization and security, while DNS focus on human-meaningfulness and security. Section 3.12 will go into greater depth here, but for now it is enough to know that BGP and DNS focus on solving slightly different problems in slightly different ways (the UN, for example, wanted to solve them in the same way by the same entity).
Looking up a hostname

When looking up an address, i.e. translating an *url* or human readable address into an *IP*-address, a decentralized phone-catalogue called *DNS* is used, see Figure 3.7b. The root of the *DNS*-tree belongs to *ICANN* and is called the root-zone (this is what the community did not want the *UN* to control (in Weber, 2009)), and the tree then spreads out to top-level domains (TLD) (i.e. governors of dot-gov, dot-se and dot-com and so forth) which in turn pass on domains (such as dn.se and google.com), who in turn can delegate even further (such as www.google.com).

For clarity, the *DNS*-system is decentralized, but has a root, a start so to say, but the root cannot control what the leaves do, only where the tree starts. This is in contrast to the *BGP*-system, which is distributed (see Figure 3.7c), as in there is no central node or root\(^9\), or single point of failure. We will get back to *BGP* later, but it is the protocol in charge of *routin*g traffic or packets across the *Internet*. One critique to the original *DNS* protocol is that there is no verification at either end, i.e. technically it is possible for an attacker (for example your *ISP*) to answer on behalf of the correct actor, which led to the standardization of *Domain Name System Security Extensions* (DNSSEC) in

\(^9\)In essence, practically all nodes are not equal, but compared to a hierarchy the nodes are much less unequal.
3. Technological frame of reference

(a) Centralized, i.e. some Internet services
(b) Decentralized, such as naming (DNS)
(c) Distributed, such as routing (BGP)

Figure 3.7: Overview of core Internet functions

which there is a trust chain. In essence all modern devices (such as computers and phones) come pre-loaded with a selection of blind trust for a number of actors\(^\text{10}\), and as long as one of these actors is part of the DNSSEC chain your computer will trust the end result.

Now it is time to go into a bit gritty detail of DNS-operation which the later parts of this thesis rely on.

Below I look up the www.dn.se host, and I am given the answer that www.dn.se is equal to secure.dn.edgekey.net via a CNAME-record, i.e. an alias, which in turn (the line after) is an alias for e10692.g.akamaiedge.net. In the end e10692.g.akamaiedge.net resolves to 23.198.17.7 in an A-record.

```
$ host -v www.dn.se
Trying "www.dn.se"
;; QUESTION SECTION:
;www.dn.se. A
;; ANSWER SECTION:
www.dn.se. CNAME
  -> secure.dn.edgekey.net.
secure.dn.edgekey.net. CNAME
  -> e10692.g.akamaiedge.net.
e10692.g.akamaiedge.net. A
  -> 23.198.17.7
```

\(^{10}\)This has caused a bit of controversy, since not all pre-loaded CAs are trustworthy, and not all processes for adding CAs trustworthy. See https://ccadb-public.secure.force.com/mozilla/CAAIdentifiersReport for CAs included in Firefox (and applications based on NSS, an open collaboration for trust), and https://android.googlesource.com/platform/system-ca-certificates/+/?/master/files/ for the ones included in Android. However, your device manufacturer might pre-load any CA. There is no “one list”, and the Mozilla list is the closest I have ever come to one.
3.7. The Internet in practice

In the example of Listing 3.1, ISPs (my provider, SUNET), a ccTLD (which SUNET queries on my behalf) and hosting providers (Akamai) are involved. The ISP will give me the answer to my initial DNS-query, but it will be with the help of data held by the ccTLD and in this case a hosting provider, Akamai, having the actual end address of the host.

There were critics to the previous model with ccTLDs and a few generic top-level domains (gTLD) and these suggestions led to the creation of more gTLDs (see Mueller & McKnight, 2004, for arguments, although written before creation additional gTLDs such as brand top-level domains (bTLD)). There were opponents to this arguing that the DNS-system cannot handle more top-level domains (xTLD) without being bottle-necked, Mueller and McKnight (2004) argued that that was moot point and the system had enough slack (and as it turned out Mueller & McKnight, 2004, were correct). Today there are several xTLDs, such as dot-xxx (technically a sponsored generic top-level domain (sTLD))11, dot-xyz (technically a gTLD) and dot-google (also a gTLD, and specifically a bTLD).

If we have a look at the technical limits of ICANN they are limited to coordinating naming and numbering, and power exerted outside of naming and numbering are neither direct nor technical in their nature (ICANN put naming and numbering together as “coordinating unique identifiers” in their bylaws).

Weber (2009) argues that there will be a problem in the future if IoT-devices all want hostnames since the DNS-system is not dimensioned for that, and neither is ICANN, although this is a moot point since most DNS-resolution “chains” are cached very little extra pressure is put on the root-servers13. The only way to substantially increase root-server pressure is if all IoT-devices did their own lookup starting from the root-zone rather than to use a more local DNS-resolver.

ICANN is both the technical and the coordinating root of the naming system (i.e. domain names and DNS) but only the coordinating root of the numbering system (i.e. ASNs which are used by BGP).

There are several suggestions to replace DNS, since it is not under (inter-)governmental control, a discussion I return to in Section 8.4, but for now it is important to understand that Digital Object Architecture (DOA), the most prominent DNS-”competitor”, cannot technically replace DNS (DOA would only replace DNS, not BGP) since they are conceptually at different layers.

---

11In this context and xTLD is any TLD which is not a ccTLD or one of the original gTLDs.

12In this context sponsored means someone external to ICANN took the initiative and funding for the TLD and that they can sell domains to others. For example Google is not allowed to sell (or give) dot-google addresses to anyone but Google branded subsidiaries, and dot-google is a bTLD, not a gTLD.

13The root-servers are not hosted by ICANN, but by several other organizations, and ICANN (through Public Technical Identifiers (PTI) and IANA) prepares the root-zone-file which is transferred to the root-server providers.
3. Technological frame of reference

Finding the route

Previously I briefly demonstrated the naming power of the IANA-function with an example in regard to DNS and looking up the IP-address of www.dn.se, and now we will continue on with actually finding a path on the Internet to the server/host.

To do this I will use a simple tool called traceroute which tries to find, and show, all Internet-level hops on the way there. There are hops on different levels than Internet/IP, but we will leave that outside of the scope for now.

In Table 3.2 I show a traceroute to www.dn.se which show all the jumps at an IP level done to get there. Hops 1 – 3 are within the university, hops 4 – 5 are withing Sunet, the Swedish university network, hops 6 – 9 are within Nordu, the Nordic university network, and the final two hops, 10 – 11 are with Akamai’s servers, 11 being the final host actually displaying the webpage. These four actors, LiU, Sunet, Nordu and Akamai, are involved at an IP-level, but with a high probability the jump going outside Nordu, i.e. between 9 and 10 goes over an Internet Exchange Point (IXP), which often takes place on another layer than IP so it will not show up in the trace.

Table 3.2: A traceroute to www.dn.se from Linköping University.

<table>
<thead>
<tr>
<th>hop</th>
<th>host</th>
<th>ip</th>
<th>rtt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ikp-r-32.ikp.liu.se</td>
<td>(130.236.32.1)</td>
<td>29.611 ms</td>
</tr>
<tr>
<td>2</td>
<td>130.236.6.204</td>
<td>(130.236.6.204)</td>
<td>25.144 ms</td>
</tr>
<tr>
<td>3</td>
<td>130.236.9.202</td>
<td>(130.236.9.202)</td>
<td>27.940 ms</td>
</tr>
<tr>
<td>4</td>
<td>norrkoping-nkg188-r1.sunet.se</td>
<td>(130.242.6.76)</td>
<td>27.850 ms</td>
</tr>
<tr>
<td>5</td>
<td>stockholm-fre-r1.sunet.se</td>
<td>(130.242.4.56)</td>
<td>30.641 ms</td>
</tr>
<tr>
<td>6</td>
<td>se-fre.nordu.net</td>
<td>(109.105.102.9)</td>
<td>50.594 ms</td>
</tr>
<tr>
<td>7</td>
<td>dk-ore2.nordu.net</td>
<td>(109.105.97.130)</td>
<td>35.857 ms</td>
</tr>
<tr>
<td>8</td>
<td>dk-ore.nordu.net</td>
<td>(109.105.97.56)</td>
<td>36.428 ms</td>
</tr>
<tr>
<td>9</td>
<td>nl-sar.nordu.net</td>
<td>(109.105.97.137)</td>
<td>46.202 ms</td>
</tr>
<tr>
<td>10</td>
<td>amsix-ams9.netarch.akamai.com</td>
<td>(80.249.208.168)</td>
<td>46.754 ms</td>
</tr>
<tr>
<td>11</td>
<td>a23-198-17-7.deploy.stat[...]</td>
<td>(23.198.17.7)</td>
<td>47.119 ms</td>
</tr>
</tbody>
</table>

Most western IXPs exchange traffic at the link-layer, so no IP-layer activities take place.
So for this example the following actors are involved: ISPs, IXP and hosting providers, see Figure 3.7. And I have assumed that all actors are benevolent, which is not always the case which I expand on in Section 9.5 (The BGP protocols have few security mechanisms, which opens up for BGP-hijacking, i.e. fooling the Internet to route traffic through your own network which you could either drop, modify or just haul along as usual\footnote{BGP-hijacking is currently a hot topic. Just as DNS got its secure version in DNSSEC, BGP has its secure version in the recent BGPsec (see Lepinski & Sriram, 2017, for full specification), which, as far as I know and indicated by interviewees knowledgeable in the area, is not generally used.}).

But just finding the way to a host with the help of BGP is not enough, since when we actually want to display a webpage we have to gather all the resources required and referenced by the webpage, so let us continue our foray into loading www.dn.se.

**Content of a website**

This particular example is to illustrate all actors involved in loading a common website, i.e. using a service on top of the Internet. I chose www.dn.se all the way from lookup, to finding the path to the host and finally downloading all the content of the website since I believe it represents a typical website today. Also, it is a Swedish website, so I will (presumably) get the intended experience. Chapter 7 is in essence a repetition of this example over thousands of websites thousands of times.

A website is usually represented as an html-file which is fetched via Hypertext Transfer Protocol (HTTP)/Hypertext Transfer Protocol Secure (HTTPS) which in turn might reference other resources which usually are fetched via HTTP/HTTPS again. The other resources could be images, javascript-files, or even a whole new page which in turn would require even more resources to be loaded. As a reminder, I consider these elements to be transferred over the Internet, but not to be part of the Internet (or Internet Coordination as specified in DeNardis & Raymond, 2013; van Eeten & Mueller, 2012).

I am illustrating data collected using the built-in developer tools in Google Chrome in Table 3.3. In our case, using www.dn.se, it turns out that we during 9 seconds on a GbE-connection load 550 objects from roughly 100 different domains without filters and adblockers. We also use more than 20 cookies which are filled with data so it is possible to track my browser in the future.

In Table 3.3 I show different load-times and domains references when browsing to www.dn.se. Do note the large difference of domains contacted depending on both connection speed and whether plugins such as adblock and ghostery are enabled or not.

15BGP-hijacking is currently a hot topic. Just as DNS got its secure version in DNSSEC, BGP has its secure version in the recent BGPsec (see Lepinski & Sriram, 2017, for full specification), which, as far as I know and indicated by interviewees knowledgeable in the area, is not generally used.
3. Technological frame of reference

Table 3.3: Accessing www.dn.se on different simulated connections.

<table>
<thead>
<tr>
<th>simulated parameters</th>
<th>results</th>
</tr>
</thead>
<tbody>
<tr>
<td>connection</td>
<td>setup</td>
</tr>
<tr>
<td>fibre</td>
<td>AG</td>
</tr>
<tr>
<td>fibre</td>
<td>-</td>
</tr>
<tr>
<td>wifi</td>
<td>-</td>
</tr>
<tr>
<td>4G</td>
<td>-</td>
</tr>
<tr>
<td>dsl</td>
<td>-</td>
</tr>
<tr>
<td>3G</td>
<td>-</td>
</tr>
<tr>
<td>2G</td>
<td>-</td>
</tr>
</tbody>
</table>

Adblock, Ghostery - ThroughPut in Mbps

It is important to keep in mind that for every extra domain used, i.e. those referenced from www.dn.se, additional address lookups are done, a path to the server found, and then the resources from that domain are loaded.

What I want to illustrate with this example is that for a user wanting to browse an ordinary website, like www.dn.se, he is in fact in contact with almost a hundred domains, doing hundreds of lookups and leaving a considerable trace behind him in the form of cookies.

From this perspective you can say that ICANN coordinates the end-to-end and best-effort principles, but the actual value lies at the edge, though both the website itself and for a different user experience in tools as adblock and ghostery (which lowers the queried domains (hosts) with 90% and clearly has a substantial influence on how the page is loaded and viewed).

I dig deeper into what this means for issues such as policy in Chapter 7.

3.8 The IANA-function

I previously gave an example of numbering and naming, and it is important to know that the function formally in charge of this is the IANA-function which administratively lies under ICANN. For more detail I refer to Chapter 5. The basics of the IANA function is the coordination of the following:

1. Numbering
2. Naming
3. Common protocol specifications

Note that, coordination is not the same as being in control of or ruling over.
The IANA function is this package of three functions which allow for IP-addresses to be used, and implicitly routing since we then have unique identifiers, as well as resolution of humanly readable names (i.e. domain names) to IP-addresses.

**Numbering** in general on the Internet is related to IP-addresses, and the IANA numbering coordination is as well. This function coordinates that only one AS claims a particular IP-address or set of IP-addresses, concerning both IPv4 and IPv6.

The numbering function is as previously mentioned closely connected to the Address Supporting Organization (ASO) - Number Resource Organization (NRO) constellation and the RIRs.

The numbering is used for routing information, see Section 3.7 for a simple example.

**Naming** is concerned with coordinating the named space on the Internet, as in comparison with the numbered space as above. This concerns top-level domain names (such as dot-se and dot-xxx) and the processes involved with acquiring TLDs.

The naming function is as previously mentioned closely connected to the Country Code Names Supporting Organization (ccNSO) and Generic Names Supporting Organization (GNSO) and through them ccTLDs and gTLDs in particular.

See Section 3.7 for an example.

**Protocol specifications** are in practice standardized by the IETF, but some specifications are coordinated by the IANA function. These specifications are those connected to the naming function, namely DNS specifications such as port 53 as the default User Datagram Protocol (UDP) port.

Chapter 5 digs a bit deeper into the relationships in play.

It might be useful to take a step back to consider what the Internet is here. In practice, the Internet at a technical level can be equated to a set of or collection of protocols for digital communication. What this means is the possibility of communication between networks, i.e. an inter-network, and for this communication to work, there needs to be a minimum level of agreement among the networks. This minimum level of agreement are the aspects coordinated by the IANA function, i.e. numbering, naming and specifications for the technical processes with regard to naming and numbering (protocol specifications). These at the core technical coordination issues brings affect a larger context than just the standards themselves, as shown with the website example even simple services on the Internet use a large amount of different resources in different jurisdictions, which is problematic in a policy context.
3. Technological frame of reference

3.9 Internet Standards

In charge of selecting and publishing standards today is the IETF through their board the Internet Engineering Steering Group (IESG). An early RFC, RFC-2026 (Bradner, 1996), describes the formal process for setting standards. Important standards include but are not limited to IP (IPv4 and IPv6), DNS, Transmission Control Protocol (TCP), UDP, BGP and Internet Control Message Protocol (ICMP). The IETF also standardize several higher level protocols, such as HTTP for transferring hypertext, but not web-protocols and web-standards such as html or javascript. Note that some higher level protocols, such as HTTPS, are combinations of other protocols, in this case either Secure Sockets Layer (SSL) or Transport Layer Security (TLS) and HTTP.

Also part of the Internet Standard process but not standards per se are the Best Current Practice (BCP) documents, which are rather process descriptions than technical standards. One example is BCP-38 (also as RFC-2827 (Ferguson & Senie, 2000) since all BCPs are also Requests for Comments) which suggests processes for handling distributed denial of service (DDoS) attacks, which have turned out to be a significant problem today.

The standard-setting coordination (today RFC and Internet Standards processes at the IETF) and the coordination of unique identifiers (today the IANA function and processes through ICANN) are what is considered the Least Common Internet in this thesis.

IPv4 and IPv6

The commonly used version of IP today is version four, usually abbreviated as IPv4, which was standardized in RFC-791 (Postel, 1981a) almost forty years ago. The newer version, IPv6 was specified more than twenty years ago (see RFC-2460, Deering & Hinden, 1998)\(^\text{16}\), and is not fully adopted. Bear in mind that IP is in charge of routing packets, IP does not guarantee delivery, or service level or similar; IP is through and through best effort. Protocols on-top, usually TCP (ensuring delivery, see specification Postel, 1981b) or UDP (fire and forget, see specification Postel, 1980), provide transmission control if needed. Both TCP and UDP work with both IP-versions. And even further up comes security (such as SSL and TLS) and application level transfer protocols (such as HTTP).

One important coordination difference between the two protocols is the allocation “object”; in IPv4 a home or small business is usually given one IPv4, which means that all devices (if more than one) needs to be NAT:ed, i.e. behind a router. This is not the case in IPv6 (\(^\text{16}\)The actual Internet standard for IPv6 was set much later in 2017, in RFC-8200 (Deering & Hinden, 2017).
### Table 3.4: Comparing different IP versions (IPv4 vs IPv6) in the context of this thesis

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Address space</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPv4 (RFC-791, Postel, 1981)</td>
<td>$2^{32} \approx 10^9$ which means a couple of billion addresses after special allocations and other blocks are removed from the address pool. Not enough IPv4 addresses to give every human an address (if that was something we wanted to do).</td>
<td>Many real world applications are based on DHCP, i.e. dynamic allocation of IP-addresses, and NAT-ing, i.e. differentiating between local network and the Internet.</td>
</tr>
<tr>
<td>IPv6 (RFC-1883, RFC-2460 and RFC-8200, Deering &amp; Hinden, 1995, 1998, 2017)</td>
<td>$2^{128} \approx 10^{38}$, a number so big it is not comparable to non-astronomical numbers. It is roughly ten billion times greater than the number of atoms in the human body ($\approx 10^{28}$), i.e. the IPv6 address space is (theoretically) large enough to address all atoms in all humans (!).</td>
<td>Has support for stateless client-based addressing and router announcements, i.e. less need for central network governance such as DHCP-servers.</td>
</tr>
</tbody>
</table>
IPv6 was designed with the intention of making NAT unnecessary (de Velde, Hain, Droms, Carpenter, & Klein, 2007) where home or small business are rather allocated several billions of public IPv6 addresses, in a so called address-block.

Table 3.4 summarizes a short comparison of IPv4 and IPv6. There are two main issues which I use later in Section 9.7, firstly the number of available IPv6 addresses is so large that not even a modern computer can count them all even given billions of years (counting all IPv4 addresses takes seven seconds on my laptop, counting all IPv6 addresses would take 10^22 years at the same speed, which is roughly a billion times longer than this universe is estimated to exist, i.e. an unfathomably long time), secondly IPv6 is designed to remove functionality provided by other protocols which design-wise belong in different layers (such as fragmentation) and consolidate routing and addressing functionality (such as including stateless address configuration) which allows for a more distributed local network layout (i.e. less centralized functionality such as DHCP-servers).

As a consequence of this, services such as Shodan are capable of scanning all IPv4 addresses and storing data such as open ports, vulnerabilities for all those hosts (i.e. billions of hosts), but cannot scan all IPv6 addresses since it would take too long time (i.e. literally billions of billions of years). All public IPv4 hosts are mapped, scanned and indexed continuously by Shodan and available through their API.

At a technical level, both of these go hand in hand: as the number of addresses (and devices) increases, the harder it is going to get to coordinate them (such as one user per address), and to route traffic through the network (larger address-space, more performance needed in routers). IPv6 is differentiated from IPv4 in that static allocations (such as IPv4-addresses set by humans) plays a smaller role by design.

### 3.10 Defining a technical only Internet

Now I have gone through some central functions of the Internet. Is it meaningful to then define a technical Internet? I.e. without looking into governance or coordination aspects.

The short answer is no.

One reason for this is that it is very hard to define what “being on the Internet” is. A working paper presented at ITS 2018 by William Lehr aptly

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17Just like a human; one, two, three, four, ... three billion eight hundred and twelve thousand and three hundred and twenty two ...

18Technically a small binary which increment an unsigned 32-bit integer until overflow.

19Shodan (shodan.io) indexes many if not almost all Internet facing hosts, and shows publicly if they are vulnerable. It is a common tool and they provide a free Application Programming Interface (API). See for example Theprez98 Schearer (2018) for a DEF CON presentation on how to use the shodan.io API for penetration testing.
named “Whither the public Internet?” thoroughly goes through and argues that defining the Internet in a technical sense is literally “a fool’s errand” (Lehr, Clark, Bauer, Berger, and Richter, 2018). The reason being, quite literally, that what would it mean to be on the Internet? IP-connectivity? IP-connectivity to what or where? If your ISP does not allow you to watch Netflix, can you still be considered as being on the Internet?

Another reason is that even at a very technical level, the Internet is not that well-defined. As mentioned above, the IANA-function, ICANN and IETF standards can be considered important, but where is the line for “not Internet”? As an example, if I send well formatted packets, and they reach their destination, I am on Internet and my packets are Internet packets, but if my packets are malformed and do not conform to standards, are they still Internet packets?

These are part of the reason I suggest that the Internet must be seen as consisting of both coordination and technology. In comparison, Lehr et al. (2018) suggests three lenses (see Table 3.5), or three perspectives, in which to make sense of the Internet. My suggested perspective (based on my thought style) includes parts of all three, and in particular Chapter 7 discusses use of the Internet in light of net neutrality in these aspects (even though the aspects are not referenced directly; architectural, the images of networks, network complementors, identification of actors, and a discussion of experience in the case of net neutrality).

Table 3.5: The three lenses in which Lehr, Clark, Bauer, Berger, and Richter (2018) suggest to make sense of the Internet.

<table>
<thead>
<tr>
<th>Lens</th>
<th>(Short) Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract Architectural</td>
<td>The Internet as an abstract technical phenomenon. Useful for seeing general topological trends, such as centralization or decentralization.</td>
</tr>
<tr>
<td>Network Complementors</td>
<td>By looking at network effects in economic theory, such as the effects CDNs or services such as Skype and Facebook have. I.e. the Internet as a platform for network effects.</td>
</tr>
<tr>
<td>Customer Experience</td>
<td>In essence the view the customer, or user, has of the Internet. A high level perspective which firmly focuses on the high level experience of the user rather lower level effects of the network.</td>
</tr>
</tbody>
</table>

Even though the lenses as rough guidelines are useful, I consider them to have some minor but specific flaws. In the case of abstract architectural, I do
not see why the abstract architecture say more than the actual architecture. For network complementors, I have read several papers which make incorrect technical assumptions of the architecture of Internet, and I believe this perspective understates the importance of understanding the architecture to draw meaningful conclusions on the complementors. Customer experience, in my perspective low level events can have high level effects, as such I find the narrow view in this perspective problematic.

3.11 A conceptual view of digital technology

A valid question might be why it would be interesting to look at technology at all when delving into Internet Coordination, as there are many texts on the Internet and its governance which in one way or another blackbox most technical matters and seem successful in their own right in relevant thought collectives.

Section 4.10 delves deeper into the particulars of technology as IT in organizations, and presents a more conceptual or mathematical argument on why it is of utmost importance to understand technology today to properly understand its variance and meaning.

Take Moore’s law as an example; in the original formulation the notion that normal integrated circuits double their number of transistors every two years. The law has proven to be accurate in the period 1975 till 2012 (currently we are in a dip, and there is ongoing debate whether we will catch up again) and is even useful in other proximate areas, such as pixel density for digital cameras, throughput for ethernet standards, and memory size (see Wikipedia Contributors, 2019a, for a longer listing of technologies matching Moore’s law). As such, doubling every two years can be seen as a time tested approximation of technical advancement in digital technology over a longer period of time (i.e. there might be dips and tops, but is accurate on average over time). This means digital technology evolve exponentially, at a year-on-year rate of roughly 40%.

These 40% might not mean that much, since for example another 40% of pixels on your smartphone would not mean that much since they would require approximately 40% more battery to power and your eyes are not good enough to see the difference. Let us, for the sake of this argument, say that a 10 times change meaningfully alters how something can be used or thought of (i.e. has significantly altered affordance in some sense). This means that every seven (7) years or so, digital technology fundamentally changes (in terms of use), i.e. a paradigm shift, in the perspective that its possible to do 10 times more with similar resources.

20Normal as in does not have any special features for extreme environments, such as protection from solar storms, military EMPs, and so forth, since such circuits normally are much less dense.
This is important since anything said in regard to digital technologies has more or less a seven year life-time of detailed relevance. For example, in 2000 we did not have the technology to put a several inch big touch-display on a battery-power device which fit in a pocket, in 2007 we did. In 2007, we could not render high resolution content on pocket size display with meaningful battery life (i.e. gaming on a smartphone), in 2019 we could do that with a large margin.

Video content; real-time video was not possible over the Internet in 2000, in 2007 YouTube was starting to get big, and in 2014 Netflix is more or less the norm (in younger circles at least) for watching movies.

Another example on the scale of digital advances; according to the Corporate Average Fuel Economy standards (part of U.S. regulations and set by Secretary of Transportation, numbers publicly available) the transportation fuel efficiency for vehicles (i.e. miles per gallon) has roughly doubled in the period 1975 till 2018, a period of 33 years, and notably has not led to a fundamental paradigm shift (i.e. vehicles in general still drive on roads, are still driven by drivers, still using steering wheels, are still fueled by gasoline and diesel, etc). In the same period, the number of transistors in an integrated circuit (or computing power, or pixel density, or ethernet throughput, etc) increased over one hundred thousand times. If fuel efficiency had increased as much, a normal vehicle would go two million miles per gallon of fuel (2000000mpg) today, which is eighty (80) laps around the globe (if you could drive on water).

Let us take an example from the artificial intelligence (AI) world. In the last fifteen years AI has gone from never losing a series in Chess (November 2005, see Levy, 2005, commonly regarded as the last human win against top computer), to never losing a series in Go (March 2016, match against Lee Sedol, Lee won one game in a five game series, see The Economist, 2017), to real time computer games such as Starcraft 2 (January 2019, see Vinyals et al., 2019) and even those involving team play such as Dota 2 (April 2019, full real-time component but limited meta-game, see OpenAI, 2019). It can be argued that just because a computer has once beaten a human opponent does not necessarily mean computers will always win. But using chess as an indicator means that it is not likely to happen, else someone should have beaten a computer in the last fourteen years. It is not meaningful to conceptualize the complexity of these game as they are so different, but rather reflect on the fact that digital technology is developing at a breakneck pace (has the first

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21 See https://one.nhtsa.gov/cafe_pic/CAFE_PIC_fleet_LIVE.html

22 Dota 2 can be said to consist of two parts, the meta-game which consists of a pick and ban phase and the actual real time game phase. The OpenAI win was with a limited meta-phase (75) using 17 out of 109 possible unique entities, but with the full real-time play component.
article written by an AI on its own already been published? The first AI for cleaning code is already here.

Scaling of AI is hard to measure (observe, define, etc), however Schwartz, Dodge, Smith, and Etzioni (2019) approaches AI from an energy use perspective and concludes that AI applications use enormous amounts of electricity. Illustrated by a quote:

The computations required for deep learning research have been doubling every few months, resulting in an estimated 300,000x increase from 2012 to 2018 (Schwartz et al., 2019).

In comparison, the Internet grows on average ≈ 10% year-on-year, as illustrated in Table 3.6. In Table 3.6, nodes refers to instances of importance in routing, i.e. AS’s and prefixes, while peering refers to the interconnections between said routable entities. As can be seen, on average each node has a little more than two connections (2.26 rounded to two decimal places). I use \( \mathcal{O}(n \log n) \) to illustrate the complexity of actually managing the network, which turns out to be below the current velocity of digital technology development (i.e. 42% over time using Moore’s law).

Now, with this conceptual view of digital technology paradigm shifting every seven years or so, it makes sense to mention there are standards in the making adhering to possible future scenarios, such as RFC-4838 (Cerf et al., 2007) (interplanetary Internet) or my crazy previous idea of assigning every atom in human bodies an address (theoretically possible), and that current Internet issues, such as net neutrality, can seem to be quite simple problems in a technical perspective, although significantly trickier if actors such as infrastructure and network operators want to capture value from complex data transferred online. Important to remember is that the Internet is thought of as the digital communications network capable of handling these paradigm shifts of usage and throughput in this text.

In essence, it all boils down to:

- Digital technology is rapidly evolving, and therefore paradigm shifts often happen.

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23 See, among others, https://www.deepcode.ai

24 Most data management problems scale as \( \mathcal{O}(n \log n) \), that is handling double the data is a tad more troublesome than double the complexity (or time consumption), but ultimately follows \( \lim_{n \to \infty} \frac{2n \log 2n}{n \log n} = \lim_{n \to \infty} \frac{2 \log n + 2 \log 2}{\log n} = 2(+0) \).

25 As discussed in Chapter 7, the net neutrality-debate mostly focuses on video streaming, and not on potentially more sensitive issues such as intentionally delaying bank transfers, corrupting neural network models, dropping traffic from autonomous asteroid mining robots (see for example Planetary Resources Inc and Deep Space Industries for two of the more serious attempts today) or in general taking advantage of the situation, such as can happen when there is a veritable monopoly with a greedy actor instead of a market.
3.11. A conceptual view of digital technology

Table 3.6: Routing complexity of the Internet in the period 2000 till 2019. Using $O(n \log n)$ to illustrate complexity of network growth.

<table>
<thead>
<tr>
<th>Year</th>
<th>Nodes</th>
<th>Peering</th>
<th>$\Delta n \log n$(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>103 104</td>
<td>112 349</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>124 318</td>
<td>135 882</td>
<td>22.9 %</td>
</tr>
<tr>
<td>2002</td>
<td>130 696</td>
<td>143 314</td>
<td>5.9 %</td>
</tr>
<tr>
<td>2003</td>
<td>145 194</td>
<td>159 895</td>
<td>12.6 %</td>
</tr>
<tr>
<td>2004</td>
<td>166 861</td>
<td>184 138</td>
<td>16.5 %</td>
</tr>
<tr>
<td>2005</td>
<td>194 153</td>
<td>212 550</td>
<td>16.8 %</td>
</tr>
<tr>
<td>2006</td>
<td>221 805</td>
<td>242 963</td>
<td>15.6 %</td>
</tr>
<tr>
<td>2007</td>
<td>260 024</td>
<td>284 388</td>
<td>18.5 %</td>
</tr>
<tr>
<td>2008</td>
<td>310 411</td>
<td>340 592</td>
<td>21.5 %</td>
</tr>
<tr>
<td>2009</td>
<td>345 041</td>
<td>376 396</td>
<td>11.4 %</td>
</tr>
<tr>
<td>2010</td>
<td>382 805</td>
<td>417 419</td>
<td>11.8 %</td>
</tr>
<tr>
<td>2011</td>
<td>440 122</td>
<td>483 716</td>
<td>17.2 %</td>
</tr>
<tr>
<td>2012</td>
<td>497 728</td>
<td>546 385</td>
<td>14.0 %</td>
</tr>
<tr>
<td>2013</td>
<td>560 721</td>
<td>614 494</td>
<td>13.5 %</td>
</tr>
<tr>
<td>2014</td>
<td>601 374</td>
<td>659 126</td>
<td>7.8 %</td>
</tr>
<tr>
<td>2015</td>
<td>654 674</td>
<td>716 588</td>
<td>9.4 %</td>
</tr>
<tr>
<td>2016</td>
<td>725 341</td>
<td>789 764</td>
<td>11.0 %</td>
</tr>
<tr>
<td>2017</td>
<td>790 262</td>
<td>862 400</td>
<td>9.9 %</td>
</tr>
<tr>
<td>2018</td>
<td>875 991</td>
<td>963 140</td>
<td>12.6 %</td>
</tr>
<tr>
<td>2019</td>
<td>971 886</td>
<td>1 099 118</td>
<td>15.2 %</td>
</tr>
</tbody>
</table>

Based on BGP data from the rrc00 node (see Section 2.7).

- The Internet is the platform for communication by these technologies, and the Internet itself is evolving and changing to keep up (but due to efficiency reasons the needed change should be kept to a minimum, as well as the reasons for change).

The second bullet point means that in a technical (and a coordination as I argue) perspective the Internet as infrastructure or platform needs to be decoupled from the applications using it. Else a change in something using the Internet (such as streaming, autonomous cars, the web, etc) might elicit a change in the Internet’s design, but by separating and decoupling the Internet as a digital communications network from its use it is possible to avoid such interdependencies (see Section 4.11 and Section 4.13 for the later arguments and assumptions in the organizational context based on software and systems design principles). A note on this might be prudent, in a non-digital world ideas and implementations might change together, but in a digital world coordinating change is assumed to be more expensive than decoupling and allowing non-coordinated change freely. As an example the development of the Linux-kernel does not take extra-ordinary height for downstream issues, and
3. Technological frame of reference

rather focus on solving kernel specific issues as hand and letting distribution maintainers fix broken things.

Later, in Section 8.7, net neutrality is discussed in detail as an example of a real world consequence of what the Internet is and means, and it is important to keep in mind that the Internet is also digital technology as well as most entities which use the Internet.

3.12 Distributed ledgers

In general terms this thesis concerns the Internet, and to a minor extent I will use blockchains to illustrate certain points in regard to the central concepts of naming and numbering. Both naming and numbering solve the essential problem of record keeping, that is, how can we know that the information is correct when we want to know “who owns what”: or in the specific case of the Internet and naming (for A-records), which DNS name resolves to which IP address; or in numbering (a general simplified case), which IP belongs to which AS 26.

DNS solves the problem with a decentralized hierarchical structure, where the root (called the root-zone) knows the location of xTLDs, who in turn know the locations of the level below and so on. BGP (and routing) solves the problem differently, and in essence all networks scream to all other neighboring networks which networks are reachable through them 27 and then it is up for each individual network to keep track of what to do with this information. As such similar information exists in multiple places in the network with BGP, whilst DNS, in essence, keeps the information in one place. Summary in Table 3.7.

This who-owns-what problem at hand (i.e. domain, property, car, right to vote etc) is often referred to as Zooko’s triangle, a reference to the nickname of the author of an influential white-paper on the issue (see Wilcox-O’Hearn, 2001). Zooko’s triangle is the old issue of keeping a property (or other asset) ledger, and the triangle suggests that entries in such a ledger and the ledger itself can be described in a trilemma: human-meaningful (i.e. low-entropy human meaningful names, such as www.dn.se or Stockholm rather than a random string of characters), secure (i.e. non other than the owner of the asset/entity should be able to modify the ledger with regard to that asset/entity, such that only the owner of www.dn.se should be able to modify where it points and the Stockholm city council redefine what Stockholm is) and decentralized (i.e. need of centrally trusted authority, the third party issue) (See both of Szabo, 1998; Wilcox-O’Hearn, 2001, for deeper discussion). Zooko (i.e.

26Technically each AS, network or entity trying external routing has to keep a database on where to send packets addressed to a certain prefix, as such “which IP belongs to which AS” is a considerable simplification.

27Technically, they send prefixes, belonging AS, the AS-path, and some other technical information to each other.
Table 3.7: Overview of DNS and BGP

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Typology</th>
<th>Storage</th>
<th>Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNS</td>
<td>Hierarchical</td>
<td>One entity knows the truth for one set of records.</td>
<td>DNSSEC builds trust chains. At a protocol level assumed correct. Not all actors are known.</td>
</tr>
<tr>
<td>BGP</td>
<td>Distributed</td>
<td>Each entity stored their own perspective of the network.</td>
<td>BGPsec is suggested but not widely used. Trust based on history or assumed, all actors not known.</td>
</tr>
</tbody>
</table>

Wilcox-O’Hearn) argued that you can only pick two of those, not three. He did not mathematically prove it, but rather argued that such a system is infeasible. DNS is secure\(^{28}\) and human-meaningful, but not fully decentralized (i.e. distributed). BGP is decentralized and secure but not meaningful for humans (in that humans can select names). Note also that this trilemma is the same as for property deeds, asset management, inventory management or any other system where it is necessary to keep track of what belongs to whom. And the common “pen-and-paper” solution is to centralize, i.e. use a trusted third party as “keeper of truths”, and to use human-meaningful names. Both DNS and BGP differ from the notion to centralize.

And it has to be stressed that the ledger problem, i.e. whom can we trust to keep a correct record of who owns what in a very general sense, has been around since the dawn of civilization, and is a societal problem as well as a technical one.

Blockchains are suggested as replacements for both DNS and BGP, see for example Hogewoning (2018) for naming suggestions (and a partial refutation).

In essence there are three different types of blockchains, see Table 3.8, who differ in specific technical details but all have the issue that nodes (or miners as they are known in the bitcoin context) need to all have the full information (as such the information or ledger exists in multiple places at the same time, by necessity). Proof of Work (PoW) blockchains, such as Bitcoin, derive trust from dedication of computing power (roughly, see Nakamoto, 2008, for more detail). Proof of Stake (PoS) derives trust from stake, that is resources in the pool. Practical Byzantine fault tolerance (pBFT) chains removes the

\(^{28}\)In the essence that only the right actor can update the record.
3. Technological frame of reference

distributed notion of a blockchain and instead focus on a fix number of nodes (per round).

Table 3.8: Overview of blockchain categories

<table>
<thead>
<tr>
<th>Type</th>
<th>Nodes</th>
<th>Speed</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoW</td>
<td>not fixed at all</td>
<td>very slow</td>
<td>bitcoin, Ethereum</td>
</tr>
<tr>
<td>PoS</td>
<td>semi-fixed</td>
<td>normal</td>
<td>Peercoin, Ethereum in the future</td>
</tr>
<tr>
<td>pBFT</td>
<td>fixed per round</td>
<td>fast</td>
<td>XRP</td>
</tr>
</tbody>
</table>

All nodes are not in communication each other, which is one of the design principles of bitcoin (see Nakamoto, 2008), and the network of nodes still work. This is similar to how BGP (i.e. routing, Figure 3.7c) is designed and works. But, as noted in Apostolaki, Zohar, and Vanbever (2017) this leads to problems since not all nodes are known. Apostolaki et al. (2017) shows an explicit attack-vector using BGP-hijacking techniques on the bitcoin blockchain and provides the necessary code\footnote{See https://github.com/nsg-ethz/hijack-btc/tree/master/delay_attack for the code needed to mount an attack against the bitcoin network.} for replication studies. In essence, since all nodes are not known the network does not realize that a large portion of the nodes are not participating after they have been fooled by the BGP-hijack (possible since protocols like BGPsec are not in common use).

In short, blockchains are a different way of solving the same problem as DNS and BGP solves, but differently. Particularly DNS has a different design than blockchains (hierarchical vs distributed). And BGP and blockchains generally solves the ledger problem in a distributed fashion, with the explicit difference that BGP allows networks to have their own versions and ledger of the world, while blockchains in general requires all nodes to keep the same ledger. As such, BGP is more of a ledger distribution mechanism than a ledger management protocol, and in reverse, blockchains can be seen as BGP like structures with forced (i.e. algorithmically decided) interpretation.

3.13 Technological framing

The purpose of this chapter is to provide a foundation of previous thoughts on the Internet and coordination and governance pertaining to the Internet. The most pertinent thought being the lack of agreement on what the Internet is and how this Internet is coordinated.

In specific technical terms DNS and BGP solve the technical problems of keeping records, an age-old problem which has encountered a new solution.
recently, blockchains. These technologies all solve the record keeping problem (i.e. Zooko’s triangle) differently.

There is also the case of mismatching technology with other technology to create vulnerabilities, for example Apostolaki et al. (2017) and PoW vulnerabilities in blockchains due to the best-effort design of BGP (which is “fixed” in BGPsec), or inconsistencies. As such it is not possible to pick and chose freely among technological components, but there has to be some alignment in functionality and assumptions for a good fit.

In general this chapter forms the (technical) foundations which look for co-ordination mechanisms of in the next chapter (Chapter 4). Also, this chapter lays the foundation for the upcoming argument that technology is not always black and white, or absolute, in its design or implementation and there can be gray-zones and matters of perspectives even for technical issues.
4 Coordination frame of reference

For you it is advantageous that there is no consensus on how the Internet is coordinated, that means you have a job

— Interviewee

There are a several thought collectives of studying interactions of people in contexts, such as organizational studies, markets studies, psychology, among others, and at a general level this thesis uses the ecology metaphor for studying these interactions.

In the previous chapter I gave an overview of a number of core Internet protocols, functions and entities, their suggested coordination mechanisms and practices. In this chapter I add in reflections on coordination in conjunction with the technical Internet I previously introduced.

The purpose of this chapter is to introduce previous literature and thoughts on the coordination and digitization in a larger sense to create a frame for that which is interesting to look at in an Internet context. This chapter uses coordination as “that which decides what you do” sense, which is not the universal case, see further discussion in Section 4.1.

Important concepts in this chapter include: ecologies, to study and make sense of the large set of actions in a large setting. Organizing as the concept of how actors in an ecology come to fruition and act. Coordination, to study how actors act in certain situation and what makes them act like that, often used as how individuals in an organization act but here expanded to how
4. **Coordination frame of reference**

actors in an ecology (which could be organizations but most definitely does not have to be) act and behave. Digitization is treated with sociomateriality and information technology (IT) alignment literature. The chapter ends with a “coordinate an Internet ecology” perspective on software design principles in order to create a framework or reasons why the Internet and its coordination mechanisms look like they do.

4.1 Concepts

Governance is a semi-contentious term which has different meanings in different thought collectives or fields. I therefore use coordination throughout this thesis instead of governance, and reserve governance for the stricter top-down view of policy and regulation from here on.

Mintzberg (1993) also uses the term coordination, but in full as coordination mechanism, and I use coordination as the set of context relevant coordination mechanisms. This view of coordination is different from texts such as Okhuysen and Bechky (2009) which through a literature review sees coordination as current activities, i.e. activities such as meetings and policies, but does not include ex ante activities such as training and background, which Mintzberg (1993) does. In this thesis I use coordination as the broader concept, i.e. more “that which decides how to act in and treat a certain situation” (i.e. my reading of Mintzberg, 1993) rather than “the set of activities connecting interdependent tasks and activities” (i.e. my reading of Okhuysen & Bechky, 2009).

4.2 Ecologies

The concept of using ecologies to illustrate organizational development has been around for a couple of decades but the use has only taken off recently. Ecologies are interesting in that they include not only formal and strong relations but also more informal connections (cf. Johanson & Vahlne, 2009, and the stricter network-model) which turn out to be important over time. It is suggested that ecologies are a good tool for understanding organizations in a larger setting (Olve et al., 2013; Westelius & Lindh, 2016; Westelius & Westelius, 2018), since organizations today to a larger extent are dependent on other entities for existence and value production. I see ecologies as another way of looking at, for example, markets. But instead of focusing on the formal aspects, such as buyers, seller, product differentiation, barriers of entry, etc, I focus on the types of actors involved, their relation, norms and cultures in the arena (market), and more soft issues such as values and conflict (cf. Helgesson, 2014; Kjellberg & Helgesson, 2007, rather than contemporary economic and completely rational markets). In essence, I see a market as something more
4.2. Ecologies

(or different?) than the entity in need of (sub-)optimization (such as the context is for texts such as Coase, 1937; Simon, 1997; Taylor, 1914).

Also, traditional network views tend to focus on value creation and capture relations and in that lens it is possible to miss the nuances in informal relations, such as those between a standard setter and the one using the standards. One typical role often forgotten in markets is the role of the provider of coinage or currency, an entity which is fundamentally needed for a market to function (a role similar to the Internet, as I spend this thesis arguing). See Mitchell-Innes (1913), Mitchell-Innes (1914) and Graeber (2012) for a, compared to Smith (1776), contrary view of the creation of money. Where Mitchell-Innes (1914) argue that coinage (tokens or money) was created as the physical manifestation of debt (i.e. IOUs)\(^1\) for accounting reasons, rather than means of exchange as proposed in Smith (1776). As such it is not clear whether markets (i.e. economies and economic activity) led to money, or money led to economic activity in which case markets are fundamentally dependent on external institutions for coinage and guarantees of value (or collection of IOUs)\(^2\). I will return to this relation later in the thesis, in particular in Section 9.9. Note here that the notion that the nation state is the guarantor of money means that the nation state lose a particularly important purpose another guarantor takes over (such as distributed crypto currencies, see for the reporting in Cuthbertson, 2019, that France is banning Libra, the Facebook crypto currency, on the grounds that it poses a threat to the “monetary sovereignty” of nation states in general and France in particular. Libra is here a contextual example of when an Internet fueled entity (a currency) threaten a nation state).

As such it is reasonable that one perspective of an ecology, such as the Internet ecology, can act as a platform in another framing or ecology, such as money does for markets. I intentionally do not include the theories developed for platform economies, even though the theories in general are interesting they (almost always) concern commercial digital platforms which have become infrastructure and therefore powerful (see, for example, Hölck, 2017; Mansell, 2017; Tiwana, 2013) rather than the intrinsic structure of the market (or ecology view) itself.

In the case of the Internet it is even more complicated since there is slew of organizations of different characters involved, such as standardizers (such as Internet Corporation for Assigned Names and Number (ICANN) and Internet Engineering Task Force (IETF)), policy-setters (in a sense ICANN and states), for-profit whole-sellers (infrastructure and network operator, such as Internet Exchange Points (IXP) and Internet Service Providers (ISP)), non-

---
\(^1\)Acronym for I Owe U (you).
\(^2\)It should be noted, to the careful reader, that Mitchell-Innes (1913) and Mitchell-Innes (1914) are quite neutral texts on the topic of money and its intrinsic conceptual composition and construction, while Graeber (2012) is seemingly written to poke a finger in the eye of neoclassical economists.
### Table 4.1: Condensed typology of Olve, Cöster, Iveroth, Petri, and Westelius (2013) including their suggested actors.

<table>
<thead>
<tr>
<th>Actor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers</td>
<td>are suppliers in multiple levels.</td>
</tr>
<tr>
<td>Appointees</td>
<td>are those who could have an impact on, for example, which business models are good or not.</td>
</tr>
<tr>
<td>Consultants</td>
<td>are those who could have an impact on, for example, which business models are good or not.</td>
</tr>
<tr>
<td>THE civil society</td>
<td>and the public often form opinions on what is considered good or passable.</td>
</tr>
<tr>
<td>Politicians and influencers</td>
<td>and the public often form opinions on what is considered good or passable.</td>
</tr>
<tr>
<td>Appointees</td>
<td>are those who could have an impact on, for example, which business models are good or not.</td>
</tr>
<tr>
<td>Politicians and influencers</td>
<td>and the public often form opinions on what is considered good or passable.</td>
</tr>
<tr>
<td>Regulators</td>
<td>are those who could have an impact on, for example, which business models are good or not.</td>
</tr>
<tr>
<td>Politicians and influencers</td>
<td>and the public often form opinions on what is considered good or passable.</td>
</tr>
<tr>
<td>Appointees</td>
<td>are those who could have an impact on, for example, which business models are good or not.</td>
</tr>
<tr>
<td>Politicians and influencers</td>
<td>and the public often form opinions on what is considered good or passable.</td>
</tr>
<tr>
<td>Standardizers</td>
<td>are those who could have an impact on, for example, which business models are good or not.</td>
</tr>
<tr>
<td>Politicians and influencers</td>
<td>and the public often form opinions on what is considered good or passable.</td>
</tr>
</tbody>
</table>
4.2. Ecologies

profit interest groups (such as the At-Large Advisory Committee (ALAC)), governments, international treaty organizations (including organizations such as the United Nations (UN) and the International Telecommunications Union (ITU)), foundations and so on.

Olve et al. (2013) suggests a number of actors to look out for in a (business) ecology, shown in Table 4.1, and suggest that the ecology lens is a way of looking at or understanding (cf. thought collective in Fleck, 1935) an organizational context. Neither Olve et al. (2013) nor Westelius and Lindh (2016) suggest that ecologies are a full-fledged theory (cf. Johanson & Vahlne, 2009, regarding network theory, often described as a full theory) but rather as a tool for making sense of the world, more in line with theory as a concept as discussed by DiMaggio (1995), Weick (1995) or even me in Section 2.2 earlier in this thesis.

It is worth a mention that Westelius and Lindh (2016) is written with the explicit purpose of reasoning on what it is the Management Control System (MCS) should control or coordinate, and end up in the notion that ecologies are a good tool for understanding the environment they are part of.

Table 4.2: Typology of entrepreneurship based on institutional trespassing, adopted from Lundmark and Westelius (2012).

<table>
<thead>
<tr>
<th></th>
<th>Legal</th>
<th>Illegal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>Formal</td>
<td>Informal</td>
</tr>
<tr>
<td>Illegitimate</td>
<td>Offensive</td>
<td>Renegade</td>
</tr>
</tbody>
</table>

In addition, I find the typology of institutional trespassing (see Table 4.2) in Lundmark and Westelius (2012) useful in its distinction of illegal (that is against the law) or illegitimate (that is behavior which is frowned upon) for framing entrepreneurial activities (where entrepreneurial activities are those which shape institutions, Table 4.2 illustrates the matrix). As the Internet is present in many jurisdictions, legality when used in this thesis is framed in the contextual jurisdiction, and legitimacy within the confines of a thought collective (and sometimes a more narrow epistemic community). Thus, both legitimacy and legality is context-dependent rather than absolutes (in my use of the matrix). Further on I refer to this matrix, Table 4.2, as the institutional trespassing matrix.

I do not assume that all actors in an ecology are legal and legitimate (see for example Mueller & Chango, 2008, where ICANN and WHOIS, the database of domain owners, are discussed as sometimes illegal but legitimate).
4. Coordination frame of reference

4.3 The organizational context

What is an organization and why does it matter? I here spend a couple of pages untangling the organization (in my perspective) and put it in the context of ecologies or a larger settings. In essence, I suggest it is possible to blend ecologies and organizations (with technology) to create an understanding of the Internet which makes sense in the larger context.

Coase wrote one of the earliest treatises on organizing, in other words firms and companies, and even though it is quite short it is considered a classic and presents some, back then, novel ideas. His work focuses on formal or contractual relationships, in effect not taking informal relationships into consideration.

In a setting where the “efficiency of the market” was a central tenet the organization was under threat. If the market is so efficient, why employ and organize, shouldn’t it be more efficient to contract for specific tasks or goods? Coase (1937) argues that it is not that simple, and there is a “transaction cost” when accessing the market, in effect an overhead, and that there are occasions when employing labor is more efficient. Such overhead might be related to searching and finding the right service, bargaining, policing and enforcement costs (Coase, 1937, does not explicitly mention training).

He also notices that there is a maximum to what can be managed internally, and uses the expression “decreasing returns to the entrepreneur function”, and points out limited management capacity and overhead costs as limiting factors in large organizations (Coase, 1937). He sees an equilibrium when the cost of organizing, i.e. expanding the firm, is as expensive as the transaction cost overhead for contracting a task (note the assumptions of rationality needed for such a sentence to make sense).

Benkler (2002) is an interesting text which revisits Coase (1937) in a more modern setting. In essence the text draws the same conclusions as Coase (1937) in that there are two primary means of production, employ or contract, but also argues for a third; peer production. The example given is Linux, and the text is jokingly called “Coase’s Penguin” (Tux, a penguin, is a common Linux mascot), and reasons that peer production such as open source software (such as Linux) is responsible for a good deal of welfare in the US (i.e. says that not only “what is good for CompanyX is good for the country” but also that which is good for NotACompanyY is good for the country).

Here a note on value is necessary, as Coase (1937) tries to find the solution to maximizing value based on input or cost, but does not define value (or its creation or capture) explicitly (can we assume money bottom-line? Which intrinsically is the subjective notion of the value of debt?). In this thesis I use separate notions for creation of value and capture of value; creation of value is creating actual value (according to the perception of stakeholders, by definition subjective) but not necessarily capturing in, as in turning a profit, and capture of value is the process of actually appropriating the created
value (as the concepts are differentiated in Santos, 2012). This distinction is important, as for example the net neutrality debate can be framed as the rules of engagement for value capture by the infrastructure and network operators of value created at the edge of the network. It bears repeating here, this thesis hold neither value not technology as absolutes (or fact for that matter).

Neither Coase (1937) nor Benkler (2002) go deeper in on what an organization is, i.e. what are the central tenets that define an organization? Can the Internet be seen as an organization? I will go through, among others, texts such as Simon (1997), Simons (1995), Mintzberg (1993), Malmi and Brown (2008) and Olve et al. (2013) before I suggest a frame of looking at an organization in an ecology.

4.4 Administrative behavior

The fourth edition of Administrative behavior: a study of decision-making processes in administrative organisations came out in 1997 but the ideas stem from the first edition in 1947. According to Simon (1997) organizations can be understood by their decision-making processes, and that this is the core of administration. Simon (1997) focuses on the variable (bounded) rationality of decision-making and describes, among other, how communication and information flows change the decision premises and therefore can alter the outcome of decisions. He states that the organization should not only be seen as a rational institution created for a rational goal, such as organizing to provide a service which individuals would not have been able to do on their own.

Prior to Simon (1997), and in many cases after, it was the norm to assume rational behavior of firms and organizations, and a concept known as homo economicus (or economic man) was used. In game theory (i.e. many financial applications) homo economicus is modeled as utility optimizing incarnations of absolute rationality. The theories in Simon (1997) of bounded rationality have much in common with neuro-scientific theories such as “Emotional theory of Rationality” (see Garcés & Finkel, 2019, which portrays similar mechanisms and limits rationality from a neuro-scientific perspective).

Simon (1997) does not further elaborate on the limitations of an organization, nor define it, but rather sees it as implicitly defined (“everyone knows what an organization is”). And the important, for this thesis, notion in Simon (1997) is that decisions are made by people and that people are not always fully aligned with the organization when it comes to decision-making. I.e. it is reasonable to expect that rules and policy cannot fully describe or predict which decisions gets taken.

To build on the previous paragraph, Simon (1997) also suggests that on an individual level outcomes are not certain, such as when a subordinate does not follow a superior’s orders, both in the case of a small deviation such as solving a problem in a different manner than specified or the more extreme
example of mutiny. Simon (1997) is interesting in an Internet Coordination context since the Internet can be assumed to contain many of these contrary values and opinions, and is not strictly hierarchical.

Also, the arguments of Simon (1997) are closer to my own experiences in governing boards and the finance sector. As an example, parts of my university were reorganized. The decision concerned roughly 800 employees and the board was given roughly 100 pages of report content (i.e. pages with actual content) spread over several reports and given roughly one hour to discuss and ask the report authors questions. How can a decision concerning 800 employees rationally be boiled down to a hundred pages and one hour of discussion?

Another example, from the finance sector; most option derivatives are priced either by Black-Scholes (see Black & Scholes, 1973, concerns options where the underlying asset is fixed) or Garman-Kohlhagen (see Garman & Kohlhagen, 1983, an extension of Black-Scholes where the value of the underlying asset might change, such as currency options) equations, which are very simplified models of both reality and correct price, yet are almost always used for list prices of options. This is a clear example of irrationality in finance, the penultimate efficient market in perspectives such as that in Coase (1937), and an indication that the thoughts in Simon (1997) regarding limited or divergent rationality are important.

4.5 Hard and soft values

Since the Internet is not only rational for-profit firms (at least as formulated in Coase, 1937) it is prudent to look into different mechanisms than strictly rational and hierarchical ones. One of the more, in the context of this thesis, useful ways of splitting up concepts such as rationality, hierarchy and meaning is the MARC model as presented in Westelius, Westelius, and Brytting (2013), and further elaborated on in Westelius and Westelius (2018). The MARC model aims to separate factors influencing organizational behavior on two different dimensions or axes; where the first is emotional (soft) — rational (hard) (my interpretation), and the other is vertical — horizontal interaction (my interpretation). I illustrate these dimensions in Figure 4.1, which again is my interpretation. Westelius et al. (2013) offers a graphical model containing meaning, authority, rationality and care with cross-influence between meaning and rationality and authority and care and a further description in text. Figure 4.1 is that text added and simplified into the model.

In short, Westelius et al. (2013) argues that management literature from a historical perspective has focused on the “hard”-side (i.e. the right side of Figure 4.1) and it is prudent to look deeper into the softer perspectives, especially for organizations which are strictly not only for profit enterprises but also to an extent organizations dependent on highly skilled labor. Westelius and Westelius (2018) follows up on the same argument and adds a sustainable
4.6 Organizing and controlling

Figure 4.1: The MARC-model, interpreted from Westelius, Westelius, and Brytting (2013) and Westelius and Westelius (2018)

management wrap to it. The core argument is that the MARC model needs balance for the organization to function. As an example, Westelius et al. (2013) argues that an organization focusing too much on well-being (i.e. Care in the model) might end up not doing anything due to lack of Authority.

Just as ecologies add nuance to the network perspective the MARC-model adds nuance to the rational organization and control perspective, similarly to Simon (1997). And as alluded to, many Internet Coordination actors are non-profits by design.

4.6 Organizing and controlling

In Structure in Five — Designing Effective Organizations Mintzberg goes through what he likes to call the primitives of organizing. He ends up with five structures of five, but here I will summarize three of the structures of five which I consider to be the most important for this thesis; the elements
of an organization, the coordination mechanism of an organization and five structural configurations for organizations. In a later thesis, Groth (1999) argues that Mintzberg was mostly right in Mintzberg (1993), but there are some additional quirks which needs to be taken into account in a digital age, such as the fact that agency does not only lie with the social but could also lie with that which was previously considered material.

Mintzberg (1993) considers any organization to consist of five different kinds of elements; firstly the operating core which is the part closely linked to production, secondly the strategic apex which is the top management of the organization, thirdly the middle line comprises those who sit between the strategic apex and the operating core, fourthly the technostructure which consists of indirect production facilitators and with the power to affect the structure of the organization, such as long-range planners, standardizers and controllers, fifthly the support staff which provides indirect support to the rest of the organization, such as public relations, payroll management and the cafeteria.

He also considers there to be five different methods of coordination in an organization, of which three are different forms of standardization. Mutual adjustment (MA) is when individuals are in charge of their own work and coordinate by communicating informally (concept originated in Thompson, 1967). In direct supervision (DS) there is a supervisor controlling the work of others by direct orders. Then there are three different forms of standardization (with origin in the concept that all work can be planned or optimized, such as Taylor, 1914); standardization of work process (SWP) when the doing of the work itself is coordinated by the imposition of standards (typically from the technostructure), standardization of outputs (SO) when the output of the work is coordinated by the imposition of standards (again typically from the technostructure) and standardization of skills (SS) where the work is coordinated and standardized by skills and knowledge (such as a medical degree or a welders training. This form of coordination overlaps with the socialization forces in DiMaggio & Powell, 1983, which turn organizations isomorphic, since these skills standardizations tend to take place outside the individual organization, and support many organizations, not just the one).

There are other texts, such as Okhuysen and Bechky (2009), which views coordination differently than Mintzberg (1993). Whereas Mintzberg (1993) sees coordination as roughly the process of how you know what to do in a given situation, Okhuysen and Bechky (2009) has a more formalized description:

Coordination, the process of interaction that integrates a collective set of interdependent tasks, is a central purpose of organizations. (Okhuysen & Bechky, 2009, p. 463)

This focuses on interdependent tasks, rather than the much broader perspective in Mintzberg (1993), as an example (in my reading) Okhuysen and
Bechky (2009) does not consider training and similar ex-ante experience to be a coordination mechanism. This difference in perspectives, or thought collectives, of coordination can explain my major problem with a significant portion of management and information systems literature.

As an example, Bailey, Leonardi, and Chong (2010) discusses technology interdependence and its impact on theories of organizing. The empirical data is based on two case studies, one of hardware engineers, and one of structural engineers, and the technological gaps they encounter in daily work (i.e. where technology does not fully overlap, and for example manual labor is needed to move data from a spreadsheet to a program for structural integrity calculations). The study is primarily based on observations and interviews in these environments. And they compare two differently schooled groups without detailing their training or describing it as important (i.e. coordination as seen in Okhuysen & Bechky, 2009).

But, visible throughout in the text (example quote shown below) that the hardware engineers happens to be computer engineers, i.e. computer-hardware-focused computer engineers.

In an example of a narrow gap, Eric, a hardware engineer, created a diagnostic test and was ready to run it on a microprocessor configuration. To do so, he simply typed a command, as described in our field notes: “At the prompt in the lower left window, he types: make vcs.log DIAG-103 [emphasis added].” (Bailey et al., 2010, p. 718)

In this quote make refers to the same make as Miller (1998) in the introduction, i.e. a very, with emphasis on very, common tool for automation of software builds (or more correctly, automation of any process on virtually any digital device with well-defined steps, inputs and outputs), which is also the tool I use to compile this thesis as described in Section 2.5. This statement (make vcs.log DIAG-103) has three parts, divided into one command (make) with two arguments (vcs.log and DIAG-103, which in the make-world technically are referred to as goals). The command is to run make, with vcs.log and DIAG-103 as goals, which should be interpreted as “run make with the intention of fulfilling the goals of vcs.log and DIAG-103”, with vcs.log and DIAG-103 undefined from where we are standing. However, we can make educated guesses as to what they are; VCS (today known as Synopsis VCS) is a high-performance tool for simulating circuitry (such as processors), and

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3Hardware engineer is a weird term, it is a bit like saying “a wheeled car” in that the attribution is assumed so it is often implicit. Just as “a wheeled car” makes you wonder what is so important with the wheels and why the particulars of those wheels not specified. “Hardware engineer” raises questions of the specificity of the hardware, since all engineering professions (originally) worked with hardware.

4. Coordination frame of reference

since the example company in Bailey et al. (2010) does circuitry, it is very probable that the *vcs.log* goal includes a VCS run resulting in a log-file, and that the *DIAG-103* goal probably refers to a diagnostic setup / run (i.e. a run with more verbose logging than say a production run)\textsuperscript{5}.

In general, computer engineers should know a thing or two about computers and bridging technical systems, a statement I can say since I am one (i.e. a computer engineer). Structural engineers on the other hand, as rule of thumb, are not proficient with computers in general, but rather with specific computing tools, which I can say since I have been teaching very basic computing and programming to structural engineers at both BSc- and MSc- level for several years during my engineering studies.

So we have a case in Bailey et al. (2010) where we have one group of people capable of building and bridging computer systems (as shown with their use of *make*, *Makefiles*, and their highly complex work (circuit design)), and the other group does not explicitly show the skills necessary to bridge computer systems, and the conclusions of Bailey et al. (2010) is that it is a current management issue which could be helped by organizing differently with the same people. Rather than, for example, the Mintzbergian explanation that people do what they are trained to do (if they want to do it), which is undoubtedly a much more parsimonious and in some sense usable conclusion in this particular case. I will later use this notion of “people do what they are trained to do” to explain why the *Internet* works as it does and the design principles are in place (see specifically Section 4.13 for software design principles in the context of organizations).

Another way to see it is lack of domain-specific understanding by the authors of Bailey et al. (2010). And to use the sociomateriality conceptualization of Orlikowski (1992), this misunderstanding did not come out of either the social or the material, it comes from understanding neither of them (although both with a domain-specific flavor). The social in the sense that the background and training of the interviewees were not understood, and material in that the technical specifics of the processes were not understood.

A third perspective on the same issue is the philosophy of science case that paradigm or thought collective guide scientific endeavors to such an extent that researchers become blind to factors outside of their own domain of assumptions, generalizations, idealizations and abstractions, which in this case is organizing and coordination in the Okhuysen and Bechky (2009) sense (i.e. current activities).

Going forward from coordination, Mintzberg (1993) ends with five different structural configurations which each primarily relies on one coordination mechanism, but is not limited to rely on only that coordination mechanism. Neither does he propose that this is an exhaustive taxonomy of firms, but

\textsuperscript{5}I am not saying that all digitization researchers should know what VCS is or what its purpose is, but I am saying that if you do not know what someone is doing, you are essentially just guessing when you try to explain why they do it.
4.6. Organizing and controlling

rather a tool for understanding how an organization functions or can be designed.

**Simple structure** relies on direct supervision and can generally be seen as a centralized form of organization where power is focused in the strategic apex. Example: small and young organizations.

**Machine bureaucracy** relies on standardization of work and is usually less centralized than a simple structure but the power is concentrated in the technostructure and sometimes external standardization powers. Example: production firms.

**Professional bureaucracy** relies on standardization of skills and is similar to the machine bureaucracy in many ways except that power stems from the professional operators rather than the technostructure, in effect the training has a large influence. Example: schools and hospitals.

**Divisionalized form** relies on standardization of outputs and can be seen as a collection of other organizations sharing a strategic apex. Power, usually, stems from the middle line. Example: large international companies where subsidiaries are mostly independent of each other.

**Adhocracy** relies on mutual adjustment for coordination and is in the words of Mintzberg “selectively decentralized” in that power is spread throughout the organization. In effect, power lies with the experts rather than in training or standardization because what needs to be done is rather unpredictable. Example: complex and research heavy organizations such as NASA and universities (worth noting here is that universities is a Mintzberg example, I (and many others I would assume) would on the other hand argue that universities take on a more and more standardized approach to most tasks, such as education (and research?).)

Important to note is that Mintzberg (1993) solely focuses on the organization itself, and does not venture into a discussion on why there are organizations. And as Groth (1999) argues, the concepts from Mintzberg (1993) are useful in that they do not limit agency to the people but rather allows for a greater variation in coordination of what actually gets done. As an example, the frameworks in Mintzberg (1993) allow for coordination between man and machine, or machine and machine, rather than limiting the coordination issue to a man-only problem.

Simons (1995) also takes the existence of organizations for granted, and concentrates on how to control and uses a concept known as MCS, which is defined as “the formal, information-based routines and procedures managers use to maintain or alter patterns in organizational activities”. Just as Mintzberg (1993) provides a classification for organizing, Simons (1995) provides a classification for management or managing. These are four boxes, like those in
4. **Coordination frame of reference**

the MARC model, and even though the contents exhibit some similarities, the sorting is different.

**Diagnostic control systems** are systems used to monitor the health of an organization. Could be instruments such as budgets and accounting systems.

**Belief systems** are softer and focus on core values, exemplified by mission and vision statements.

**Boundary systems** are those setting limits of interaction or freedom, could be policies, codes of conduct and similar instruments.

**Interactive control systems** are settings for person-to-person interaction that provide feedback different from the purely diagnostic one. Could be information of more strategic character and / or connected to the market rather than the organization itself.

It should also be said that Coase (1937), Mintzberg (1993), Simon (1997) and Simons (1995) are all quite general in their formulations and capable of standing the test of time, and I see them as helpful in envisioning organizing and **coordination** in a changing world (such as a digitized one).

4.7 **Packages of controls**

In an MCS perspective, Malmi and Brown (2008) presents a framework for looking at and discussing management control. For me, their greatest contribution is their typology categorization. Their view of management is the intentional action or initiative from the manager, and from this background they create their topology and follow terminology of management control tools to be used when discussing management control systems. Malmi and Brown (2008) implicitly assumes a planned organization, in need of control, and accounts for different ideas and controls entering the arena at different stages. Grabner and Moers (2013), as previously mentioned, further discusses the possibilities of interdependent **MCSs**. The Malmi and Brown (2008) typology is of interest in this thesis since it suggests ways to change behavior.

The topology itself is divided into five areas which are defined as follows:

**Culture** controls are such values, beliefs and social norms that can be influenced on management initiative.

**Planning** controls are plans, both long and short term, to guide organizational behaviour.

**Cybernetic** controls are those related to measurements and feedback, such as budgets, financial, non-financial and hybrid measurement systems.
4.8. The relevant organization?

**Reward / compensation** are systems whose purpose it is to reward or compensate a group or individual for certain actions.

**Administrative** control is how to control an organization through its structure, processes and how it is organized.

The typology is overarching and includes the works of previous scholars. Two examples; *Culture* controls includes belief systems as proposed by Simons (1995) and *administrative* controls include many of the organizational concepts by Mintzberg (1993). It can be thought of as a sorting box when doing an inventory of management control mechanisms in place, intentional or not (as discussed in Grabner & Moers, 2013). In comparison to the MARC model this control package is focused on the hard values, where the *Culture* controls contain many of the soft values.

I will use Malmi and Brown (2008) specifically to organize and sort the control mechanisms in place on, or perhaps within if seen as an organization, the Internet. The boxes of Malmi and Brown (2008) also provided me with a toolbox of Management Control (MC) mechanisms to look for when interviewing and reading documents.

4.8 The relevant organization?

In my view, these texts have their own strengths and weaknesses, but looking at them together, one thing becomes obvious, they are all focused on the organization. Coase (1937) argues for why we organize and Mintzberg (1993) describes how it is possible to organize while Malmi and Brown (2008), Simon (1997), Simons (1995) focus on how to control or manage an organization. What happens outside or between organizations? How do they interact and what happens there? (And what are they?) Previously I introduced the ecology concept to understand these inter-organizational interactions, but there are other views or perspectives to understand them.

I argue that business literature, to a great extent, understand organizations but not how they interact outside a market context. Large organizations are mostly a thing of the past, and the majority of employment is in small firms today (see for example statistics in Nazar, 2013), and almost all organizations exist in an environment with different forces such as standardizing, regulation and competition. Malmi and Brown (2008), Simon (1997), Simons (1995) argue for how to intentionally and formally manage and control an organization, but that is not applicable to the relation Spotify has to its content producers, the musicians, since Spotify neither employs nor owns them. Neither is it applicable to how *Taxi Kurir* manages its indirect car-fleet, since it does not own them nor employ their drivers.

Coase (1937) describes the need for organizing since the transaction costs, i.e. overhead, for contracting all tasks separately was too high and implies
Coordination frame of reference

that there is an optimization peak somewhere between organizing everything and contracting everything. That the peak has shifted towards contracting is a common conclusion (see for example labor market data analyses such as any of Katz & Krueger, 2016; Weber, 2017), but what would happen if it shifts almost all the way to contracting?

Grabner and Moers (2013) build on some of the concepts in Malmi and Brown (2008) to accommodate for unintentional interaction between management control systems, but still limit themselves to systems which had a management intent. Where are the theories discussing how non-management decisions, for example technical decisions, end up having unintended management or coordination implications in a believable fashion? (I will return to sociomateriality in a moment, but there are issues there as well)

Guided by previous literature I see an organization as a social construct (cf. Berger & Luckmann, 1991) of entities with agency (such as people) with an official common goal. There are three things to point out here; first, I consider that an organization very much could be an organization almost without people, for example a collection of machine intelligence providing investment advice could very much be an organization, and second, I do not limit the concept of organization to formal organizations, such as those with a VAT-number, organization number, legal status or similar but consider endeavors going in a direction as organizations, such as the Linux-kernel contributors. Thirdly, it is possible for an entity, such as a person, to be part of multiple organizations, such as the Linux-kernel developer employed at IBM and therefore part of the IBM organization but also part of the Linux-kernel organization.

4.9 Institutional isomorphism

Both Meyer and Rowan (1977) and DiMaggio and Powell (1983) say that as technological change in an organization slows down due to enough competitive advantage, organizations become isomorphic in how they act and behave. Meyer and Rowan (1977) aptly named their paper “Institutionalized Organizations: Formal Structure as Myth and Ceremony” in showing that formal structures are not just present for efficiency reasons but also due to socialization and external pressures/reasons. This is in line with Mintzberg (1993) in that formalization happens when technological change slows down and scaling value capture becomes important, and also in line with Simon (1997) in that organizations are not perfectly rational.

DiMaggio and Powell (1983) uses a similar train of thought and end up with three types of isomorphic forces; coercive (such as external forces), mimetic (such as trying to copy a competitor) and normative (such as socialization of professions), where the three are not separate empirically but rather an analytical instrument to make sense of isomorphic pressure.
4.10. Materiality lost?

My understanding, of Meyer and Rowan (1977) and DiMaggio and Powell (1983), is then that as long as there is an efficiency reason for an organization to change what it is doing or how it is doing it, that organization would be less formal, less socialized and less isomorphic than an organization of comparable size which has little reason to change from an efficiency standpoint. I will later return to this topic in the light of the changing nature of the Internet, since a changing Internet implies low formality, the opposite of that, i.e. high formality, should imply that the Internet and its coordination is changing slower than previously.

4.10 Materiality lost?

Sociomateriality, a concept stemming from Orlikowski (1992), suggested a (then) novel way of looking at technology in organizations. Rather than to look at technology as deterministic or as the outcome of strategic choice and action, Orlikowski (1992) suggests a perspective which takes both perspectives into account. I should point out that I mention sociomateriality instead of, as an example, socio-technical systems (see Trist & Bamforth, 1951), since I encountered sociomateriality first. In essence, Orlikowski (1992) boils down to:

This paper has proposed an alternative theoretical conceptualization of technology which underscores its socio-historical context, and its dual nature as objective reality and as socially constructed product. [...] The ongoing interaction of technology with organizations must be understood dialectically [i.e. from both perspectives], as involving reciprocal causation, where the specific institutional context and the actions of knowledgeable, reflexive humans always mediate the relationship (Orlikowski, 1992, p. 398)

Table 4.3: My interpretation of Orlikowski (1992)

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<tr>
<th>link to</th>
<th>Sociomateriality</th>
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<tr>
<td></td>
<td>the social</td>
</tr>
<tr>
<td>Social construction</td>
<td>strong</td>
</tr>
<tr>
<td>Objective reality</td>
<td>weaker</td>
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Which could be rephrased as; technology and organization interaction is complex, not least since they are both social constructions and both parts of objective reality, so to fully understand the interaction we need to understand both. In Table 4.3 I illustrate that even though the social in sociomateriality
is mostly a social construction it also carries traits of objective reality. And that even the material bears trait of both social construction and objective reality, even though the object link might be stronger. Since Orlikowski (1992) uses the terms social construction and objective reality, I do the same (even though I argue that objective reality is relative in nature, due to relativistic effects⁶, which we actually get into with digitization, such as for GPS-service).

However, modern literature can be accused of relying more heavily on understanding of social constructions rather than the understanding of technical reality. For example Orlikowski and Iacono (2001), titled “Desperately seeking the ‘IT’ in IT research: A call to theorizing the IT artifact”, calls for greater exploration of the material. One can see Bailey et al. (2010) (the make example) as an example of failure to adhere to the material, the problem was understood as one of social construction.

De Reuver et al. (2017) argue that information systems scholars might indeed have forgotten the material, and that it is time again to pick it up with digital platforms (in line with Orlikowski & Iacono, 2001). In a sense, this is what Orlikowski (1992) suggests, understand both the social and the technical. Except that de Reuver et al. (2017) leaves much of the technical behind or as a social construction. As an example, their technical definition of a digital platform is technical nonsense, in a sense making the material part a social construction rather than (relative) objective reality, in essence looking at only the top row of Table 4.3. They define (or describe in a social construction manner) digital platforms as:

Digital Platform (technical view): An extensible codebase to which complementary third-party modules can be added (de Reuver et al., 2017, p. 4, table 1)

These are words which are syntactically correctly put together, but have an unclear semantic meaning, and indicate something which they later disprove. As an example, “extensible codebase” indicates that there has to be an extensible codebase for there to be a digital platform. But in their example, they refer to platforms which are extensible⁷, not codebases which are extensible. To clear up any technical confusion here, a codebase is static, it is not executing, or running, or doing anything, it is a collection of files containing source code (human-written or automated, see for example Potvin & Levenberg, 2016, for the important understanding that most lines of code are not

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⁶It might be said that reality is objectively (or absolutely) relative, which is quite the philosophical conundrum. See Einstein (1905) and other works concerning the derivation and existence of what is now known as the Lorentz transformation, which states that the order of events, physical size (length, width etc) and time itself it relative to the frames and velocities of the frames from within observations were made.

⁷A word for the technical reader, all things digital can in one way or another be extended, here I use extensible in the notion that it is designed to be extended, i.e. that value is added by extending it.
written by people). A digital platform, on the other hand, is typically understood as something that provides a service. The extensibility of the codebase of a platform has is not causally connected with the extensibility of the platform itself (much like putting salt or pepper on a carrot seed will not change the taste of the carrot). De Reuver et al. (2017) however use digital platform as something that in itself is extensible, in effect disproving or redefining their definition when using it.

In the perspective of this study, the most interesting notion of de Reuver et al. (2017) is that the text explicitly mentions that digital platforms (regardless of definition) are of utmost importance to understand, and that a new direction of research is needed. But does not mention the most widespread digital platform there is today, the Internet, although the argument is implicitly relevant to it.

Another very current example of “materiality lost” is blockchains, today used as buzzwords for “something” since it is often unclear what the blockchain is used for. As argued earlier in Section 3.12, blockchains are essentially a technical way of handling trust, not a universal solution to all issues in the world. But something still needs to trusted, in the case of bitcoin it is the consensus of the network. But what is that consensus? Technically it is the current longest chain supported by the largest pool of computing power (see Nakamoto, 2008, for technical description of process), which means that to control trust you need the most computing power (Proof of Work (PoW)).

There are multitudes of examples of blockchains. One such is Lantmäteriet (the Swedish agency for boundaries and maps: they do not have an official translation, which appears intentional) and their recent blockchain experiment, in which they suggest using the blockchain to store property ownership and digitize the process of transferring ownership, and conclude that they can speed up the 34 steps of transferring property significantly using a blockchain solution (see Kairos Future, 2016, for the report). But rather than leveraging the distributed nature of a blockchain they are stating the benefits from going from pen and paper to a digital system, where the storage (whether a classical database or a blockchain) is of no significant value, since they are still using Lantmäteriet as the trusted party. And remember, as previously argued, the notion of a blockchain is distributing trust by some mechanism (such as computing power for bitcoin), not centralizing it. This is the same fundamental problem solved in the design of the Internet in different ways by Domain Name System (DNS) and Border Gateway Protocol (BGP) with surrounding protocols and systems.

Another way of framing sociomateriality is through IT alignment, roughly the problem of aligning IT (with disagreement on what IT is) with business and/or organization, either from an outcome (i.e. profit or performance) or process (i.e. how and what) perspective. Chan and Reich (2007) state in a literature review of IT alignment:
It seems clear from the literature that there are at least two distinct conceptualizations of alignment. The first is alignment as an ongoing process, which requires specific IT management capabilities, encompasses specific actions and reactions and has discernable patterns over time. The second is alignment as an end state, which focuses on the antecedents, measures, and outcomes of alignment. The authors see the value of both streams and consider both alignment perspectives to be necessary. Future research that examines alignment should build on the appropriate literature (Kearns and Lederer, 2003). Work that links these two perspectives is likely to be the most difficult but the most beneficial. (Chan & Reich, 2007, p. 310)

Chan and Reich (2007) further argues that it is of importance to understand what alignment is, and for practitioners this means that separating IT and business is a bad idea. Even if Chan and Reich (2007) is not explicit, I assume it means that core business needs to know and be proficient in IT. Chan and Reich (2007) implicitly suggests that IT should become a part of core business rather than a separate organizational entity; explicitly the text argues in terms of joint responsibility rather than organizational structure. Raymond, Pare, and Bergeron (1995) shows similar results in a quantitative study of organizations and IT. However, fit or alignment itself is hard to define, as per the following quote which states that there was fit since fit had been configured (i.e. circle reasoning):

[on why there was fit / alignment]
All three cases involved a software package that had been configured to fit the functionalities and requirements of each hospital. (Lapointe & Rivard, 2007, p. 92)

IT alignment literature, such as Chan and Reich (2007), Raymond et al. (1995) and Croteau and Bergeron (2001), gives that the common approach is to implicitly frame technology as the outcome of strategic choice and action (i.e. organizational choices shape IT, rather than a more complicated duality relation, and if the alignment is not sufficient, it is assumed that the IT systems should be redesigned), rather than looking at the duality of the matter as argued in Orlikowski (1992). Note that some literature on alignment, such as Leonardi and Barley (2010) (overview of IT and organization literature) and Zuboff (1988) (practical example of alignment literature), seem to see IT as a standardizer, and discuss the alignment of the standardization forces (cf. standardization of outputs (SO) and standardization of work process (SWP)) rather than the actual design of and possibilities of changing or aligning the technology itself (and in turn what leads to the design of technology).
4.11 Separation of concerns

Over to software and computer design, which in a few pages will be turned back into organizing. “Concerns” is a concept in computer engineering which, a bit simplified, means “all matters which are of concern in a context”, such as dependencies, hardware requirements, security etc.

Separation of concerns is a computer science concept that different modules, classes or components in a computer system should have different concerns. I.e. the purpose of the system needs to be neatly mapped onto the system itself. The concept first appears in Dijkstra (1982), and is often connected to the following quote:

Let me try to explain to you, what to my taste is characteristic for all intelligent thinking. It is, that one is willing to study in depth an aspect of one’s subject matter in isolation for the sake of its own consistency, all the time knowing that one is occupying oneself only with one of the aspects. We know that a program must be correct and we can study it from that viewpoint only; we also know that it should be efficient and we can study its efficiency on another day, so to speak. In another mood we may ask ourselves whether, and if so: why, the program is desirable. But nothing is gained —on the contrary!— by tackling these various aspects simultaneously. It is what I sometimes have called “the separation of concerns” [emphasis added], which, even if not perfectly possible, is yet the only available technique for effective ordering of one’s thoughts, that I know of. This is what I mean by ”focusing one’s attention upon some aspect”: it does not mean ignoring the other aspects, it is just doing justice to the fact that from this aspect’s point of view, the other is irrelevant. It is being one- and multiple-track minded simultaneously. (Dijkstra, 1982, p. 1-2)

As a practical real world example, separation of concerns is akin to a functional organization design where organizational units are tasked with doing one task really well. This resembles standardization of outputs (SO) in the Mintzberg (1993) typology in that you are interested in the output but do explicitly not care how it is done, but it also bears resemblance to mutual adjustment (MA) in that power is distributed rather than directional. In essence, SO through MA.

Another example of separation of concerns in an organizing context is separating code into multiple repositories for large projects. This is to make sure that each repository contains independent modules and (hopefully) reduces versioning interdependence between modules or units, such that it is possible to test and maintain these repositories separately (note that here separation of concerns refers to the handling of the code, not the code itself).
For the technical Internet, separation of concerns is partially manifested through different layers, as the web is a service on top of the Internet, Transmission Control Protocol (TCP) run on top of Internet Protocol (IP) and so forth. Breaching the separation of concerns concept for Internet layers is commonly known as layer violation. that is, doing something on one layer which “naturally” belongs on another layer.

Separation of concerns is a design principle; the notion of separation of concerns is the embodiment of one entity having one task, and one purpose. In Section 4.12 I propose an opposite of separation of concerns, namely integration of concerns, and in Section 4.13 take it one step further to suggest that these opposing design principles can be used as a base to describe the design of the Internet, both in terms of technology and coordination.

4.12 Integration of concerns

In computer science, separation of concerns lacks a good opposite, nemesis or antagonist (separation of concerns is almost always portrayed as the way to go, the protagonist or right way). Therefore, I use the concept integration of concerns to describe the opposite of separation of concerns. “Integration” is chosen since the term is used in business and marketing in contexts such as “supply-chain integration”, “service integration” and “vertical integration” among many. Section 9.1 further elaborates on this topic.

Integration of concerns is when one module does everything, rather than being optimized for one particular task or function. For example, in a directly inverted fashion to the norm, Google uses one repository for all code (Potvin & Levenberg, 2016, both authors are Google employees). Potvin and Levenberg (2016) motivates the decision with arguments such as that it is easier to control the code-base if it is in one place and that since automation and auto-generation of code writes more code than people, maintenance is easier centralized (here integration of concerns applied to the versioning and testing of code, not the code itself).

In organizational theory integration of concerns is related to vertical integration and coordination models such as the simple structure in Mintzberg (1993). Referring back to the graphs, integration of concerns draws on features of the centralized mode, i.e. Figure 3.7a. Integration of concerns is the opposite of separation of concerns, and focus is on integrating, growing and keeping functionality, and is the opposite of the design principle of the Internet (as argued in this thesis).

In a digital technology perspective, integration of concerns represents functionality bundled together. For example, Bluetooth and the profiles for hands-free (HFP and HSP) and media (A2DP) each bundle the sound codecs. Therefore, the higher level module (HFP, HSP and A2DP) depend on lower level modules (the codecs which are part of the profiles). As a result, phone-calls
and music over Bluetooth have different quality. A separation of concerns approach would have allowed for the same selection of codecs to be used for both hands-free and media, i.e. no dependencies between implementations of codecs and implementations of profiles.

Going further into digital communications, another example of integration of concerns is bundling data communications (such as Internet access / service) with a streaming service, as is the case for most cable-TV services. To clarify, it not common to be able to watch Netflix over a normal cable-TV-subscription (although Xfinity, Comcast’s cable brand, is doing exactly that, but only for Netflix, not for other streaming services or data services). In business, integration of concerns is related to concepts such as supplier convergence and specifically triple play in the case of data services.

### 4.13 Organizational software design

The purpose of this section is to merge the world of management and computer science into a comprehensible unit in terms of analysis. Organizational design and software design share several traits. As a basis for this section, I use Mintzberg (1993) (first edition written in the seventies) and Gamma et al. (1996), two texts which today are more than forty and twenty years old, both innovative in their time, and are not considered refuted as concepts but merely attacked at detail level. Gamma et al. (1996) is a software design book aimed at practitioners and students, and draws on the practical implication on many of the thoughts in Dijkstra (1982) (implicitly).

In general, modern software design principles are centered around changing requirements, or a changing context. As such, they share attributes with the adhocracy concept of Mintzberg (1993) where rigorous planning often is not worth it. I.e. the overhead investment into planning is not worth it since the problems are not similar enough, there are not enough repeating patterns.

Here I refer to a couple of well known propositions in software design, and explain how they resemble organizational concepts, both in practice and in theory. The reader should be aware that there are no explicit theoretical connections, and that I rather point out similarities between two schools, software design and organizational design, and provide examples of what an organization following software design principles would look like (although I should point at that I am not propositioning a general theory, rather a synthesis of what organizing might look like to an engineer and what tools he would use. Any real general theory would surely be too unwieldy to have any real value, especially printed on paper). Practically, Amazon’s services and teams internally (although not the fulfillment centers (the warehouses)) are organized in a software design fashion (see Atchison, 2016, which draws from Amazon), to the like of some and hate of others (see Kantor & Streitfeld, 2015, for rich empirics). As such, it is prudent to assume that software design
principles do not lead to well-balanced organizations, as the case presented in Kantor and Streitfeld (2015) which is used in Westelius and Westelius (2018) as the prime example of an unbalanced organization in a MARC context.

The software design principles here are the ones most toed during my Computer Science and Engineering degree, as well as the ones I have found most useful when I have built systems in changing environments both professionally and in my spare time. Proposition 1, Proposition 2 and Proposition 3 are high level, or meta concepts, while the SOLID concepts (Propositions 4 to 8) are implementation and in a sense more domain specific and can be seen as the consequences of the high level concepts. The SOLID principles all originate from Martin et al. (2003), although the acronym (SOLID) is not used in that text. This section does not suggest that this is the “best way” to organize, the purpose is rather to show and illustrate what organizing following software design principles in a changing environment would look like. And some, like Proposition 6 are obvious in an organizational context since people are able to replace each other to some minimal extent, and as such, some principles rather concern matters which are explicit in a software design sense but can be implicit in an organization design sense. As an example, people do not need to be designed with the explicit ability to speak, most people can already do that, while software components would have to be explicitly designed with speaking in mind (see Proposition 2 for the general “all which is required has to be specified” argument).

These principles are accompanied by three examples each; one software engineering example (the world they belong in), one product example (often a car or another vehicle), and one organization design example (which sometimes seems like a good design, and sometimes as a horrible one). The product example is used as a middle ground between the software design and organization design examples since the software examples are sometimes contrived and domain specific. Since cars are modular by design, that is they contain well known distinct components such as steering wheels, winter tires, summer tires, seats and engines, they are a surprisingly good analogy for software and its modules and components.

**Proposition 1 (Mantra) Low coupling, high cohesion**

Proposition 1 is an overarching and central mantra in software design. Its essence is that one module or class should not be dependent on numerous different modules or classes (i.e. low coupling), and that one module or class should focus on doing one thing, and doing that thing well (i.e. high cohesion). Separation of concerns says almost exactly the same thing: separate concerns

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8This is one of those everyone knows, yet no-one can give the first source so credit can be duly given. A googling on “low cohesion high coupling” gives PDFs from presentations of many universities with serious computer science degrees and I was bombarded with it during my engineering degree.
4.13. Organizational software design

so that each unit is focused on one thing and not dependent on the whole world for doing that thing. It also implied that one module should not break if another unrelated module changes.

The mantra itself is applicable at many levels, such as classes, modules, components, or even composition techniques (i.e. that the methods and processes for designing systems based on modules or other systems should in itself adhere to the mantra).

As a car example, the car should be designed in such a way that changing from winter tires to summer tires should not force a change in another part of the car, such as seats or steering wheel. However, changing tires can require a change of wheel-bolts without breaking the design principle.

In the organizational context it could be read as that an organization (or part of an organization) should be designed to do one thing, and one thing only, but do it well. As such, units should be self-sufficient in that they only rely on (the implementations of) a few support units or staff. This ties into functional organizations and how they can be designed. Specifically Mintzberg (1993) and SO is an explicit example of output specific sub-units, although the mantra also implies that the outputs should be as “natural” (i.e. not unnecessarily complicated) as possible. However, in organizational studies the functional organization is not the only nor a well-loved way to go, but Proposition 1 resembles it.

Proposition 2 (Gamma et al., 1996) Program to an interface, not an implementation

Proposition 2 describes that heed shall not be taken to actual internal implementation but rather to what should go in and out of a certain module or unit9, which in organizational terms is the same as coordinating on SO, i.e. focus on inputs and outputs between processes rather than internal processes. Mintzberg (1993) connects this (primary) form of coordination with conglomerates rather than for example single purpose or product organizations, due to outputs being one of the few artifacts possible to standardize in a diversified conglomerate.

This principle applied to cars might, as an example, mean that the wheel hub should be designed in such a way it works for the concept of wheels in general; rather than for example only winter tires or only summer tires, or only Goodyear tires. The design should also specify what is required of the wheel to work with the wheel hub.

An organization design example might be an assembly plant which is designed not to be process dependent on components from one particular supplier, and therefore only buys components of a particular standard which

9An interface is a description or contract for how a module or class should behave, and is (typically) separate from the implementation (of the class or module). An Application Programming Interface (API) a one particular type of interface.
it knows will fit in its internal process (and seller and buyer might be two organization internal units). And the supplier should be able to change its internal processes without making the buyer re-organize. Proposition 2 also bears traits of the notion that that which is required by the product (or the service) should be specified, i.e. if a car manufacturer requires engines to use gasoline and not diesel, that requirement should be explicit to the engine-supplier rather than implicit, or if a sub-unit is supposed to generate a positive bottom-line, that should be explicit as well.

**Proposition 3 (Gamma et al., 1996) Composition over inheritance**

Proposition 3 describes, roughly, that it is better to have a relationship (i.e. know someone who can solve the problem) with an entity than to be that entity yourself (or rather adding the needed functionality intrinsically), since large concentrations of functionality breaks “low coupling high cohesion” (Proposition 1) and the separation of concerns strategy. The opposite, inheritance over composition, would be integration of concerns.

Note, that in a software context, inheriting or composing functionality is similarly complex, and gives similar results right now. And the principle states that over time it is more suitable in most cases to compose rather than inherit functionality since inheritance clumps functionality together (even if it might allow quick-fixes in large and complex software systems).

This design principle in a vehicle context implies, for example, that the wheels should be separate from the wheel hubs. Or that the wheel hubs be separate from the engine. That is, do not put functionality in something which already has a (separate) function.

In organizational literature, Coase (1937) brings up a comparable example; outsource or in-house. Software design is adamant on outsourcing (composition) over in-housing (inheritance) except in specific cases, which in a business context is comparable to optimizing the whole rather than each individual business entity (the purpose of market regulation, value creation and value capture). This design principle also entails that composed (outsourced) tasks (objects) can be discarded and replaced at a lower cost than rehiring staff (redesigning the module).

This design principle is not clear cut, but rather suggests that in cases where it is possible both to increase the tasks or output of an organizational unit and contracting in that functionality from another unit (in the same or another organization), it is from a software design perspective preferable to contract it. Coase (1937) argues similarly, design it so profit (or something else) is optimized rather than following a principle blindly.

In the typology of Mintzberg (1980), only the adhocracy has a “keep units small” design characteristic.

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10 Technically, composition is to contain a reference to another instance, while inheritance is extending the representation.
Proposition 4 (SOLID) Single Responsibility Principle

Proposition 4 originated in Parnas (1972) and was popularized in Martin et al. (2003). It is a problematic principle to take meaningfully out of a software context, since it is quite domain specific to the art of building software, and is kept here to show that not all concepts are reasonably translatable and to avoid cherry-picking since I use other parts of the SOLID-principles in more meaningful ways. In software design it means that a class or module should have one reason, and one reason only, to change. That is change due to external circumstances, in software design for reasons such as changing specification. This is the reason software often is designed with a back-end and a front-end, since the front-end can change due to usability reasons and the back-end due to performance reasons (remember that software design assumes that everything will change over time). It can be seen as a tougher version of Proposition 1 and stems from that more general principle.

Vehicles in general are designed along this principle, although it is impossible to follow fully. For example, cars are designed so that when the season changes, only tires have to be changed, and not windows or car seats. Or when refueled, only the fuel-lid has to be opened, and not seats or engine removed. Minimize that which has to change when a (expected) change occurs.

An organizational version would be that organizations should be designed in such a way that no sub-unit ever has more than one reason to change. I would argue such an organization is impossible, since there are two obvious examples for reasons to change the design of units in all firms; the bottom-line, and a changing legal environment. I.e. it would be necessary to have units not affected by the law and other units not affected by the bottom-line to adhere to this design principle. Thus, it is not a feasible organizational design principle. As such, in an organizing perspective a more meaningful principle would be; design an organization so that any foreseeable external change forces change within as few units as possible.

A practical example and consequence related to Mintzberg (1980); design a technostructure for each standard in use so that any external change to standards only forces one technostructure group or unit directly to change. Even though the operating core has to change their behavior as well, their coordination does not change since their coordination is to follow standards (in a machine bureaucracy where much of the power is in the technostructure). As such, the operating core does not need to be explicitly aware that external standards change (low coupling), but rather (passively) accept the altered internal standardization when it comes through the normal coordination mechanism.

Proposition 5 (SOLID) Open Closed Principle

Proposition 5 says that objects and classes should be open for extension but closed for modification. In essence that means it is allowed to add func-
4. Coordination frame of reference

tionality to products or services, but not change or remove already existing functionality. The reason for this is that the one producing the product might not know where it ends up and the original function should not (intentionally) be broken.

As a vehicle example, it should be possible to extend the car by design, such as adding a child seat, putting up sunscreens or adding a larger silencer without breaking the car. But functionality should not be removed; such as the steering wheel, the engine or gas tank.

In an organizing context this principle can be understood as that an organization should be designed in such a way that a manager can add to his unit but is not allowed to change or remove already existing processes and other givens, such as reporting to HQ, following a certain standard or the location of his factory. I have not encountered a similar design principle in literature, perhaps since similar principles are implicit in organizing contexts.

A precise but technical example is the DNS protocol, a protocol which is detailed in its specification but also extensible. For example, when visiting a website the “A”-record, the (IPv4) address record, is requested of that name and then the page for that IP. For example, when browsing for dn.se, the “A”-record of dn.se is requested, but another record type could be requested, for example the “MX”-record of dn.se (which would return the IP of their mailserver) or the “BEEF”-record (which is not in common use nor specified, and the reply is to the effect of “record does not exist, authoritative answers can be found from [another server]”11). I as a user can extend the DNS protocol without explicit permission from the creators of the DNS protocol by design (and if I wanted to share my new extension I could do that through the IETF Request for Comments (RFC) process).

Proposition 6 (SOLID) Liskov Substitution Principle

Proposition 6 states that if a module works with type T, then that module should also work with any subtype S of T as well. This principle builds on Proposition 5 in that if you have built a product, then if someone extends that product (for example my “BEEF”-record in the example above) it should still be usable in all scenarios where the unmodified original product could be used.

In a vehicle context, this design principle implies that wheel hubs should be designed in such a way that they work with all wheels. Or that the vehicle can be refueled at all gas stations. For example, Tesla broke this design principle by having their own charging standard, although later backtracked to support the common standards12 (i.e. the CCS-line of standards).

11In practice, many libraries, such as BIND, prevent users from trying to look up “invalid” record types, such as “BEEF”. Therefore, BIND breaks Proposition 5 as the user cannot query or add custom records easily. See http://www.iana.org/assignments/dns-parameters/dns-parameters.xhtml for common record types

12Older models with adapters and refitting (expensive-ish), newer models support CCS.

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In an organizing sense, this principle means, as an example, that all sales teams (the subtypes) should be able to follow the sales-process (the module). In a general sense, people, teams and other groups in organizations should be able to do the roles they are assigned, and even be switched around (within their sets of tasks). Typically, this is assumed rather than designed for in organizations.

The substitution principle is in this sense a form of standardization, and using terminology in Mintzberg (1993) standardized in three dimensions; SS, SWP and SO, so that all entities within a group (or grouping for a task) can replace each other in all aspects that matter for doing that specific task or set of tasks.

This principle is directly contradictory to the MARC model’s suggestion of balance, since Proposition 6 suggest conformity (a hard value) rather than leaving space for flexibility (a softer value), and even disregards being seen and accepted (two core tenets of Care in MARC) and holds that only the formal fit to the task at hand matters.

Proposition 7 (SOLID) Interface Segregation Principle

Proposition 7 implies that it is better to have many smaller externally available specifications (i.e. interfaces) rather than one big specification. In practice this application of separation of concerns on design of interfaces (or standards and specification). The reason is that users, clients or modules should not have to know more than necessary to use an interface such as an API. The common example is an ATM which should have separate APIs for withdrawals, deposits and maintenance. This since a client interested in a withdrawal should not have to learn about deposits.

In the vehicle case, an example is to design so that one module should a set of partial specification per use-case, rather than a comprehensive specification for all use. For example, an engine might have one fuel specification, one performance specification, one axis specification and so forth, rather than bundling the complete specifications into one specification document. Also, vehicles should be designed so that passengers, drivers and mechanics naturally have access to relevant parts (without, for example, forcing the passenger to understand the mechanics interface to sit in the car).

This principle translated to an organization context, means that it is considered beneficial by design for an organization to have multiple procurement and sales functions rather than having a central function, or designing contractual relations with other organizations in such a way that there are many smaller contracts rather than one bigger contract. In essence Proposition 7 concerns specialization, but geared towards external contact and visibility rather than internal implementation (i.e. core business in an organizational context). A note though, in software terms the specification or interface is
4. Coordination frame of reference

usually not part of the implementation per se, but a procurement or sales function certainly would be part of the implementation of an organization.

Another way to translate interfaces to an organization context implies standardization. Where SO is the natural comparison, and Mintzberg (1993) concerns standardization in relation to other forms of coordination. And suggests that standardization is common together with bureaucratic functional groupings. This resembles the formulation of Proposition 7, that is to standardize and specify around a use-case or organizational function.

Many international standards, such as ISO-216 (paper sizes), the international system of units, ISBN, barcodes, driving signals, musical notation and braille, are specific and only concern one area. Thus, they rather follow separation of concerns than integration of concerns.

The reason behind Proposition 7 in a software context is one of maintenance; it is easier to maintain separate smaller interfaces than larger ones, for example in testing and versioning, and clients and users avoid having to learn and understand interfaces they will not use.

**Proposition 8 (SOLID) Dependency Inversion Principle**

Proposition 8 is a principle with two important parts. The first is in essence the same as Proposition 2, depend on standards, specifications or definitions rather than the implementation. It reads:

High level modules should not depend on low level modules. Both should depend upon abstractions.

The first part can in a vehicle context be understood as that the cars should be designed so the steering wheel is not dependent on the type of engine, such as gas or electric, and the engine should not depend on either summer or winter tires nor the design of the steering wheel.

A direct comparison to organizing, using terms in Mintzberg (1980), is that the strategic apex should not depend on the actual operating core; both should depend on descriptions. Practically, it means that the strategic apex should not concern itself with how the operating core does things, rather what they do in the sense of fulfilling the agreed on strategy. The coupling should be kept low (Proposition 1).

The second part reads:

Abstractions should not depend upon details. Details should depend upon abstractions.

Returning to the car example, it means that the controls of the car (the abstractions), such as steering wheel and pedals, should define what the car does (drives around with the help of engine and wheels) and control it without knowing or specifying its internals. This means that the car might change
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engine from a combustion engine to an electrical engine while the controls stay the same and do the same. I.e. breaking the principle implies that the controls produce a different result, such as turning the wheel left turns the car right or increases the gas.

An organizational way to interpret the second part is that the organization should depend on its contracts with external entities, rather than the contracts with other entities depend on its organization. The contracts need to be designed in such a way that the organization should be able to change its internal implementation while keeping the external contracts valid.

In the organizing sense, these two parts together say that organizations should be designed in such a way that interdependencies, such as relying on how another unit does their job, should be kept to a minimum. And when interdependencies are needed, they should be between representations or ideas rather than actual execution. As an example, the strategic apex can rely on that a unit builds engines, but should not depend on that certain people are employed there (or another aspect not formally specified).

These principles are a short comparison of software design principles and organizational design principles, and the primary purpose of these principles in this thesis is to evaluate the Internet in light of these principles, specifically in Section 8.7 where I go through the coordination and the technology aspects of the Internet (and net neutrality) and compare with these design principles. In short, it could be that the technical Internet is designed in accordance to the software design principles (as proposed in Table 4.5) and the coordination of central Internet issues (such as unique identifiers) in accordance to software design principles transferred into an organizational context (as in Table 4.4).

In essence, I assume a normative isomorphism (i.e. managers go to similar schools and therefore organize similarly) of DiMaggio and Powell (1983) but with engineering as the normative force (i.e. engineers go to similar schools and design technical systems and the coordination of those systems similarly).

According to the sense of the MARC model, these principles lies further in the hard-values side of rationality and authority, and can therefore be assumed to create an imbalanced organization if followed. That is, not an optimal organization in the MARC sense. And it is not surprising that software design principles are hard rather than soft, since the principles are built to handle code, and not people. But it should be possible to build an organization (or ecology?) based on engineering design principles (i.e. optimizing on effect of change on the system itself) and balance it with the help of MARC (see suggestion in Table 4.4).

Further on this thesis argues that the Internet and its coordination and technology fit well with engineering design principles.
### Design principles

<table>
<thead>
<tr>
<th>Principle</th>
<th>Organizational Internet Design Consequence</th>
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<tbody>
<tr>
<td>(1) Law of Demeter</td>
<td>The organizational Internet should be designed so that units can function independently and take only minimal knowledge of other units.</td>
</tr>
<tr>
<td>(2) Interface Segregation</td>
<td>The organizational Internet should be designed so that units can function independently and rely on as few other units for operation.</td>
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<tr>
<td>(3) Liskov Substitution</td>
<td>The organizational Internet should be designed so that monolithic structures are minimized and functionally distributed.</td>
</tr>
<tr>
<td>(4) Single Responsibility</td>
<td>The organizational Internet should be designed so that new units can be created and integrated without affecting the existing structure.</td>
</tr>
<tr>
<td>(5) Open/Closed</td>
<td>The organizational Internet should be designed so that units can be extended both internally and externally with minimal disruption.</td>
</tr>
<tr>
<td>(6) Dependency Inversion</td>
<td>The organizational Internet should be designed so that the constituents, such as the strategic apex and the operating core, can have interdependencies without relying on each others implementations.</td>
</tr>
</tbody>
</table>

Table 4.4: An interpretation of software design principles in the organizational context with the help of Gamma, Helm, Johnson, and Vlissides (1996).
Table 4.5: An interpretation of software design principles (in particular Gamma, Helm, Johnson, & Vlissides, 1996; Martin, Rabaey, Chandrakasan, & Nikolic, 2003) in the sense of a technical Internet.

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<thead>
<tr>
<th>Design principle</th>
<th>Technical Internet design consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Low coupling, high cohesion” (1)</td>
<td>The Internet should be designed so that protocols solve one task well, and not rely extensively on other protocols for that function.</td>
</tr>
<tr>
<td>Program to an ‘interface’, not an ‘implementation’ (2)</td>
<td>The Internet should be designed so that protocols do not depend on the internal implementations of other protocols but rather rely on what they (are supposed to) do.</td>
</tr>
<tr>
<td>Composition over inheritance (3)</td>
<td>The Internet should be designed so new protocols should be created rather than extending the functionality of protocols beyond their original intention.</td>
</tr>
<tr>
<td>Single responsibility principle (4)</td>
<td>The Internet should be designed so that only one protocol, if possible, has to change if external circumstances change.</td>
</tr>
<tr>
<td>Open closed principle (5)</td>
<td>The Internet should be designed so that protocols are naturally extensible if possible.</td>
</tr>
<tr>
<td>Liskov substitution principle (6)</td>
<td>The Internet should be designed so that protocols with similar function can replace each other.</td>
</tr>
<tr>
<td>Interface segregation principle (7)</td>
<td>The Internet should be designed so that protocols are specified by around cohesive functionality and avoid extra functionality when not necessary.</td>
</tr>
<tr>
<td>Dependency inversion principle (8)</td>
<td>The Internet should be designed so that layers do not depend on the implementations of other layers.</td>
</tr>
</tbody>
</table>
4. Coordination frame of reference

4.14 The missing links

Close to the end of this chapter I believe it is suitable with a reflection on the literature which is missing to build a stronger case for this frame of reference.

As this thesis concerns the case of alignment of technology and coordination, empirically with the Internet and theoretically with digitization, literature concerning organizations undergoing technological change with the velocities mentioned in Section 3.11 would have been helpful.

I have looked into using software development and organization literature to use a proxy for digitized organizations. However, there are few published texts with empirical data. A typical example is Virmani (2015) which briefly discusses coordination and managing continuous delivery (of software), but without empirical data. Another example is Vassallo et al. (2017) which looks as software builds as seen from the build server but does not go deeper into organizing or coordination. Schermann, Cito, Leitner, and Gall (2016) argues for a topology of organizations in how they treat quality assurance for releases, and mention the artifact of software development, code, but do not discuss how the code is created, built or designed. On a more personal note, I have supervised a Master’s Thesis which had a look at aligning general organization coordination and MCS with agile software project methods, and found significant dichotomies, specifically the clash between agile teams and a quite strict top-down management in the case company (the thesis was never published and is as such not available, although it was successfully defended). One explanation for the lack of literature on the subject is present in Mäki-Runsas, Wistrand, and Karlsson (2019), which states that most such endeavors fail, i.e. software development organizations in general fail to adapt in line with technological change and therefore (my extrapolation) literature on aligning technology and coordination (or organization) may not exist.

See also argumentation in Schwartz et al. (2019) that artificial intelligence (AI) development in particular and technological development in general is done by firms rather than universities (or similar not-for-profit) organizations.

This is in line with my own experience as a software developer, and that of others, see for example Zaar (2017, an implementation story) and the example of containerization and servitization of large scale software systems, and Rufino, Alam, Ferreira, Rehman, and Tsang (2017) and Burns and Google (2016) on the same topic. I do not recognize how I used to work with software development in texts on coordination and organizing, specifically on topics of agency. In the settings I have worked professionally with software design and engineering, education levels vary between a Master’s and a PhD in computer science.

13I use digitized organization as an organization which naturally uses IT, and is not only using IT as a standardizer.
14An often centralized function which builds all committed code to ensure function, through, among other, different kinds of automated testing procedures.
15I.e. splitting up a larger system into multiple smaller services, not the service vs product concept in marketing.
4.14. The missing links

Science or engineering or computational mathematics, while software development in literature seems to be described as something anyone can do given the right coordination. But practically, in my experience, only background and training (standardization of skills (SS) in Mintzberg terms) and tools (SWP in some sense) matters in day-to-day problem solving and development in my experience. Management and customers dictate general direction, but provide almost no day-to-day coordination. As such, management literature will miss the complexities of technology, as I argue that Bailey et al. (2010) does, and meaning of training and prior knowledge, as I argue that Bailey et al. (2010) also does, to how software is actually developed and modified (cf. Bailey, Leonardi, & Barley, 2012, which studies representations of “the virtual” but does not problematize the construction or changes in / of the virtual, in essence constructing an IT-artifact out of virtual work. As an example, modern software development tools such as build servers, containerization, code generation, algorithmic governance etc are not problematized).

Jensen and West (2019, a Microsoft Security Response Center bulletin) is a good and recent example of technology and management disconnect, which is a refutation to the then circulating belief that Microsoft has security issues with RDP and Teams\(^\text{16}\) which allow the Dopplepaymer ransomware to spread. Microsoft’s response, however, is quite harsh:

> In our investigations we found that the malware relies on remote human operators using existing Domain Admin credentials to spread across an enterprise network. (Jensen & West, 2019)

This is the political version of Microsoft calling their customers stupid, i.e. PEBCAK\(^\text{17}\). Or, rephrased in my words:

> The Dopplepaymer malware is spread by domain admins, presumably due to ignorance, and is to no fault of Microsoft at all, since we cannot protect you against your own ignorance.

This quote can serve as an introduction to the two perspectives I introduce later in this thesis, the integrative perspective where it is possible to buy a service with service level agreements (such as ignorance protection, or a service which does not require domain relevant knowledge), and the distributed perspective without integrated service level constructs.

My train of thought is that literature on software development (i.e. very digitized organizations) might be generalized to digitized organizations (i.e. where digital and non-digital solutions are used more or less interchangeably)

\(^{16}\)Remote Desktop Protocol (specifically BlueKeep) and Microsoft Teams, two Microsoft products.

\(^{17}\)Acronym for “problem exists between chair and keyboard”, derogatory but quite common term in security circles (which, quite frankly, is a harsh social circle or thought collective).
which in turn might provide reasonable methodological starting points for an endeavor into Internet Coordination. And my previous examples here to serve as indicators that there are many ongoing discussions but few conclusions on how digitized organizations or ecologies work (perhaps due to rapid change so stabilization cannot occur? Cf. only paradigm shifts in Kuhn, 1962, and no time for normal science to properly conserve ideologies and methods), and it is quite natural that such events are hard to capture.

As such, I might with a bit of hubris say that, the Internet as presented in this thesis might be one of the first cases where alignment of coordination and technology is successfully captured and shown in a larger setting. Even if my “more-empirics-than-theory” approach requires a quite verbose story-telling since I cannot make assumptions on the perspectives of presumptive readers and therefore be explicit with passages I could have left out if written to (in?) a single cohesive thought collective with its assumptions, idealizations, abstractions and generalizations.

4.15 Framing

I see the world as consisting of both social and material constructions, in essence taking Orlikowski and Iacono (2001) one step further in saying that for the Internet to make sense, it is necessary to both understand coordination and technology. And both technology and coordination can be organized in different ways.

![Figure 4.2: Overview of core Internet functions](image)

Figure 4.2: Overview of core Internet functions

I also look at the Internet as not only an organization, but rather as an ecology. The reason is that organizations at some conceptual level are assumed to be going in the same direction, whether be it the development of the Linux-kernel, or enrichment of the shareholders, whilst ecologies rather are used to model the arena where organizational life plays out, regardless of assumption of commonality of direction. In addition, markets are not only driven by financial rationality, but a mixed pot of values where different actors have
different goals (financial gain, happiness, power, etc) and roles (regulator, supplier, influencer, etc). Also important, is the notion of digitization and agency, since not only people are organized but also digital entities doing tasks, whether it is naming, routing or evaluation business contracts (see LawGeex, 2018).

I again refer to Figure 4.2 (same base figure as Figure 1.2 and Figure 3.7) for understanding both coordination and technology.

![Figure 4.3: Research approach](image)

Make note that Figure 4.2 does not take into consideration the direction of coordination or power, this means that in practice there are setups different from these but I argue that at a fundamental level there are three base architectures, centralization (Figure 4.2a), decentralization/hierarchical (Figure 4.2b) and distributed/adhocraphic (Figure 4.2c). An example of power going different ways can be found in an electoral system, a hierarchical system where power goes upwards (i.e. Figure 4.2b with upwards direction) where voters vote for representatives, which in turn vote on the next level. The US presidential election system is designed this way. The opposite, where power originates at the top, coordination goes “down”, could be an organization where the top-level is delegating or decentralizing power, or a technical stan-
4. Coordination frame of reference

dard such as DNS where a root or top node is sitting on power which it in effect delegates to other nodes.

Figure 4.3 is a reminder of the approach taken, that we are now armed with a broad understanding of coordination, technology and Internet Standards, and can start looking for the actors (organizations?) which together decide what the (technical) Internet is and its coordination (Chapter 5). Once we have figured out what constitutes the Internet, we can reason and figure out how the Internet can be changed or disrupted (Chapter 6). This leads to consequences on actual use of the Internet both for actors identified in Chapter 5 and society as a whole, illustrated with net neutrality (Chapter 7 and Section 7.13). Then, I tie the Internet case together (Chapter 8) and look for trends which can be generalized to other settings (Chapter 9).
5 Internet coordination

The Internet is not governed, it is coordinated
— Interviewee

Notes

An earlier draft of this chapter was presented at ITS 2017 in Passau, available in proceedings as follows:


In particular the text has been extended and ties closer to existing literature. The presented paper, Lindeberg (2017b), focused on the empirical setting for Internet Coordination.

As a former conference paper, this chapter retains the structure of a paper and is self-contained in content.
5. Internet coordination

Abstract

There is no consensus on either what the Internet is or how it is coordinated. This paper suggests a perspective on the Internet which demarcates it from related concepts such as “the web” or “telecommunications”. This perspective suggests that the Internet has two important dimensions; a coordination and technical dimension.

Through the use of interviews, academic literature, standards documents, news articles and policy documents, this text illustrates through an ecology lens how central Internet functions are coordinated and the consequences that has on how the Internet can be considered governed and how policy can affect it. The core of the necessary minimum coordination required for the Internet concerns coordination of unique identifiers, but not issues such as cybersecurity or intellectual property rights, as are sometimes included in the Internet Governance concept.

In addition to a perspective on the Internet, this text suggests that the Internet has no governor in the traditional sense, but is de facto bottom-up coordinated through several important processes and actors, including but not limited to the IETF standards track and ICANN multi-stakeholderism.

The text also highlights issues in the current system where many issues are centered on the ISP and its role in the Internet ecology.

5.1 Introduction

The role of the Internet has never been as contested as it is now. In the US net neutrality was abolished, the European Union (EU) has passed directives enforcing copyright policing at the lowest levels on Internet Service Providers (ISP) to prevent the Internet to be used for copyright infringements and Internet Corporation for Assigned Names and Number (ICANN) is finalizing its formalized multi-stakeholderism transformation. In addition, there are political debates and news articles (The Economist, 2014, 2016a) portraying the Internet as being governed by ICANN and literature implicitly assuming ICANN is in control (Weber, 2009) or explicitly being worried about their power (Mueller, Mathiason, & Klein, 2007). Other literature, such as DeNardis and Raymond (2013) and Liu (1999), have a more nuanced view to the Internet and its governance but include related concepts such as cybersecurity and intellectual property rights in the Internet Governance concept. Today, there is a tendency for governments and international agencies to impose more control mechanisms on both Internet infrastructure and content, aimed at protecting individual rights and copyrights (see EU copyright directives, in particular Articles 13 and 15). These initiatives, such as net neutrality and EU copyright policies, have one thing in common, their reliance on the same model of how the Internet works: that it can and should be controlled from a governmental level to support public and commercial
5.1. Introduction

interests. This assumption is useful in the context that it validates policy
as an instrument for controlling the Internet and that it is even possible to
control the Internet. However, there are in reality many more actors whose
actions have consequences, as implicitly seen in Zittrain (2008) and argued in
van Eeten and Mueller (2012).

In particular, I find limited research investigating the effects that uninten-
tended and unplanned day-to-day operations of Internet-actors, such as ISPs
fighting botnets (as noted in van Eeten & Mueller, 2012), dealing with users
wanting to set up mailservers, country code top-level domains (ccTLD) man-
aging domains or Internet Exchange Points (IXP) peering traffic, have on
the governance of the Internet. Thus, there is a need of understanding how
these informal governance actions interact with those of more formal Internet
governors, such as ICANN and the Internet Governance Forum (IGF). And
possibly even more importantly, there is a need for a working perspective of
the Internet in light of these recent policy changes.

My research aims to map the practical governance roles, formal and in-
formal, of a number of central Internet organization, and to use an ecology
perspective to further the understanding of how each actor affects the Inter-
net.

To do this, I use an ecology lens to explain the coordination mechanism
in place on the Internet today. Governance is traditionally understood in
the sense of a defined governor top-down controlling or governing a set of
activities or actors. However, governance can also be understood as the sum
of processes and interactions of actors that collectively produce governance.
This is the primary reason why I use coordination rather than governance as
a concept to avoid confusion with the top-down perspective. The purpose of
this paper is to show how the Internet can be understood in a coordination
perspective.

I conceptualize coordination on two levels in an ecosystem, a perspective
derived from management control and organization design literature such as
Mintzberg (1993) and Olve et al. (2013). The two levels are actors and actions.
Actors of the ecosystem, such as people, organizations and civil society form
the first level. Second are the actions of specific actors that affect the Internet,
such as voicing opinion or collaborating between actors to create standards.

The primary contributions from this paper are two-fold: first, practitioners
can use the ecology model for better understanding governance actions of their
operations, and second, the academic contribution will be a more nuanced
view of Internet Coordination by using ecologies as a metaphor for the complex
network of actors and infrastructure that is the Internet, a nuanced view that
gives room to the practicalities of a reality with multiple actors with different
interests.

The rest of the paper is organized as follows. First, I go through the
method used and how it relates to my research interests. After that, I present
some key concepts and definitions. Then comes my semi-exhaustive overview
5. **Internet coordination**

of Internet institutions and actors, followed by how they coordinate and ending with my view of how the Internet is governed in practice and the answers to my guiding research questions:

1. What is the Internet?

2. Who, together or alone, can be considered to coordinate the Internet?

In this text, I am capitalizing the Internet when referring to the concept of the Internet, as it the norm according to organizations such as the Internet Engineering Task Force (IETF) and ICANN.

### 5.2 Method

Web of Science, Linköping University Library and Google Scholar was used to find relevant literature on the Internet and Internet Coordination. Specifically I started with the search phrases “Internet Governance” and “Internet Coordination”, went through both referencing and referenced works. It was clear that there was no consensus on either what the Internet is nor what Internet Governance or Internet Coordination is.

I have not found literature on certain topics. That means I have not found the literature, it does not mean it does not exist. I have through colleagues at other universities been given access to articles I could find on Google-scholar, i.e. know of their existence, but not available in full-text at Linköping University Library. This should count as an indicator that there is academic literature I have not read nor know the existence of.

Also problematic is that there are no journals focused on all aspects of Internet Coordination or Internet Governance. Internet Governance as a term exists in the fields of law, policy and economics where the governance part of Internet Governance implies only top-down control (such as regulation) is interesting. The fields of management and information systems touch on the Internet, but from the perspective of organizations external to the Internet themselves using the Internet.

There are several conferences where Internet Coordination is touched from a policy perspective, including but not limited to GIG-ARTS, GIGANET and ITS conferences.

This text refers routinely to Requests for Comments (RFCs), which are reviewed and published documents in the IETF RFC track. This track is roughly comparable to a conference or a journal where submissions subject to review and can be accepted for presentation/publication. There is no reason to consider an RFC concerning an Internet issue any less rigorous than a comparable academic publication on the same subject (see RFC-2026, Bradner, 1996, for a publication process overview).

Another issue I have had with academic literature is that there is a multitude of texts which concern Internet Governance, in any sense of the definition,
5.2. Method

but which does not consider itself to be Internet Governance literature, just as van Eeten and Mueller (2012) points out, which increases the possibility of missing important texts. One such text is Zittrain (2008), which is implicit in its use of governance, control and coordination.

The literature overview led towards a rough understanding that governments and ICANN were central to Internet Governance, which is my engineering background disagreed with, since I had in my more than ten years of writing software reliant on the Internet for communication never ever taken policy perspectives into consideration when designing software. Therefore, I sought out interviewees with potential knowledge to challenge both the literature and my own understanding of the Internet’s coordination.

The interviewees were selected through a semi-snowballing approach, drawing on snowballing as described in Goodman (1961), but with the intention to span different mindsets or thought collectives using the nomenclature of Fleck (1935). Haas (1992) and Adler and Haas (1992) discuss a similar phenomenon, epistemic communities, which are described as the groups which shape the policies decision makers later accept. Cowhey (1990) explicitly discusses epistemic communities in the telecommunications context. I thus set myself the task was to find and interview people who were part of the epistemic community setting the agenda of the Internet.

Many interview requests were denied, either explicitly or implicitly (such as by stopping to answer an email chain). My understanding is that there are two primary reasons for these denies; first, the potential interviewee was not sure he / she could go on the record on behalf of employer (even if asked to be interviewed as a person of experience rather than as an employee of an organization), and second, did not believe they could contribute or find the topic interesting enough.

The formal interviews are shown in Table 5.1. The interviews were semi-structured in that they started with questions and discussions regarding definitions and views, and then on average contained a one-hour-long discussion about the interviewees view and opinions on Internet and Internet Coordination. I noticed that I have a better understanding of the different views and perspectives after the interviews than before since I came into the interviews read up on theory but unprepared for the real world. But since the formal interviews were recorded, I have been able to listen through them again to try to avoid personal bias based of my understanding at the time of the interview.

I found it helpful to be knowledgeable in the technical side of the Internet, since many if not most parts of the discussions contained technical components, and they did not have to be simplified for arguments’ sake, nor did the discussion have to slow down or end. This, as far as I know, distinguishes the approach from other texts on Internet Governance, such as DeNardis and Raymond (2013) and van Eeten and Mueller (2012). DeNardis and Raymond (2013) in particular suggests six (6) areas or subsections of Internet Governance (shortened); (1) management of unique identifiers, (2)
Table 5.1: Formal interviews used in this paper

<table>
<thead>
<tr>
<th>Type of Organization</th>
<th>Role(s)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccTLD</td>
<td>Security officer</td>
<td>“ccTLD (1)”</td>
</tr>
<tr>
<td>ccTLD</td>
<td>Security officer and</td>
<td>“ccTLD (2)”</td>
</tr>
<tr>
<td></td>
<td>CEO</td>
<td></td>
</tr>
<tr>
<td>IXP</td>
<td>Research director</td>
<td>“IXP (1)”</td>
</tr>
<tr>
<td>IXP</td>
<td>Research director</td>
<td>“IXP (2)”</td>
</tr>
<tr>
<td>EU-parliament</td>
<td>EU-politician</td>
<td>“Legislator”</td>
</tr>
<tr>
<td>ISP</td>
<td>Research director</td>
<td>“ISP”</td>
</tr>
</tbody>
</table>

Internet standards, (3) peering, (4) cybersecurity governance, (5) information mediation (e-commerce, app-stores, etc), and (6) intellectual property rights management. My proposed definition of Internet has the consequence that Internet Coordination only concerns the first three (1-3).

Each interview was summarized and sent back to the interviewee for comments and review. I received no feedback that indicated that I had misunderstood anything of importance to this paper. In addition to the formal interviews I also draw on informal communication, such as emails, phone-calls and conversations with the interviewees.

Regarding language, I have been interviewing both in Swedish and in English. I used Swedish in the cases were Swedish was the native language both for me and the interviewee, and English in all other scenarios. I do not consider my level of English as native, but good enough to be technically correct, even though I at moments had to ensure I had understood a certain idiom or expression correctly.

I do not consider my interviews nor literature overview to be exhaustive, which I have taken into consideration in the validity of my conclusions by holding that the data I have is valid, but that it does not permit me to say anything about what is missing. Regarding my use of academic literature, as previously mentioned the term Internet Governance is not universal and as such I am quite sure I have not read or encountered all relevant literature.

I consider the research to be neither inductive nor deductive in its character, but rather that theory was used as guidance for interviews abductively (see Kovács & Spens, 2005), allowing me to build up the Internet Coordination ecology presented in this paper. The ecology in itself is a generalization of interviews, books, academic literature and other web resources, into a descriptive ecology: in the sense of Lee and Baskerville (2003), a generalization of theory and data into a description.
5.3 Organization and coordination

A particular strength of this study is that I have not assumed what the Internet is, and all formal interviews were started off with the interviewee defining what the Internet is for them and their context, which allowed for distinctions of what the Internet is to different people and in some sense their organizations. Although it should be pointed out that several of the interviewees considered themselves lobbyists of varying degrees (i.e. part of epistemic communities), which implies that they might want to portray a particular view of the Internet to suit their agenda.

5.3 Organization and coordination

The invisible hand is a concept used by Smith in An Inquiry into the Nature and Causes of the Wealth of Nations (commonly referred to as The Wealth of Nations) and other works, and is by him the concept of self-regulation for optimal efficiency and implicitly financial gain (Smith, 1776). In this text, I use the concept of the invisible hand as not centrally regulated or controlled, rather than self-regulation for economic self-interest, but still meaning that organizations and individuals can act as if guided by an invisible hand. This in contrast with the visible hand, which would be explicit laws and regulations coordinating and controlling actors. In its original meaning, the invisible hand referred to market forces (see Smith, 1776), while not all forces mentioned in this text which are not regulatory or bureaucratic in nature are market forces. This text uses invisible hand as a metaphor for means of production not orchestrated by hierarchy.

The term organization is hard to define in a digital online world, and gets even harder when involving entities whose purpose is to facilitate coordination between other entities. In this text, organization is used loosely to identify a group or collection of people with a similar goal or purpose, i.e. an actor in an ecology. This makes it meaningful to discuss ICANN or IETF as organizations even though the opinions formed at their meetings are strictly not only from people employed at ICANN or IETF (or representatives there).

In this text, I borrow the coordination concepts in Mintzberg (1980, 1993). Mintzberg considers there to be five different methods of coordination in an organization, of which three are different forms of standardization. With mutual adjustment (MA), individuals are in charge of their own work and coordinate by communicating informally. In direct supervision (DS), a supervisor controls the work of others by direct orders. Then there are three different forms of standardization: standardization of work process (SWP) when the doing of the work itself is coordinated by the imposition of standards, standardization of outputs (SO) when the output of the work is coordinated by the imposition of standards and standardization of skills (SS) where the work is coordinated and standardized by skills and knowledge. I also add a sixth coordination mechanism, appointment of person (AP), to be able to show
appointments meaningfully. Mintzberg (1993) argues that it is possible for an organization to use a combination of methods for \textit{coordination}, and that his concepts should be considered as guiding when identifying the important \textit{coordination} concepts in an organization. He also defined five organizational forms matched to the different primary \textit{coordination} mechanisms, the important in this text being the \textit{adhocracy} based on MA. In an \textit{adhocracy}, power is decentralized and de facto decisions are taken close to the problem at hand.

I will here use his concepts to describe how institutions and organizations are coordinated, which is not directly what Mintzberg (1980, 1993) intended in his intra-organizational perspective. The concepts themselves are not explicitly limited to an intra-organizational settings, and as such I consider it feasible to that similar \textit{coordination} mechanisms exist between groupings in an ecology and between groupings (units) in an organization. For example, regulation will fall under either DS or SWP depending on formulation.

In addition to Mintzberg I will also use Olve et al. (2013) and its typology of business ecology actors, as shown in Table 5.2. Olve et al. (2013) suggest using a business ecology lens for understanding an organizational context, and divide ecologies into settings comprised of several actor types from the perspective of one actor. I.e., A might be a supplier to B, but a competitor to C, who are both influenced by the standardizing entity D. Olve et al. (2013) is explicit in that the list of actors is not exhaustive but rather a suggestion of where to start to identify important forces in a business ecology. As such I expand on the roles and add “squatter” to the list of roles in Table 5.2, where squatters are those which form and influence actors in the ecology without actively doing anything explicitly (I argue that ICANN has this role, i.e. actors behave differently due to the existence of ICANN even if they per se do not act). In my understanding of ecologies, I do not limit agency only to organizations. As for example Ensmenger (2012) implies, in the modern world technology must be considered to have agency. For example, the IETF can be seen as a standardizer in Table 5.2 but as argued in this text, the standards are more important than the standardizer itself (and its composition), especially since those using the standards of the IETF do not need to be in touch with IETF at all.

These texts are written with different readers in mind; Mintzberg (1980) is a conceptual article presenting his initial ideas, Mintzberg (1993) is a book aimed at practitioners (i.e. managers) and Olve et al. (2013) is a book aimed at practitioners describing the concepts of business ecologies, business models and strategic pricing.

5.4 What is the Internet?

One problem I see today is that the \textit{Internet} in itself is very rarely defined, and in different contexts it seems to have different meanings. Also, \textit{Internet Governance} and \textit{Internet Coordination} are rarely defined, and I even got a
5.4. What is the Internet?

Table 5.2: Typology of Olve, Cöster, Iveroth, Petri, and Westelius (2013) including their suggested actors. The descriptions are translated and condensed.

<table>
<thead>
<tr>
<th>Actor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers</td>
<td>are suppliers in multiple levels.</td>
</tr>
<tr>
<td>Customers</td>
<td>are the chain of customers all the way to the end-user or consumer.</td>
</tr>
<tr>
<td>Distributors</td>
<td>and intermediaries.</td>
</tr>
<tr>
<td>Competitors</td>
<td>are already existing alternatives to the service or product being supplied.</td>
</tr>
<tr>
<td>Substitutes</td>
<td>are potential non-existing alternatives, either competitors in different markets or products or services capable of upsetting an ecology.</td>
</tr>
<tr>
<td>Financiers</td>
<td>and other type of financing who could or not have a stake in the behaviour of the actor.</td>
</tr>
<tr>
<td>Standardizers</td>
<td>are organizations who’s main product is standardization for a market or ecology.</td>
</tr>
<tr>
<td>Regulatory</td>
<td>are often governmental organizations with legislative power (such as national regulatory authorities). Dif-</td>
</tr>
<tr>
<td>organizations</td>
<td>fers fundamentally from standardizers in that they are not providing a service or product but rather enforce-</td>
</tr>
<tr>
<td></td>
<td>able legislation.</td>
</tr>
<tr>
<td>Politicians and</td>
<td>are those who could have an impact on, for example, which business models are good or not.</td>
</tr>
<tr>
<td>influencers</td>
<td>and the public often form opinions on what is considered good or passable. An example is the current #metoo campaign.</td>
</tr>
<tr>
<td>The civil society</td>
<td>and other types of concept or idea marketers usually impacts which impulses will act to form a market or ecology in the future.</td>
</tr>
<tr>
<td>Consultants</td>
<td></td>
</tr>
</tbody>
</table>
comment that it is beneficial for researchers like me that no such definition or consensus exists (from “IXP (1)”), since our jobs are dependent on there not being a consensus.

In Table 5.3, I show a selection of Internet definitions or descriptions, which are condensed down to the two primary views in Table 5.4.

Table 5.3 is based on previous literature and interviews, where I previously saw the Internet as a technical phenomenon (due to my engineering background), but the interviews suggested that coordination and/or governance also might play a part. I therefore reread literature I had read previously with the intention of concluding whether the Internet contains a coordination component or not. Table 5.3 contains quotes and descriptions from various sources and if they are explicit (i.e. explicitly mentioning a dimension), implicit (i.e. mentioning a dimension in the passing or in a description but not explicitly) or not mentioning (-) either a technical (column “T”) or a coordination (column “C”) dimension. Column “A” notes whether applications on top of protocols such as Internet Protocol (IP) and Transmission Control Protocol (TCP)/User Datagram Protocol (UDP) are considered a part of the Internet or not. True (T) refers to positive, and false (F) to negative on whether the issues are part of the Internet. As an example, ET in column “A” that the source considered applications using the Internet (such as the web) are considered part of the Internet (and therefore a matter of Internet Governance), and IF in column “C” that the source implied that coordination is not a dimension of the Internet, although not explicitly (such as saying that the Internet “is technical” rather than the Internet “has no coordination aspect”).

Worth extra notice is RFC-2026 (Bradner, 1996), which predates the others by a decade and ICANN by two years. It is a representation of the technical idea of the Internet. Also worth notice is Markus (2006), which is the framing available in the class action lawsuit against several U.S.-based ISPs for domestic spying, i.e. that which lead up to the “Snowden revelations” and the FISA Amendments Act of 2008, which freed traffic providers from liability of spying on their customers (in essence traffic providers spied on behalf of the NSA). Both of these, and “IXP (1)” and “ccTLD (2)”, have a technical understanding of most things Internet, such as routing and naming.
5.4. What is the Internet?

Table 5.3: Internet descriptions, a selection from literature, interviews and non-academic sources.

<table>
<thead>
<tr>
<th>Source</th>
<th>T</th>
<th>C</th>
<th>A</th>
<th>Quote/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>van Eeten and Mueller (2012)</td>
<td>ET</td>
<td>IT</td>
<td>IT</td>
<td>Approaches Internet Governance as a “mess” of “[p]rices and markets, traditional hierarchical firms, hierarchical state power, interpersonal and inter-organizational networks and new, scaled-up forms of peer production”. Describes the Internet as a mostly technical issue.</td>
</tr>
<tr>
<td>Mansell (2012)</td>
<td>ET</td>
<td>-</td>
<td>ET</td>
<td>Not strictly defined but discussed as a technical phenomenon, which is in need of governance since the current regime favors established strong parties. The Internet should be governed in a similar fashion as cable-TV and telephony.</td>
</tr>
<tr>
<td>Zittrain (2008)</td>
<td>ET</td>
<td>IT</td>
<td>IT</td>
<td>Sees the Internet as a technical phenomenon and is implicit in saying that there are coordination mechanism particular to the Internet which are part of shaping the Internet.</td>
</tr>
<tr>
<td>DeNardis (2012)</td>
<td>ET</td>
<td>ET</td>
<td>IT</td>
<td>As quoted, “[t]he theoretical starting point of this paper is that arrangements of technical architecture are inherently arrangements of power”, and elaborates further on the need of understanding the technology to improve understanding of how the Internet is governed.</td>
</tr>
</tbody>
</table>

(continues on next page)
Table 5.3: Internet descriptions, a selection from literature, interviews and non-academic sources (continued).

<table>
<thead>
<tr>
<th>Source</th>
<th>T</th>
<th>C</th>
<th>A</th>
<th>Quote/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICANNwiki ET ET</td>
<td>-</td>
<td>-</td>
<td>“The term Internet is used to describe the interconnected servers, computers, and networks that work through a standard protocol and provide the structure for information to be accessed on &quot;The Web.&quot;” In essence, the technical perspective of the Internet.</td>
<td></td>
</tr>
<tr>
<td>Wikipedia ET ET</td>
<td>-</td>
<td>-</td>
<td>“The Internet is the global system of interconnected computer networks that use the Internet protocol suite (TCP/IP) to link devices worldwide.” I.e. the technical perspective of the Internet.</td>
<td></td>
</tr>
<tr>
<td>RFC-2026 (Bradner, 1996) ET ET EF</td>
<td>-</td>
<td>-</td>
<td>“The Internet, a loosely-organized international collaboration of autonomous, interconnected networks, supports host-to-host communication through voluntary adherence to open protocols and procedures defined by Internet Standards”, explicitly technical, explicit in voluntary adherence, and a defined set of Internet standards (i.e. not the web).</td>
<td></td>
</tr>
<tr>
<td>ITU ET - IT</td>
<td></td>
<td></td>
<td></td>
<td>Although not formally defined, ITU documents discuss the Internet in terms similar to “Internet protocol-based networks” where the Internet is seen as a strict technical concept where regulation is external to the Internet itself.</td>
</tr>
<tr>
<td>“ccTLD (2)” ET ET EF</td>
<td></td>
<td></td>
<td></td>
<td>The notion of a “commons” digital network governed by its users. Explicit in that the applications on top are not the Internet.</td>
</tr>
</tbody>
</table>

(continues on next page)
5.4. What is the Internet?

Table 5.3: Internet descriptions, a selection from literature, interviews and non-academic sources (continued).

<table>
<thead>
<tr>
<th>Source</th>
<th>T</th>
<th>C</th>
<th>A</th>
<th>Quote/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“IXP (1)”</td>
<td>ET</td>
<td>ET</td>
<td>EF</td>
<td>The notion of a network (for digital communication) governed by its users (although the interviewees worded them differently). Explicit in that applications and concerns on top are not the Internet.</td>
</tr>
<tr>
<td>“Legislator”</td>
<td>ET</td>
<td>-</td>
<td>IT</td>
<td>“The Internet is a part of telecommunications”, implicitly in a regulatory sense, and further elaborates that it would be positive if ICANN was subsidiary to the ITU.</td>
</tr>
<tr>
<td>“ISP”</td>
<td>ET</td>
<td>IT</td>
<td>IT</td>
<td>“Global network based on IP-addressing”, and further elaborates that addressing and routing are key concepts (i.e. the IANA-function), and there is a gap between the Requests for Comments themselves and how they are implemented (practice).</td>
</tr>
<tr>
<td>Markus (2006)</td>
<td>ET</td>
<td>-</td>
<td>EF</td>
<td>“It is perhaps also worth noting that AT&amp;T and its peers and their many transit customers do not merely connect to the Internet; rather they are the Internet. The Internet is not a single, huge and over-arching network, but rather a collection of networks that collectively comprise a worldwide communications stratum.”</td>
</tr>
</tbody>
</table>

In Table 5.4 I present the two main synthesized perspectives from Table 5.3, where both perspectives agree on the technical dimension (i.e. set of protocols and that they in practice work a certain way) but differ in the coordination dimension (i.e. is the Internet de facto coordinated differently than broadcast media or telephony).

In the literature, I find the first flavor in Table 5.4 to be most prevalent, which is in accordance with van Eeten and Mueller (2012) except they refer
5. Internet coordination

Table 5.4: Two different flavors of the Internet based on previous literature and interviews.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet as a part of telecommunications (i.e. a service)</td>
<td>In this concept, Internet is seen as a part of telecommunications. It happens to be something that runs on telecommunications infrastructure. This means that Internet in this scope roughly encompasses the concept of digital communication today. I have encountered two flavors of this concept as well, which differentiates themselves on whether applications on top are a part of the Internet or not. In Table 5.3 shown as the Internet as a technical but not a coordination concept, regardless of inclusion of applications on top, in essence assuming that the Internet is governed by similarly to how telecommunications is governed (i.e. policy and regulation).</td>
</tr>
<tr>
<td>Internet as a set of protocols for digital end-to-end communication affected by its users</td>
<td>This definition of Internet comes from interviewees who explicitly stated that the Internet is not a part of telecommunications. They might share the same infrastructure sometimes, but are fundamentally different in that telecommunications is regulated top-down while the Internet is regulated by a bottom-up process. This Internet-concept does not encompass the web or any other application which might use the Internet, and as the Wikipedia entry on the Internet states; “Not to be confused with the World Wide Web” (Wikipedia Contributors, 2017a). This concept is explicit on that the Internet is the concept of end-to-end communication using pre-agreed upon standards for digital communication, where one such standard might be IP. This view is illustrated by “ccTLD (2)”, “IXP (1)” and van Eeten and Mueller (2012) in Table 5.3.</td>
</tr>
</tbody>
</table>
5.4. What is the Internet?

to formalized institutions and Internet Governance rather than telecommunications and the Internet. Seen today, the two definitions are quite similar, i.e. with respect to what the Internet is today in terms of protocols etc, but the second flavor also includes a notion of governance and not only the protocols themselves.

In this text, I suggest a definition in line with the second flavor. This has consequences on what Internet Governance is, since Internet Governance naturally has to be dependent on how we define the Internet.

One such explicit factor is that the Internet definition I’m using incorporates not only a set of protocols but also that the user is in charge of these protocols. I have condensed all of this into the following definition:

the Internet is a set of protocols for digital end-to-end communication affected by its users

This has the implication that the definition assumes that the users can control both development and standards, and therefore also control how packages flow and are filtered. From this perspective, or thought collective in the Fleckian-sense (see Fleck, 1935), net neutrality is not a regulatory issue, and is rather an inherent attribute than a debatable issue. An “Internet” without practical net neutrality is not the Internet according to the above definition because the users are not in control, but rather the network operators. Of interest to note in this definition is the use of “affected” rather than “governed” or “controlled”, this due to that users may, rather than will or shall, affect what the Internet is, and everything users do on the Internet does not affect what the Internet is.

To summarize, my definition has two core elements:

Table 5.5: Dimensions of the Internet

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination</td>
<td>Explicitly loose bottom up with focus on empirically motivated decisions.</td>
</tr>
<tr>
<td>Technical</td>
<td>End-to-end best effort digital communication, realized through standards and implementations of standards.</td>
</tr>
</tbody>
</table>

For avoidance of doubt, the second point in Table 5.5 is more or less along the line of previous literature and opinion. The first point is contentious, both since it is implicit in most contexts, and since there are those that disagree with it. Also, many texts, such as van Eeten and Mueller (2012) and Hofmann, Katzenbach, and Gollatz (2017), jump directly to Internet Governance without touching base with the Internet.
5. Internet coordination

Using the suggested definition, we have a new dimension, the coordination dimension, for reasoning in regard to Internet issues. Seeing the Internet as bottom-up coordinated shows the explicit difference between the Internet and traditional telecommunications such as cell-phone telephony governed by national regulatory authorities often coordinated at an international level at the ITU.

Previous literature uses the term Internet Governance to discuss the co-ordination of the Internet. I instead suggest to use Internet Coordination to include all coordination which together gives the Internet.

With Internet, I do not mean the web (i.e. websites, html, javascript, etc), one of the many services available on the Internet. In some sense, the Internet is focused on the Internet layer in the “Internet protocol suite” or layer-3 in the OSI-model, and when this text refers to filtering, it is not only in the sense of slowing down a web page, but also other protocols such as FTP, SIP, SSH and SMTP.

5.5 The universes

The Internet Foundation In Sweden (IIS), the ccTLD for dot-se, released a book in 2010 describing Internet Coordination (the author, Jonson, uses Internet Governance as a term) from a Swedish context, without fully detailing what that would entail, where Jonson divides Internet Coordination into three universes; the Internet Society (ISOC)-universe, the ICANN-universe and the United Nations (UN)-universe (see Jonson, 2010). These universes are used as models for dividing Internet actors into different boxes, and therefore each actor can only appear in one box (which is one major different between ecologies as models and the universes as boxes). I use this division of universes since it together with my interviews provides a good demarcation of different important constellations in the coordination of the Internet (in my ecology modeling endeavors).

5.6 The ISOC-universe

Jonson (2010) describes the ISOC-universe, and indirectly IETF, to be what he calls the technological governance of the Internet. He describes the initial processes to be ad-hoc and bottom-up, which Mintzberg (1980) would describe as coordination by mutual adjustment, and points to two forms of ad-hoc-standardization documents, RFC and Best Current Practice (BCP). Jonson (2010) is here a bit inaccurate, since the IETF (and specifically the IESG) only deals with Requests for Comments, but an RFC fulfilling certain requirements can become an Internet Standard or a BCP, where Internet Standards are those Requests for Comments of special importance to the Internet (RFC-2026, Bradner, 1996), and BCPs those Requests for Comments.
which cannot be considered application standards or technical standards (see Bradner, 1996, for distinction and definition) but describe common practice which should be adhered to (such as RFC-2827 (Ferguson & Senie, 2000), BCP-38, saying that traffic operators should do their best to rid their networks of IP-packets with false sender info).

The mission of ISOC is to “Keep the Internet going”, where I assume they are using the end-to-end communication definition of the Internet since Jonson (2010) argues that ISOC roughly is the “technical association of the Internet”. “The Tao of IETF: A Novice’s Guide to the Internet Engineering Task Force” (IETF, 2012) describes decisions as being based on consensus and indirectly bottom up, which the process description agrees with (RFC-2026, Bradner, 1996).

The IETF in itself is an open membership engineering group for Internet standards, and is described as being a semi-functioning old boy’s club (“ccTLD (1)”). According to “IXP (1)” IETF has problems passing suggestions since all decisions in the Internet Engineering Steering Group (IESG) have to pass a consensus process (see Bradner, 1996, for process description). This might be part of the problem that IETF today is seen as slow-moving, such as in Li (2015).

Other actors in the ISOC sphere include the Internet Architecture Board (IAB) and the Internet Research Task Force (IRTF). IAB is a committee of IETF and acts as an advisory body of ISOC, and according to Li (2015) it used to be another functioning old boy’s club which got overthrown and got inefficient. Earlier, IAB has been involved in producing many of the Internet-standards we have. IRTF is the research aspect where IETF is the engineering aspect, and are primarily distinguished in that IETF produces standards but IRTF produces research (RFC-4440, Floyd, Paxson, & Falk, 2006), which I implicitly understand as technical research focused on Internet stability. There is circumstantial evidence that IETF is guided by commercial interests (RFC-4440, Floyd et al., 2006) and IRTF is lacking traction in the academic community (Li, 2015). According to “IXP (1)” it is not problematic if commercial interests are guiding IETF, since organizations often have a stake in what they do, also I would argue that it would be possible for organizations to use Requests for Comments for their own commercial interest.

For example, I assume that Requests for Comments can be seen as standards by the non-initiated, and therefore it gives a market advantage by being able to show that your products fulfill Requests for Comments. As of June 2017, there are approximately 8100 Requests for Comments available and in Table 5.6 I show the number of Requests for Comments authored or co-authored by a number of organizations. Technically, it is not an entirely correct representation of authorship but should give a rough estimation (I matched domain-names in contact emails to organizations). As seen, in Table 5.6, Cisco is part of as many Requests for Comments as IBM, Microsoft,
5. **Internet coordination**

Juniper, Google, Apple, Yahoo and Facebook together. Academia is intentionally left out in the table due to lacking a key term to search for (as dot-edu is only used by US institutions). As can be seen the actors in Table 5.6 authored roughly half or all **Requests for Comments**, the remaining half is, presumably, academia and other large organizations.

<table>
<thead>
<tr>
<th>Org</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>8082</td>
</tr>
<tr>
<td>Cisco</td>
<td>2074</td>
</tr>
<tr>
<td>IBM</td>
<td>811</td>
</tr>
<tr>
<td>Microsoft</td>
<td>609</td>
</tr>
<tr>
<td>Juniper</td>
<td>369</td>
</tr>
<tr>
<td>Yahoo</td>
<td>159</td>
</tr>
<tr>
<td>Google</td>
<td>75</td>
</tr>
<tr>
<td>Apple</td>
<td>53</td>
</tr>
<tr>
<td>Facebook</td>
<td>21</td>
</tr>
</tbody>
</table>

“IXP (1)” does not see a problem with that businesses have a large impact in the **IETF** standardization process, and says that in many cases it is beneficial since they then have an interest in their standards being used, and in this case standards are nothing but a different kind of product. Informally I have heard that publishing **Requests for Comments** conforming to your products was a common way to market your equipment as the standard, which might be one of the reasons Cisco, IBM and Juniper have authored or co-authored so many **Requests for Comments**. But do not forget that according to RFC-2026 (Bradner, 1996), to become an **Internet Standard** two separate entities must have implemented the standard, and they should work together (“running code”).

**ISOC** itself is funded mostly through the **Public Interest Registry (PIR)** (“IXP (2)”), i.e. through sales of dot-org, dot-ngo and dot-ong domain names. The support from **PIR** to **ISOC** is shown as contributions and grants (ISOC, 2015b), and is listed as **Programme Support** in their financial statement and amounts to $32 M (ISOC, 2015a) of their $40 M (ISOC, 2015a) revenue. The major expenses of **ISOC** are global engagements (such as supporting Internet growth in non-digitized markets) and support for **IETF** meetings and surrounding activities.
5.7 The ICANN-universe

The ICANN-universe is described as the necessary universe to bridge the technical ISOC-universe to the US and other states (Jonson, 2010). ICANN as an organization is described as being very close to the IANA function as well as the US state through National Telecommunications & Information Administration (NTIA) and the Department of Commerce (Jonson, 2010), up until the IANA-stewardship contract expired and the formal relation was dissolved (Gruenwald, 2016). Both the NTIA and the Department of Commerce are US government entities.

ICANN as an organization is bound by its bylaws, which among others state that “ICANN does not hold any governmental authority” (ICANN, 2016a) and that their mission, in short, is to coordinate allocation and assignments of names in the root zone and IP and AS numbers, to facilitate coordination of the operation of Domain Name System (DNS) and to collaborate with other bodies. The ICANN mission statement, i.e. Section 1.1 MISSION of “BYLAWS FOR INTERNET CORPORATION FOR ASSIGNED NAMES AND NUMBERS”, does not contain the word govern in any form. In the interviews “ccTLD (1)”, “ccTLD (2)” and “IXP (1)” I was given explicit answers that ICANN does not govern the Internet but rather facilitates coordination, and that ICANN should not go outside of that mandate. Noteworthy is that the bylaws prior to October 2016 described ICANN’s primary mission to be “coordination” (ICANN, 2016b) whilst the current bylaws rather focus on “ensuring” stable and secure operation of the Internet (ICANN, 2016a). In sense ICANN is not limited to coordinating and has been given a larger mandate by its constituents (the Empowered Community (EC)) to act on its own.

To contrast, “Legislator” implies that ICANN has governmental-like authority by explicitly stating that it is problematic that there is no governmental regulation of ICANN.

Internally, ICANN has several Supporting Organizations, who in turn depend on or consist of members of other organizations. ICANN also has several Advisory Committees. All of these can be seen as being part of the multi-stakeholder model often connected to ICANN.

ICANN, as the bylaws state, is focused on naming and numbering; where naming broadly can be divided into ensuring a functional domain name system for ccTLDs (country codes such as dot-se, dot-de and dot-uk), generic top-level domains (gTLD) (generic top-level domains such as dot-com, dot-org and dot-biz) and others (reserved names such as dot-local, dot-arpa and dot-onion), and numbering IP-address allocation.

ICANN can broadly be divided into groups which are part of the multi-stakeholder environment (formally the EC) and groups which are not. In essence, the Supporting Organizations (i.e. Address Supporting Organization (ASO), Generic Names Supporting Organization (GNSO), Country Code...
5. Internet coordination

Names Supporting Organization (ccNSO) and two Advisory Committees (At-Large Advisory Committee (ALAC) and Governmental Advisory Committee (GAC)) constitute the EC which is a Californian non-profit which formally elects the ICANN board (ICANN, 2016a, 2017d).

The EC takes the role of a chapter meeting in a contemporary non-profit organization. Worth noting is that Security and Stability Advisory Committee (SSAC) and Root Server System Advisory Committee (RSSAC)) are not part of the EC, according to “IXP (2)” because neither the RSSAC nor the SSAC are interested in being anything other than advisory to the board regardless of who sits on the board (an indication of schisms inside ICANN). In recent change of bylaws the GAC and the ALAC changed from being advisory (i.e. no formal power) to having formal power over the ICANN board through the EC. As such the GAC and ALAC are de jure no longer just Advisory Committees, as RSSAC and SSAC intend to be (according to “IXP (2)”).

The EC has most powers associated with a chapter meeting, such as electing the board and amending the bylaws (ICANN, 2016a), but also more uncommon powers such as rejecting Public Technical Identifiers (PTI) governance actions (i.e. those connected to the IANA function), recalling and appointing board members at any time and selling assets (ICANN, 2016a, 2017d).

The EC was created in conjunction with the IANA stewardship transition in October 2016, and it has turned into a powerful structure lacking members (“IXP (2)”). Lacking members in the sense that there are many empty seats in the formal EC structure. Also, the processes shown in ICANN (2017d) are expensive and cumbersome to maintain (“IXP (2)”).

The board of ICANN consists of sixteen (16) voting directors and four (4) non-voting liaisons (ICANN, 2016a). In total eight (8, seats 1-8) of the board members are nominated by the nomination committee, six (6, seats 9-14) by ICANN Supporting Organizations, one (1, seat 15) by the ALAC and the last director (seat 16) is the president of ICANN. The four (4) non-voting liaisons are selected by the GAC, the RSSAC, the SSAC and the IETF. The IETF-liaison is the only member appointed by a non-ICANN constellation. Also interesting to note is that the ALAC elects a voting member while the other Advisory Committees elect non-voting liaisons (ICANN, 2016a). Previously the Technical Liaison Group (TLG) appointed one member as well (GNSO, 2012), so in a sense the technical and standards community has gone from two seats, i.e. IETF and TLG, to only one liaison seat with IETF.

The board of ICANN elects its chairperson on an annual basis, and the chairperson has to be a director of the board other than the president (ICANN, 2016a). Also, the board elects all officers, including but not limited to the president, and they are nominated by the chairperson (ICANN, 2016a), and I am unsure whether this practically means that it is impossible to appoint officers which are not favored by the chair or not.
5.7. The ICANN-universe

Table 5.7: ICANN board composition (see ICANN, 2016a, for bylaws)

<table>
<thead>
<tr>
<th>Seat</th>
<th>Nominates</th>
<th>Elects</th>
<th>Voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-8</td>
<td>Nomcom</td>
<td>EC</td>
<td>yes</td>
</tr>
<tr>
<td>9,10</td>
<td>ASO</td>
<td>EC</td>
<td>yes</td>
</tr>
<tr>
<td>11,12</td>
<td>ccNSO</td>
<td>EC</td>
<td>yes</td>
</tr>
<tr>
<td>13,14</td>
<td>GNSO</td>
<td>EC</td>
<td>yes</td>
</tr>
<tr>
<td>15</td>
<td>ALAC</td>
<td>EC</td>
<td>yes</td>
</tr>
<tr>
<td>16</td>
<td>Chair</td>
<td>board</td>
<td>yes</td>
</tr>
<tr>
<td>N/A</td>
<td>GAC</td>
<td>GAC</td>
<td>no</td>
</tr>
<tr>
<td>N/A</td>
<td>RSSAC</td>
<td>RSSAC</td>
<td>no</td>
</tr>
<tr>
<td>N/A</td>
<td>SSAC</td>
<td>SSAC</td>
<td>no</td>
</tr>
<tr>
<td>N/A</td>
<td>IETF</td>
<td>IETF</td>
<td>no</td>
</tr>
</tbody>
</table>

The interviews highlight that the most important aspect of ICANN is ensuring that people and organizations keep talking and that the IANA function remains functional (“ccTLD (1)”; “ccTLD (2)”; “IXP (1)”). According to “IXP (1)”, one implicit purpose of ICANN is to take up space, so there is no vacuum for the UN or other organization to rush in and take control of central Internet coordination mechanisms.

ICANN today is primarily funded through reselling of gTLDs and related application fees (revenue wise), and their revenues are increasing year upon year, which could be problematic in the long run, since ICANN is no longer dependent on the Internet community as a whole (as argued by “ccTLD (2)”). In 2010 ICANN had a revenue of $65 M and in 2016 closer to $200 M where the absolute majority of the increase comes from gTLD sales and applications (ICANN, 2010, 2016c).

IANA-function

The IANA function today lies under ICANN via the Public Technical Identifiers (PTI) organization (NRO, 2017). Technically, IANA is responsible for the coordination of IP-address and ASN allocation globally, which is done via the Regional Internet Registries (RIR) and Number Resource Organization (NRO)-ASO (NRO, 2017). It is often implied that the IANA function is the most important function of ICANN (ex Aerts, 2007; “ccTLD (2)”; Dolderer & Bäss, 2006; “IXP (1)”; Oleg & Chahadé, 2015).

It is also interesting to note that a twenty-year-old text, Gillett and Kapor (1997), describes that the IANA functions will “probably” be governed in a bottom-up participation based model like the rest of the Internet (i.e. the
5. Internet coordination

ICANN, but a year later ICANN was formed and the IANA functions firmly stayed within the ICANN organization.

**TLG and TEG**

Both TLG and Technical Expert Group (TEG) are groups in ICANN, with the TLG consisting of representatives from European Telecommunications Standards Institute (ETSI), International Telecommunications Union’s Telecommunication Standardization Sector (ITU-T), World Wide Web Consortium (W3C) and IAB (ICANN, 2012). The TEG consists of all TLG members, ICANN board and invited participants (ICANN, 2017c). Both TLG and TEG as such collaborate with other epistemic communities.

In TEG (2016), a meeting transcript from a TEG meeting, it can be seen that neither the line between policy and standard, nor domain name and protocol specification is completely clear. Standards and protocols technically belong in the IETF sphere and policy and domain names in the ICANN or IANA sphere (RFC-2860, Carpenter, Baker, & Roberts, 2000) but TEG (2016) illustrate several discussions on where to draw the line on this twenty year old issue.

**ccTLDs**

ccTLDs are the national level registries and registrars for country code top-level domains. The actual code for each country is the corresponding ISO two-letter country code. ccTLDs in general are connected to ccNSO but they are not forced nor do they need to be members. ccTLDs are in general not contractually bound to ICANN, but can rather be seen as constituents of ICANN (“ccTLD (2”)”. ccTLD registries are in general funded by ccTLD sales and technically not limited in their pricing (as described by “ccTLD (2”)”). As such it is possible for ccTLDs to set insane prices, and my understanding of the dynamics is that tradition rather than, for example, homo economicus, is limiting the current prices.

Most ccTLDs together constitute the ccNSO, a part of the EC.

**gTLDs**

gTLDs are generic top-level domains, such as dot-com and dot-gov, as well as the “new” gTLDs such as dot-xxx and dot-google. ICANN, and not GNSO, approves all new gTLDs. The gTLDs speculated that they would turn a profit by investing in a new TLD, but some gTLDs have issues with keeping subscribers, such as dot-xyz who lost 30 million out of 35 million subscribers when it was time to renew subscriptions (“IXP (2”)”).

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5.7. The ICANN-universe

It might be reasonable to argue that domain names are worth less over time with search engines as Google present, but “IXP (2)” argues that owning a gTLD has a significant value.

RIRs

RIRs are closely connected to the NRO (and ASO) and their primary activity is distributing IP-addresses and Autonomous System Numbers (ASN) to ISPs and other actors. If an RIR runs out of IP-addresses, they ask ICANN and the IANA function for more. RIRs are distributing numbers and are a key extended-aspect of the IANA numbering function.

It is important to understand that ISPs are by all means required to have an ASN to be part of the Internet, else you cannot get traffic routed via Border Gateway Protocol (BGP)\(^1\) and the ISP would in effect be isolated from the other networks.

The Internet is quite commonly referred to as a network-of-networks (RFC-2026, Bradner, 1996), which technically can be understood as a network-of-Autonomous Systems (AS), where each AS needs an ASN for routing purposes.

Current IANA delegated ASN assignments are published by IANA, and as of now there are five RIRs, as shown in Table 5.8. AFRINIC and LACNIC are the two newest RIRs; where AFRINIC now has Africa and has taken over the geographical area from RIPE and ARIN, and LACNIC has taken over Central and South America from ARIN.

<table>
<thead>
<tr>
<th>RIR</th>
<th>region</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIPE</td>
<td>Europe</td>
</tr>
<tr>
<td>AFRINIC</td>
<td>Africa</td>
</tr>
<tr>
<td>APNIC</td>
<td>Asia &amp; pacific</td>
</tr>
<tr>
<td>ARIN</td>
<td>North America</td>
</tr>
<tr>
<td>LACNIC</td>
<td>Latin &amp; South America</td>
</tr>
</tbody>
</table>

Technically, the RIRs together constitute the NRO through a Memorandum of Understanding (MoU), as previously mentioned, is virtually the same organization as the ASO, with ASO being the chapter present in the bylaws of ICANN and NRO being the pre-existing organization.

\(^{1}\)Here broadly using the term BGP to signify all relevant internal and external routing protocols.
5. Internet coordination

5.8 The UN and ITU universe

Last in Jonson (2010) is the UN and ITU, two worldwide organizations whose members are states, where ITU is the UN’s specialized agency for information and communication technologies (ITU, 2017a). Neither the UN nor ITU has a technical or governing role in the Internet infrastructure (Lee, 2012), but there are interests that want to put the UN in a more central role of the Internet ecosystem (“IXP (1)”; “Legislator”).

In 2012, ITU held the World Conference on International Telecommunications (WCIT) 2012, where the role of the UN in the Internet was discussed, and in short the states decided that the Internet should be under greater ITU influence (Dourado, 2012; “IXP (1)”). “IXP (1)” reasons that fundamentally there is nothing wrong with governing the Internet by UN-like means, but then all countries have to be working democracies and voting power somehow related to population. Dourado (2012) cites US Ambassador Terry Kramer as saying “Internet policy should not be determined by Member States, but by citizens, communities and broader society” (Dourado, 2012), i.e. implicating that member states are not perfect representations of citizens, communities and the broader society in this particular case. “IXP (1)” is explicit in that the problem is not the UN itself, but rather that all of its members are not democratic enough. Most Western states voted against the resolution, even though a majority of all states voted in favor of it (see Cherryil, 2012; ITU, 2012; Masnick, 2012).

It might be prudent with a note on treaties in the ITU here, the ITU can suggest treaties but the countries themselves have to ratify them. And a majority of countries have not (at the time of writing this) ratified the treaty, and it is unclear if a majority ever will.

“IXP (1)” reasons that the question is bigger than it first might seem, and that the resolution was not only about the Internet but also concerns how states are to relate themselves to international fragmentation and nationalism, i.e. should the Internet (and similar phenomena) transcend national borders or not.

I want to highlight that ITU predates the UN with eighty years or so, being incorporated in 1865 as the International Telegraph Union, starting with the role of supervising the agreement for international telegraphing and over the years including telephony, radio, television, space and satellites, (according to the UN) the Internet and mobile connectivity (see ITU, 2017b). Worthy of note is that ITU (2017b) are neutral when presenting the history of the telegraph, the radio and telephony and describe how the ITU was created as a necessity, but while discussing the Internet the text looses neutrality and describes how “hardly anyone would be able to use this powerful resource without ITU-brokered and approved global standards” (ITU, 2017b). I believe they refer to the telecommunication standards set by the ITU, which technically are important, although conceptually not important for the Internet.
5.9 Other influential organizations and actors

As mentioned earlier, one weakness in this study is the lack of formal input from a vast selection of ISPs (I have only one formal ISP interview), which I find particularly disheartening since “IXP (1)” said that the real power lies with the ISPs, since they can implement whatever they want no matter what has been decided elsewhere when it only concerns their own networks. I also was told that ISPs in general are not interested in Internet Coordination (also “IXP (1)”), implying that ISPs are more interested in the Internet as a service to sell rather than a phenomenon or idea to coordinate.

Technically, an ISP has one or many ASs, which are the nets together forming the Internet (cf. earlier Figure 3.5 with all prefixes and ASs visible in 2000 and 2019). ASs are closely related to ASNs, which are the numbers given to each AS and used for routing purposes, and as mentioned before, the ASN is one of the unique identifiers coordinated with the IANA function through the RIRs.

In this text, I see ISPs as being the vendors of Internet access to Internet-users, i.e. not all AS owners are considered ISPs. Some are rather wholesalers for Internet-access. The ISPs are in more or less complete control of what Internet-access is for the ordinary user, since the user’s ISP can prevent certain services (Netflix, Google, Facebook etc), protocols (Bittorrent, Telnet, SMTP...
etc) and ports (incoming \textbf{port} 25 (mailserver), 80 (webservers), 443 (secure webservers), etc). Most users do not have the financial ability nor interest to connect to an IXP and peer with other networks (“IXP (1)”) and therefore are at an ISP’s mercy. ISPs also own a large part of the Internet infrastructure, i.e. cables and equipment at both edges and inside ASs (in general).

In large parts of the world there is legislation in place to regulate ISPs into not modifying or otherwise changing, inspecting or logging traffic going through their networks, with the laws in Europe being quite prominent (as argued by “IXP (1)”; “Legislator”). Although the main aspect of the laws are in line with \textbf{net neutrality}, there are occasions when traffic operators are allowed to filter or drop traffic; one example being when a user is DDoS’d or when traffic can be considered harmful to another network (i.e. the traffic itself is considered harmful to the network itself, much as in a large amount of trucks being able to damage roads or cause congestion regardless of what they are carrying).

\textbf{Internet Exchange Points}

IXPs are a place where Internet traffic and access is exchanged. IXPs usually exchange traffic at layer-2 (“IXP (1)”), i.e. one layer below IP, even though there are IXPs out there which theoretically could switch at layer-3.

ISOC (2015c) argues that governments and other entities should help foster IXPs since they are vital for a working Internet-infrastructure ecology, and says that ISPs have cost incentives to collaborate and start IXPs. IXPs are another Internet-access wholesaler actor-type, which sells access in a different magnitude than ISPs. In the common setting, ISPs are customers of IXPs. Usually the traffic through an IXP is high enough that filtering or monitoring of traffic is impossible (according to “IXP (1)”), but IXPs could always shut off their services or perhaps other organizations with sufficient resources could be interested in having on-site equipment (as was the case with the National Security Agency (NSA) in the US, see Markus, 2006)).

IXPs are often regulated in law, but less commonly so since legislation sometimes only regulate traffic operators or service providers, and some national legislation does not consider IXPs as such (according to “IXP (1)”). In Sweden, IXPs are under similar laws as other traffic operators (s) (such as ISPs and telephony provider, see “SFS 2003:389”), which is uncommon.

\textbf{Internet Systems Consortium}

The Internet Systems Consortium (ISC) is a public benefit incorporated in the US who operates a root server and are a major contributor to the BIND DNS software. BIND is the most commonly used DNS software for root servers in use today (“ccTLD (1)”; Wikipedia Contributors, 2017b).
The *ISC* is interesting because *BIND* is the de facto *DNS*-standard implementation today. As an example, *DNS* has support for extensions, i.e. additional data-types, but as long as *BIND* (and other software) does not support them, they are not per se available, a discussion which can be seen in for example the TEG (2016) transcripts.

5.10 Coordination

On the previous pages, I have given an overview of organizations I deem important for the *coordination* of the *Internet*, and here I focus on how these and others interact and what the consequences are.

Let us start from the first research question, *What is the Internet?* I argue that it is meaningful to discuss the *Internet* as “a set of protocols for digital end-to-end communication affected by its users”, to illustrate both the technical and the *coordination* dimensions of the *Internet*. If either one of those change significantly, it would no longer be the *Internet*.

The second question, *Who, together or alone, can be considered to coordinate the Internet?* I argue with reasonable reliability that no central organization governs the *Internet* in the traditional sense. For example, neither *ICANN* nor the *IETF* govern the *Internet*, the *Internet*’s being is constructed through its *coordination* which allows for voluntary participation. *ICANN* and the *IETF* do, on the other hand, have an impact on how and who actually has power over the *Internet* and how the *Internet* can be used.

Previously I defined the *Internet* as not only containing a set of protocols but more importantly also the notion of who is in charge of said protocols. It might at first seem inconsequential as long as the protocols work, but I argue that whether the protocols are governed by the users or some other entity has a large practical impact. It is also important to remember that *user* is not limited to a person or similar, but any kind of entity using or rather participating in the (*coordination* and use of the) *Internet*, such as a state, corporation, non-profit or a group of youngsters in a garage.

*Internet* Coordination concerns everything that affects how the users might communicate end-to-end with the *Internet* now and in the future. In Figure 5.1 and Table 5.10 I show the organizations interesting in an *Internet Coordination* context and how they coordinate and connect.

Important to note is that Figure 5.1 contains actors of different types and sizes. For example, there is one board of *ICANN* with 16 people, and there are tens of thousands of *ISPs* where the largest employ tens of thousands of people. There are also actors which are not organizations, such as the *IANA*-function and *Internet Standards*, who exert influence or agency through their existence and function. The technical *Internet*, roughly, is *infrastructure and network operators* using *Internet Standards* for *IANA*-function technical *coordination*, and not much more than that. The *coordination* dimension is more complex...
and includes actors surrounding the technical core, such as ICANN, IETF, ISOC and their subgroups and constituents.

Figure 5.1, although not exhaustive, highlights how organizations are connected differently than Table 5.10, where I rather focus on coordination. In Figure 5.1, a harder and darker line implies greater influence, with the strongest lines being from gTLDs to GNSO, ccTLDs to ccNSO and RIRs to ASO, since they are the constituents of the Supporting Organization. Currently, the EC is not in the figure due to drawing limitations, but the EC is GNSO, ccNSO, ASO, ALAC and GAC in conjunction.

Governments are, through policy and regulation, influencing businesses and communication in general, and also provide regulation which could be seen as standards. The other two main contributors to Internet de jure and de facto standards are the ITU and IETF. Important to remember is that ITU is an organization which has states as members and the IETF has anyone as members. Businesses in Figure 5.1 include but are not limited to ISPs and IXP.s. The important business in maintaining Internet function are the infrastructure and network operators (for example IXP.s and ISPs) which are given a smaller role in the coordination of the Internet (even though they, if the ISPs wanted to, could redefine what the Internet is for almost all users).

In Figure 5.1, the civil society represents not only organizations but also individuals and academia, in the same manner as I interpret civil society in the WGIG (2005) Internet Coordination definition. And the civil society can lobby towards governments as well as the UN, although it should be noted that lobbying usually requires funding and is hard for a single individual to do (“Legislator”). ALAC is the ICANN EC participant tasked with representing the civil society.

It is noteworthy that ICANN receives funding from ccTLDs even though they originally were not contractually bound to each other, although there are more and more contracts being written in the later years (ICANN, 2017b). For example the Swedish ccTLD dot-se is controlled by Swedish Internet Foundation (IIS) but they do not have a contract with ICANN, rather an exchange of letters (see Aerts, 2007). In these letters IIS acknowledge that ICANN exists, and that as the performer of the IANA function, they are interested in having mutual agreement in place, but also clearly state that they are not in a contractual relationship nor intend to be, as quoted: “It is the intention of both parties that this exchange of letters will not form the basis for any claim for any legal or equitable relief, or create reliance on the part of either party. For avoidance of doubt, nothing contained in this letter shall give rise to any liability, monetary or otherwise by either one of us to the other” (Aerts, 2007). IIS chose not to contribute with funds to ICANN the fiscal year of 2016.

ICANN has historically been funded to a greater extent by its constituents, such as ccTLDs, but are currently financed primarily from gTLD sales, which could be problematic in that ICANN is gaining independence from its constituents financially. As both Aerts (2007) and Dolderer and Bäss (2006)
5.10. Coordination

![Diagram of Internet Coordination ecology overview]

Figure 5.1: An Internet Coordination ecology overview
5. **Internet coordination**

Imply the main reason they, as ccTLDs, are contributing funds to ICANN is the operation of the IANA function, and the dot-de-registrar in particular states in their letters of exchange; “In particular, we look forward to further improvements of the IANA function as the core service ICANN provides to ccTLDs” (Dolderer and Bäss, 2006) without further specifying what such an improvement might be. These agreements are generally referred to as MoUs.

This coordination between ICANN and ccTLDs is close to mutual adjustment over the years, but there are examples of contracts as well such as the Accountability Framework for many non-Internet-pioneering nations. One such example is the ccTLD of Ukraine, whose contract is, roughly, comparable to the dot-de or dot-se but written in formal legalese and clearly naming the International Chamber of Commerce for dispute resolution, whilst the dot-de and dot-se letters indirectly say that disputes are irrelevant because the letters are not contracts.

In theory, ICANN is a membership organization and it would be possible for its constituents to agree on another organization (as argued by “ccTLD (1)”; “ccTLD (2)”; “IXP (1)”, in interviews) but for practical reasons unlikely. Even though ICANN from the theoretical perspective lacks decision rights on its own, ICANN has influence on the process of ICANN-meetings, since as organizers they have de facto influence.

There are those that see the geographic closeness between both ICANN and IETF to the US as problematic (for example Lee, 2012; “Legislator”), although it can be argued that similar problems might arise no matter where the organizations are located (as argued by “IXP (1)”) and the most important issue is that the IANA functions are hosted in a functioning at least semi-democratic environment. During the IANA stewardship transition period, there were outcries from Americans against the US giving up control over the Internet (see Raustiala, 2016, for a summary of opinions on the topic), even though the US government had never had control over the Internet in such a manner.

“IXP (1)” suggests that virtually the same people show up again and again at most ICANN meetings, arguing for the same thing over and over again, and since there is no proper veto-mechanism in place at ICANN meetings, they sooner or later get their policy suggestions through. In addition, “IXP (1)” mentions that you encounter the same people in both IETF and ICANN meetings and groups, which gives fuel to a Quora answer to the question *What are the relationships among ICANN, IETF, and IANA?* by engineer Li: “Heavily incestuous [spelling corrected]” (Li, 2017).

On the context of participation and funding, both “ccTLD (1)” and “IXP (1)” mention that most of the founding organizations were not reimbursing or otherwise allowing for participants without funding to attend. “ccTLD (1)”
5.10. Coordination

Table 5.9: Internet-actor types according to the typology in Olve, Cöster, Iveroth, Petri, and Westelius (2013)

<table>
<thead>
<tr>
<th>Organization</th>
<th>Roles</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICANN</td>
<td>society, policy, squatter</td>
<td>ICANN, even though not as focused standardizer as IETF, exerts standardized pressure through a political like influence. Parties at ICANN meetings agree on policy. ICANN acts as a squatter in the sense of being seen as the Internet Governance arena, even though policy agreed on at ICANN meetings cannot be de jure enforced.</td>
</tr>
<tr>
<td>IETF</td>
<td>standardizer, innovator</td>
<td>Standards, mainly through Requests for Comments, are the main products of the IETF.</td>
</tr>
<tr>
<td>ISPs and IXPs</td>
<td>distributor, financier</td>
<td>Mainly distributors of the Internet service, and to a lesser extent stakeholders in the standardization process.</td>
</tr>
<tr>
<td>CDNs</td>
<td>customers and suppliers</td>
<td>Suppliers of content and customers of ISPs and IXPs.</td>
</tr>
<tr>
<td>Govts, UN and ITU</td>
<td>regulators</td>
<td>Regulatory power, although my interview context diminished such power and rather suggested that other coordination forces are more important than regulation.</td>
</tr>
<tr>
<td>Users</td>
<td>customers and suppliers</td>
<td>The primary customers in the Internet ecology, can be both organizations and people, but are also the suppliers indirectly.</td>
</tr>
<tr>
<td>??</td>
<td>marketers</td>
<td>There seems to be no clear innovators or idea marketers in the Internet ecology outside of ICANN and IETF today. Innovation seems to be centered on services on the Internet rather than the Internet or the coordination of the Internet today. Depending on perspective, the ITU can be considered an innovator (or disruptor).</td>
</tr>
</tbody>
</table>
5. **Internet Coordination**

mentioned that this has slowly changed over the years, with ICANN today reimbursing many of the travels needed for representative duties.

It is prudent here to point out that in an Internet context users are not products, even though that might be the case in a web-context.

Informally I have been told that there is a problem with many governmental processes that there is no well recognized difference between telecommunications and the Internet, which lets telecommunication lobbyists set the UN and governmental agenda even for the Internet. “Legislator” mentions that there are many telecommunication lobbyists at an EU-level, but few which would be considered Internet lobbyists in the light of this text, and which helps create the perception that telecommunications and the Internet are the same with regard to regulation. Another reason for telecommunication lobbyists outnumbering the Internet lobbyists is that the money is in telecommunications and not Internet Coordination (at least for lobbyist according to “IXP (2)”). As an example, a large ISP on the U.S. market enjoys higher profit margins and sells a larger variety of services than a typical European ISP who sells well-defined wholesale traffic services.

![Diagram of Internet Coordination ecology](image)

**Figure 5.2:** The two central concepts in the Internet Coordination ecology

“IXP (2)” suggests that there are two primary reasons for Internet and telecommunications being treated as one and the same;

1. You frame telecommunications and the Internet similar.
2. You want telecommunications and the Internet to be the same.

“IXP (2)” argues that the first reason is due to not understanding the fundamental differences between what the Internet and telecommunications are, and explicitly notes that it “can quite easily be solved through informative dialogue”. The second type is problematic for the Internet as it is today, since governmental long term pressure is the greatest threat to the Internet today (according to “ccTLD (1); “IXP (2)”). In this chapter, I do not delve deeper into this, but merely note that people in the Internet epistemic community are worried by the recent political shift towards nationalism and a lack of open Internet leadership.

In Figure 5.2, I show the two central concepts which together decide what the Internet is today. Important to note is that the Internet here concerns end-to-end digital communication and not, for example, the web or other services such as Facebook, Netflix or YouTube. The two concepts directly influence what the Internet is. It is important to put Figure 5.2 in the context of Figure 5.1 to understand the coordination context, which creates the Internet which at its concrete technical level is infrastructure and network operators coordinating unique identifiers through the IANA-function using Internet standards. The IANA-function and Internet standards are intertwined to a great extent. For example, the IANA-function is maintaining coordination according to Internet standards.

As mentioned before, ICANN is the most prevalent organization in the public debate regarding Internet Coordination, since it is easier to have a discourse regarding a visible hand than an invisible one, and in the context of Internet, it opens up for a governance discussion without prior knowledge of Internet protocols and standards. As an example, Raustiala (2016) sees Internet Governance as a question of whether the Internet should be governed by a multi-stakeholder or a multilateral (i.e. nation states) model and does not go deeper into the organizations constituting the Internet, and indirectly assumes that the naming and numbering function of the Internet implies great power. Whilst “IXP (1)” and “ccTLD (1)” say it is the other way around, i.e. that ICANN has power because they are given the right to coordinate numbering and naming and that the power of coordinating the naming and numbering function of the Internet can be taken away.

Real power seems to lie in the hands of the ISPs since they are the de facto providers of Internet access to end users, and therefore almost freely can decide what Internet access entails, an argument driven by “IXP (1)”. Practically, it is not unusual for ISPs to block certain ports, for example port 25 which is necessary for a mail server to function properly, since it could be in the interest of the ISP to control which protocols can be used. In the case of the mail server, ISPs and others have a responsibility regulated in law, at least in Europe, to handle traffic which could damage or otherwise disrupt other networks or users (argued by “IXP (2)”), which means they blocked the
port needed for private customers to operate their own mail servers according to IETF agreed standards to combat spam to some extent.

“IXP (1)” mentioned that it is unfeasible for IXPs to monitor all traffic, but I believe that ISPs in general have more processing power closer to the end users, i.e. the Internet’s edge (in practice home routers or data centers), where it actually would be feasible to filter or monitor traffic. The ISPs thus in practice define what Internet access is (see, for example, Netnod, 2019).

One interesting aspect of ISP power is BCP-38, an IETF document describing the best practice in regard to a DoS problem where the attacker is spoofing his IP-address (RFC-2827, Ferguson & Senie, 2000). According to “IXP (2)” and “ISP” the problem is easily solved at the Internet’s edge, and should be in the interest of all, but the soon twenty-year-old problem is still around. One of the reasons is that the BCP itself does not provide a guide for solving the issue but rather describes the problem itself in great detail (“IXP (2)”). Important to understand, in a technical sense, is that the only way to find if the source is address-spoofing is at the edge of the Internet, i.e. at the edge of an ISP’s network facing a consumer, once the packet is on the Internet (i.e. being routed somewhere) it is not possible to distinguish it from any other packet (according to “IXP (2)”).

On the topic of packet filtering and priority, the EU recently adopted a policy which requires prioritizing packets on the Internet in conjunction with Public Protection and Disaster Relief (PPDR). “IXP (2)” reasons that it is simply not possible to accomplish and that the belief that it would be, stems from the common misunderstanding that the Internet works as a traditional telecommunications network, and that regulation like this could either be enforced or ignored, which then would lead to further undermining of the concept of the Internet as being bottom-up governed (or coordinated).

In Table 5.10, I list actors and their relations and classify them in a Mintzberg (1980) coordination fashion. I have taken liberties with the typology and have added AP to model appointments, that is indirect influence, and use direct supervision (DS) for direct application of influence. I use mutual adjustment (MA) for relations which are not formal but there is interaction and standardization of outputs (SO) for standardization processes. Here preferring SO rather than standardization of work process (SWP) or standardization of skills (SS) since the standardization concerns outputs or handover of data between networks rather than focusing on training (i.e. SS) or actual implementation (i.e. SWP). All the relations shown in Figure 5.1 are not shown in Table 5.10. The purpose of Figure 5.1 is to show organizations and actors related to each other and primarily to their universes, and in Table 5.10 to focus on particularly interesting relations in a coordination context.
### 5.10. Coordination

Table 5.10: Internet-actors and their relations.

<table>
<thead>
<tr>
<th>Org A</th>
<th>Org B</th>
<th>A→B</th>
<th>B→A</th>
<th>Relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICANN</td>
<td>IANA</td>
<td>DS</td>
<td></td>
<td>ICANN is the administrative seat of the IANA function.</td>
</tr>
<tr>
<td>ccTLDs</td>
<td>ICANN</td>
<td>MA</td>
<td>MA</td>
<td>Accountability Framework (contractual) or Letters of Exchange (non-contractual). Usually the ccTLD supports ICANN financially to perform the IANA function. Formalized influence from ccTLD go through ccNSO.</td>
</tr>
<tr>
<td>ISPs</td>
<td>ICANN</td>
<td>-</td>
<td>-</td>
<td>Technically ISPs can be members of a GNSO stakeholder group and through that sway policy decisions at ICANN. ICANN has no power over ISP in general, except via IANA and RIR.</td>
</tr>
<tr>
<td>IXP</td>
<td>ICANN</td>
<td>-</td>
<td>-</td>
<td>As with ISPs, IXP can be members of a GNSO stakeholder group, but formally ICANN has no power over IXP.</td>
</tr>
<tr>
<td>IANA</td>
<td>RIRs</td>
<td>SWP</td>
<td>MA</td>
<td>A coordinating relation for distributing number resources, such as IP-addresses.</td>
</tr>
<tr>
<td>ICANN</td>
<td>IETF</td>
<td>MA</td>
<td>MA</td>
<td>IETF appoints an ICANN non-voting board liaison, and both organizations communicate.</td>
</tr>
<tr>
<td>EC</td>
<td>ICANN</td>
<td>AP</td>
<td></td>
<td>The EC more or less formally controls ICANN.</td>
</tr>
<tr>
<td>RIRs</td>
<td>ASO</td>
<td>AP</td>
<td></td>
<td>RIRs together constitute the ASO board.</td>
</tr>
<tr>
<td>ccTLDs</td>
<td>ccNSO</td>
<td>AP</td>
<td>MA</td>
<td>Most ccTLDs are ccNSO-members and coordinate themselves through ccNSO.</td>
</tr>
</tbody>
</table>

(continues on next page)
5. Internet coordination

Table 5.10: Internet-actors and their relations (continued).

<table>
<thead>
<tr>
<th>Org A</th>
<th>Org B</th>
<th>A → B</th>
<th>B → A</th>
<th>Relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>xSO</td>
<td>ICANN</td>
<td>AP</td>
<td></td>
<td>Supporting Organizations appoint one ICANN director each. ALAC and GAC also appoint.</td>
</tr>
<tr>
<td>xAC</td>
<td>ICANN</td>
<td>MA</td>
<td></td>
<td>Advisory Committees advise ICANN. in practice SSAC and RSSAC since ALAC and GAC appoint.</td>
</tr>
<tr>
<td>IETF</td>
<td>ISPs</td>
<td>SO</td>
<td></td>
<td>It is usually in the interest of ISPs to adhere to enough IETF standards, since they are whole- salers. In practice not all ISPs follow all Requests for Comments.</td>
</tr>
<tr>
<td>IETF</td>
<td>IXPs</td>
<td>SO</td>
<td></td>
<td>See IETF - ISPs.</td>
</tr>
<tr>
<td>IXPs</td>
<td>ISPs</td>
<td>MA</td>
<td>MA</td>
<td>Usually ISPs buy access to an IXP so they can peer with other network owners, since it is in the interest of the ISP to give better access to their customers.</td>
</tr>
<tr>
<td>ISPs</td>
<td>ISPs</td>
<td>MA</td>
<td>MA</td>
<td>Usually ISPs peer with each other since it is in their interest to increase the reach of their customers.</td>
</tr>
<tr>
<td>ICANN</td>
<td>UN</td>
<td>MA</td>
<td>MA</td>
<td>There does not seem to be a formal connection, but they clearly recognize each other, and a majority of UN members seem to want increased control over the Internet through ICANN.</td>
</tr>
<tr>
<td>ICANN</td>
<td>ITU</td>
<td>MA</td>
<td>MA</td>
<td>See ICANN - UN relation.</td>
</tr>
<tr>
<td>ITU</td>
<td>UN</td>
<td>?</td>
<td></td>
<td>Technically ITU is an agency of the UN, but their members differ slightly (?).</td>
</tr>
</tbody>
</table>

As seen in Table 5.10, most of the coordination of Internet mechanisms can be seen as done by MA, but there are clear streaks of AP with the implemen-
tation of the EC. Also, most formal Internet Coordination power is related to the ICANN universe: even though ICANN is not powerful within the Internet epistemic community, ICANN has perceived power from a governmental and regulatory perspective.

In the terms of Olve et al. (2013), if we consider the Internet to be a service providing a best-effort end-to-end packet delivery solution, among the external, i.e. non-Internet actors, the most influential actors are customers and the civil society. Regulatory, legislative and political influence seem to play a small role in how the Internet has developed and is developing. Among the Internet actors, there is no clear regulator, but rather two coordinators: ICANN with the IANA function for numbering and naming and IETF for Internet standards. Interestingly enough, I find little pressure from the civil society within or among Internet actors, but rather towards politicians and governments, which probably is due to public interest being geared towards social rights rather than infrastructural challenges.

As previously mentioned there are legislative and regulatory pressures from governments towards ISPs, such as traffic priority regulation, which lacks greater impact due to regulators not understanding the underlying Internet mechanisms in place (“IXP (2)”). “IXP (2)” paints a picture which academically can be found in Hölck (2017), in that it is easier to regulate vertically integrated services, but once services are separated into platforms, or platform networks, the complexity increases and regulation becomes significantly harder (Hölck, 2017), and domain specific knowledge is required by the regulators (as argued in different ways in/by Hölck, 2017; “IXP (2); Mansell, 2012). On the same topic, I was informed by an ITU veteran that those with domain-specific knowledge (usually the engineers) have never been as far away as they are today from the decision process in the ITU, a view which is corroborated by “IXP (1)”. This change is to a certain extent also happening in ICANN meeting settings (as implied by “ccTLD (1); “IXP (1)”). In that sense it can be argued that ICANN is slowly changing into that which the founding ideals considered to be one of problem with the UN and the ITU from the start. It is possible to argue that the original engineering and technology focused epistemic community which created ICANN and ISOC is being shifted out by a policy focused epistemic community.

Out of the previously mentioned organizations, ICANN, is growing the fastest, both in terms of employees and revenue, and a glance at the financial reporting shows us that the majority of the revenue increase is gTLD related. It is important to consider that part of the revenue gathered by ICANN in the last few years is temporary (“IXP (2)”) in the sense that a part of it is calculated to be used in a legal setting2, even though the amount is not

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2I.e. ICANN predicts that their will be upcoming lawsuits and legal actions with regards to recent changes in top-level domains (xTLD) frameworks. ICANN is administratively placed in the US, so I assume that they are preparing for US levels of damages and reimbursements.
5. Internet coordination

known. In general, many of the organizations mentioned are growing, but at a much slower pace. To put the revenue into perspective, IIS and DENIC (the German ccTLD) were together contributing around $100,000 per year (Aerts, 2007; Dolderer & Bäss, 2006) to ICANN and the IANA function, whilst ICANN has increased over $100,000,000 in revenue the last seven years (ICANN, 2010, 2016c), which is roughly 1000 times as much. ICANN funding through the years is illustrated in Table 5.11 (absolute values) and Table 5.12 (percentages). And it begs to consider if the role of ICANN might change over the coming years, or if the mission of the organization stays the same even though their revenue seems to be ever-increasing. In contrast, “IXP (2)” suggest that running a top-level domain (TLD) inherently is just a cost, and that gTLDs will only generate a profit as long as customers see a value in owning them. Which can be contrasted with other “ways of finding your way on the Internet”, such as googling instead of using the DNS system, which inherently would decrease the value of owning a TLD.

Table 5.11: ICANN revenue by sample sources. Compiled from ICANN financial statements and ccTLD contribution statements, as such some values are presented by ICANN (years 2014 and 2018), and prior years are calculated from aggregated financial statements and written information with regards to relative sizes and changes between ccTLD, registrar och registry fees.

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2006</th>
<th>2010</th>
<th>2014</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccTLDs</td>
<td>$603</td>
<td>$1002</td>
<td>$1605</td>
<td>$1828</td>
<td>$2337</td>
</tr>
<tr>
<td>Registries</td>
<td>$718</td>
<td>$5830</td>
<td>$31915</td>
<td>$47143</td>
<td>$83282</td>
</tr>
<tr>
<td>Registrars</td>
<td>$2368</td>
<td>$19312</td>
<td>$30189</td>
<td>$34831</td>
<td>$46788</td>
</tr>
<tr>
<td>gTLD app. fees</td>
<td>$</td>
<td></td>
<td></td>
<td>$36574</td>
<td>$−12548</td>
</tr>
<tr>
<td>Revenue domains</td>
<td>$3690</td>
<td>$26144</td>
<td>$63709</td>
<td>$120376</td>
<td>$119859</td>
</tr>
<tr>
<td>Revenue tot</td>
<td>$5965</td>
<td>$29821</td>
<td>$65768</td>
<td>$123384</td>
<td>$133761</td>
</tr>
</tbody>
</table>

Amounts in thousands of $.

If seen as an organization, the Internet is primarily using MA as coordination mechanism and decisions are in general taken by those close to the problem in line with how Mintzberg would define an adhocracy. As argued by Mintzberg (1993) having a primary coordination mechanism does not mean that other forms of coordination are not used, only that if there is contradictory coordination from different mechanisms, the coordination given by the primary mechanism is the one adhered to.

As an example, if your boss instructs you to do one thing (DS), your colleague asks for help on something else (MA) and your training directs you to do something different (SS). Then if you are in an MA dominated environment
Table 5.12: ICANN revenue percentage per revenue source. Percentage of total revenue in financial statements of ICANN for given fiscal year.

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2006</th>
<th>2010</th>
<th>2014</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>ccTLDs</td>
<td>%</td>
<td>10.1</td>
<td>3.4</td>
<td>2.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Registries</td>
<td>%</td>
<td>12.0</td>
<td>19.6</td>
<td>48.5</td>
<td>38.2</td>
</tr>
<tr>
<td>Registrars</td>
<td>%</td>
<td>39.7</td>
<td>64.8</td>
<td>45.9</td>
<td>28.2</td>
</tr>
<tr>
<td>gTLD app. fees</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td>29.6</td>
</tr>
<tr>
<td>Domain names</td>
<td>%</td>
<td>61.9</td>
<td>87.7</td>
<td>96.9</td>
<td>97.6</td>
</tr>
</tbody>
</table>

(i.e. adhocracy) you would probably do what your colleague asked, whilst if you are in a “simple organization” (as defined in Mintzberg, 1993) do what your boss told you (DS) or follow your training if you are in a professional bureaucracy (SS). Since the Internet coordination has most tendencies of an adhocracy, it would be expected for Internet actors to rather do what their peers expect them to rather than what regulation tells them to do.

As another example, Mueller and Chango (2008) discusses the issue of why the WHOIS system prevails even though it is contradictory with data protection laws, i.e. why does the WHOIS service not follow regulation and common global governance understanding? Given that the Internet could be considered as an adhocracy, it would be expected that the WHOIS system would prevail since it coordinated by MA rather than DS or SWP (in this case regulation).

Another important aspect of adhocracies is that they are hard to change in the perspective of forcing change through the organization, the components of an organization rather tend to change when they want to. This has the very important implication that there is no someone or something which can change the Internet on its own, and also representing the organization of the Internet externally is problematic since there is no elected leader or authorized signatory for the Internet. I will continue on this topic in both Chapter 6 and Chapter 7.

5.11 Conclusions and further research

Tying it all back to the first research question; “What is the Internet?” I suggest that the Internet can be seen as a set of protocols for digital end-to-end communication affected by its users, which in essence gives two dimensions of the Internet, one technical and one coordination. The technical dimension is not subject to much disagreement (it is a digital end-to-end communications network of some kind) but the coordination dimension is contested (literature
5. **Internet coordination**

Table 5.13: Research directions

<table>
<thead>
<tr>
<th>Question</th>
<th>Short answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the Internet?</td>
<td>The Internet can be defined as a set of protocols for digital end-to-end communication affected by its users.</td>
</tr>
<tr>
<td>Who, together or alone, can be considered to coordinate the Internet?</td>
<td>Today it is still possible to argue that Internet users are the de facto Internet coordinators through a multi-stakeholder approach in ICANN setting for policy and naming, and a adhocacy setting in IETF setting for Internet Standard, although there is pressure towards a top down multilateral governance system. This is evident through such events as the WCIT treaty and the formalization of ICANN coordination processes into formalized multi-stakeholderism.</td>
</tr>
</tbody>
</table>

tends to see the Internet as only technical, while I suggest that its coordination is intrinsic to its existence). In the suggested definition, protocols such as IPv4 and IPv6 are products of the Internet's coordination rather than the protocols being the Internet itself (as the; “the Internet is a collection of protocols” approach suggests).

Also, by bringing in a coordination dimension it becomes clear that regulatory enforcement of a different structure than the bottom-up processes causes clashes. As implied by “IXP (1)”, are these intentional clashes going to change the coordination mechanisms of the Internet (and therefore the Internet) or are they happening because the national regulatory authorities and other governmental or state groups lack domain specific knowledge (of the technical nature of the Internet, as suggested in Mansell, 2012).

This Internet framing has other implications for future research; as I limit the definition to the coordination of and the unique identifiers and protocols concerning the unique identifiers and Internet Standards the focus of Internet Coordination and Internet Governance is quite narrow and well-defined. This implies that issues such as intellectual property rights and cybersecurity are by definition not Internet issues, and should be treated elsewhere (i.e. not in arenas discussing Internet Coordination, such as IETF and ICANN today). To elaborate further, Internet Coordination (and Internet Governance) is limited to the core of the wider Internet Governance formulation in DeNardis and Raymond (2013), to levels 1-3 out of their six. Cybersecurity, app-stores, and intellectual property rights are then not Internet issues per se.

The second question, “Who, together or alone, can be considered to coordinate the Internet?” The primary conclusion is that there is no governor in
the traditional sense of the word, the visible hand is neither strong nor enforcing, and plays only a minor role. Rather, coordination is attained through the invisible hand, which this text presents a glimpse of. A larger study is needed to fully understand and see the invisible hand.

In general, public and governmental attention has shifted away from the governance and the coordination of the Internet itself to products or services offered on the Internet, such as the web, Facebook, Google, Netflix etc. With that said, and as previously argued, the coordination of central Internet protocols and functions does not enough attention, as I argue in the rest of this thesis.

ISPs have the possibility to shape what Internet-access is and to that extent they are very powerful actors. IXPs are capable of redefining Internet-access if they had reason to, although lacking the detailed control of an ISP. At another level, there is ICANN and a multi-stakeholder solution, which formally takes into consideration a more diverse set of actors than a comparable UN or ITU multilateral process.

Over time, the Internet and its governing mechanisms have changed from being bottom-up and self organized where decisions are taken where necessary, an MA adhocracy to use the terms of Mintzberg (1993), to becoming more formal and standardized. One example of this is ICANN’s detailed policy process through the EC which puts the organization of ICANN more into the SWT in the Mintzberg-typology. External forces are pushing towards a standardized or formalized version of Internet Coordination (where Internet Governance would be a proper term), which puts ICANN in focus since it is one of the few organizations functioning remotely like a governmental or intergovernmental entity.

This text does not judge any organizing to be objectively better than the other, but if the works of Mintzberg (1980, 1993) are to be believed, it is easy to go from mutual adjustment to other forms of coordination, but hard to go back since hierarchies, processes and structures have their own raison d’être. And the question we should ask is if standardization of processes is a necessary change to keep the Internet as the Internet as it grows, or if this will fundamentally change the bottom up organizing of the Internet into something different.
Internet social resilience

[messed up] the zone-file by removing the trailing dot. For a couple of hours the [...] zone was unresolvable.

— Interviewee

Notes

An earlier draft of this chapter was presented at ITS 2017 in Passau, available in proceedings as follows:


In particular the text has been extended with theories and literature concerning take-overs in general and non-profit settings. The Internet and Internet Coordination are defined in lines of Chapter 5 / Lindeberg (2017b).

As a former conference paper, this chapter retains the structure of a paper and is self-contained.
6. Internet social resilience

Abstract

This text explores the social resilience of the Internet, which means who can change how we do end-to-end best effort digital communication and how can they change it. The Internet is assumed bottom-up coordinated to enable a wide range of actors, including but not limited to ICANN, IETF, UN, ITU and infrastructure and network operators. Based on literature on takeovers this text goes through relevant groupings for the coordination of the Internet. The text goes through varying factors capable of through social means changing what the Internet is by intention or error. Findings include that even though it would be possible for a disruptor to take control over formal processes in ICANN and the IETF, controlling them would not imply control over the Internet. Disruption of the Internet is more likely to come from a changing world order with focus on national Internet coordination rather than a distributed international coordination effort.

6.1 Introduction

If we assume that the Internet is not strictly governed, but instead, along the lines of Zittrain (2008) and van Eeten and Mueller (2012), think that the Internet is more of a construct with emergent qualities, governed by consensus and formed by day-to-day actions of its constituents (i.e. Internet-actors), then it is interesting to look at how sensitive this structure can be to external interference.

Practically, the Internet can be seen as a technical network, whose technical aspects in turn are managed by people. The area I explore is “how could someone disable or vastly change the Internet?”, a question which is usually answered by technical means and has a vast flora of literature, for example Çetinkaya, Broyles, Dandekar, Srinivasan, and Sterbenz (2013), Cohen, Erez, Ben-Avraham, and Havlin (2000), Rohrer, Jabbar, and Sterbenz (2014), Sterbenz et al. (2013), Wu, Zhang, Mao, and Shin (2007), Yuan, Zhang, Li, Zhang, and Li (2008) who all look at how the network itself can be technically disabled. I venture to ask if “someone” could disable or similarly incapacitate parts the Internet. This text explores these social vulnerabilities.

I use the term social resilience as an umbrella term for resilience to social changes and disruption in contrast to technical resilience. This study was conducted by a literature review of social resilience in organizations, albeit a limited one since the vast majority of takeover literature is based on equity (i.e. stock based) takeovers rather than non-profit takeovers. This defines and contrasts different forms of takeovers in the organizational sphere. In addition to that, I used interviews as a sensitizing tool to guide further exploration in which mechanisms and organizations are important for Internet function.

Is it possible to disable or change the Internet by systematically targeting key people or by taking over an Internet-organization? In essence there are
two main goals of disruption in the Internet case: disabling the Internet or controlling part of the Internet for political or economic reasons.

Could a terror group be interested in disabling the Internet? Could a commercial actor be interested in controlling or imposing tariffs on certain types of content? I boil these concerns down to two questions:

1. How can the Internet be controlled through social means?
2. How can the Internet be disrupted through social means?

Even though similar in character, these questions are vitally different, “can the Internet be controlled” vs “can the Internet be disrupted”. Whereas the first requires control over the Internet, the second stipulates a strong enough force to change the Internet into something not the Internet, such as abolishing core principles, such as the end-to-end principle, or make the Internet stop working.

In summary the Internet is socially resilient from a control perspective, not because structures can not be controlled by social means but because controlling these structures does not imply control over the Internet. As an example, the formal multi-stakeholder structure of Internet Corporation for Assigned Names and Number (ICANN) is possible to “game”, which would in practice enable policy control over the Internet Assigned Numbers Authority (IANA)-function. But even though the IANA-function is core to Internet functionality, switching to another IANA- or another naming and numbering function is not technically complicate; ergo, in practice controlling the IANA-function implies little control over the Internet, compared to, for example, owning all infrastructure.

There are, though, two connected but different means of non-technical disruption which would disrupt the Internet as we see it. The first would be if problematic Internet-of-Things (IoT) implementations give rise to public debate leading to increased regulation, in essence disrupting the end-to-end principle. This would be a “bottom-up” push towards increased regulation for safety and security. The second would be international pressure, primarily from the United Nations (UN) and International Telecommunications Union (ITU) who already have suggested that they should take control of the IANA-function or create their own similar function (such as the handle-system).

This text assumes a working knowledge of Internet functions and organization. The interested reader is encouraged to read the empirical part of Chapter 5 for a thicker description of the actors. I approach the Internet as “a set of protocols for digital end-to-end communication affected by its users” (Chapter 5), which is a bottom-up ecology view of the Internet where not only actors such as ICANN, the Internet Engineering Task Force (IETF), the

\(^1\) See description of Digital Object Numbering Authority (DONA) vs Domain Name System (DNS) further on in the text.
6. Internet social resilience

Internet Governance Forum (IGF) or the ITU matter, but also Internet Exchange Points (IXP) and Internet Service Providers (ISP) play a significant role.

6.2 Method

This text is based on literature, interviews and readings of statues and bylaws of identified organizations in Chapter 5.

Table 6.1: Formal interviews and their references in this text.

<table>
<thead>
<tr>
<th>Role</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryptographic Officer</td>
<td>“Cryptographic Officer”</td>
</tr>
<tr>
<td>Advisory Committee</td>
<td>“Advisory Committee”</td>
</tr>
<tr>
<td>Working Group Chair</td>
<td>“Working Group Chair”</td>
</tr>
<tr>
<td>EU-politician</td>
<td>“Legislator”</td>
</tr>
</tbody>
</table>

All interviews focused on quality and depth rather than quantity, and are intended as good but not exhaustive starting point for further inquiry. The formal interviews were semi-structured and recorded. The interviews were part of a larger study focused on the ecology issues of Internet Coordination with streams of question going into the social resilience area with relevant participants.

The interviewees were chosen due to their supposed knowledge and understanding of the Internet and its inner workings, since that enables a detailed discussion of how control of specific mechanisms would affect the Internet as a whole. For example, I had the opportunity to discuss the IANA Root KSK Ceremonies and its effect on the Domain Name System Security Extensions (DNSSEC) system with a trusted Cryptographic Officer, which provides an understanding of the Root KSK process that documents alone cannot provide. Table 6.1 is an overview of interviews referenced explicitly in this text.

Interviews with two Internet experts were also used as sensitizing tools for further digging into technical standards and coordination processes. The issue of social resilience was mentioned as important by a minority sub-group of the entire interview series. Here, I focus on the accounts of two experts who were explicit in that the Internet is facing larger social challenges than technical challenges. This text portrays the social resilience issues on their own rather than try to compare their magnitude to technical resilience issues. Furthermore, I draw and contrast the technical Internet perspective with the political perspective of “Legislator”.

In addition to formal interviews, I have used informal information, such as discussions or online discussion forums, to further guide my inquires. I do
not refer to or base any conclusions on these but rather refer directly to the end source, such as a standard or event to illustrate a point.

I prepared for the interviews by reading through historic ICANN-bylaws, IETF documents regarding processes and elections (such as Request for Comments (RFC)-2026 (Bradner, 1996)), public memorandums of understanding such as country code top-level domain (ccTLD) agreements, the Number Resource Organization (NRO)-Address Supporting Organization (ASO) memorandum and process documents for most of ICANN’s constituents. Through reading these documents I risked bias, i.e. assuming how the Internet is coordinated in terms of social resilience, but made the decision that knowing the history (and the actors involved) was more important than entering the interviews without bias.

The bulk empirical description, particularly the ICANN and IETF descriptions, is based on a synthesis of documents (such as bylaws, statutes, process documents etc) and interviews, and quotes are used for illustrative purposes. As a reader service, I refer to the relevant document where necessary, although referencing practices makes it harder to spot standards (vs academic literature) since Requests for Comments are referenced by author rather than number. As an example RFC-2026 is referred to as Bradner (1996) in the bibliography, therefore RFC-2026 will be displayed as RFC-2026 (Bradner, 1996) in the text.

6.3 The Internet

As I have previously argued in Chapter 5 defining the Internet is not easy and conclusions drawn will be dependent on the definition used. I will here adopt the same Internet description as in Chapter 5, which is the Internet as a set of protocols for digital end-to-end communication affected by its users. In this definition, the web is one service possible due to the Internet. Another such service might be TV or radio over the Internet. The Internet is quite distinct from telecommunications in organization and regulation, in that the Internet is regulated through distinct bottom-up processes whilst traditional telecommunication is regulated top-down (see for example description in Cowhey, 1990, of international telecommunications regimes), even though telecommunications and the Internet occasionally might share the same infrastructure (see Chapter 5). Also important is the end-to-end principle, the idea that value-adding services should be at the edge of the network and not in the network itself, i.e. a separation of the process of propagating traffic according to standards and providing service above the traffic layer.

In the scope of this chapter, central functions are the IANA function and its constituents, i.e. Regional Internet Registries (RIR) for maintenance of numbering (i.e. AS:es and IP-address allocation) and top-level domains (TLD) for naming. Important organizations are ICANN and its Empowered Community
6. **INTERNET SOCIAL RESILIENCE**

(EC) model (formal multi-stakeholderism), the IETF (informal meritocratic multi-stakeholderism) and the infrastructure and network operators themselves, such as ISPs and IXPs.

I refrain from using the expression Internet Governance and instead prefer Internet Coordination for the purpose of this text, the reason being that “governance” as a term is contentious depending on scientific field and thought collective, and that fields which use Internet Governance as a term tend to focus on policy and regulation rather than Internet function and operation per se.

This has the effect that one part of the research question roughly can be equated to how can someone(s) disrupt or control the IANA function, whilst still ensuring that their IANA function is the one whose coordination is trusted (since controlling the IANA function is meaningless if it is not trusted). And another part would be how the outcomes of the coordination is implemented, if at all.

One common argument is that the Internet only works if everyone is doing their thing and their thing only, as illustrated by:

> [the Internet] works as long as everyone does what they are supposed to do, neither more, nor less. Who does it is not important, but rather what they do. (“Advisory Committee”)

This was said in the context of whether infrastructure and network operators have to be private entities or could be government operated. This is part of the bottom-up mentality of Internet Coordination.

On a technical note this text refers to naming and numbering, two of the core IANA-functions. Both of these processes are involved in practically anything Internet. Naming is resolving human-readable identifiers (such as urls like www.google.com) to Internet intrinsic addressing (i.e. IPv4 or IPv6 today) and is usually the first thing you have to do when you do anything on the Internet, such as browsing the web. This is known as DNS and is sometimes referred to as the “phone book of the Internet”. The other process is numbering, which has to do with ensuring that your traffic knows where to go to get to a certain address. These two processes are separate in that they can be considered to happen on different layers, and for this text it is important that naming (i.e. DNS or “phone book services”) is dependent on numbering (i.e. routing related tasks) to function properly. Without DNS it would still be possible to route traffic, but human-readable names (such as www.google.com) would not work.

---

2The technically knowledgeable reader knows that it is possible to do much more than just map a human-readable name to an IP-address, but that is not important in this context.
6.4 Takeovers

Takeovers in academic literature has historically focused on equity based takeovers (see for example Brickley & James, 1987; Grossman & Hart, 1980) and there are few touchdowns on non-profit takeovers. Since ICANN and IETF and connecting structures and organizations are based on voting on semi-democratic grounds rather than equity-based voting, it is of importance to create an understanding of the issues at hand. Reiser (2006) goes as far as to say “The offhand comment, and lament, has often been made that non-profits are not subject to takeovers” and argues that takeovers are happening in the non-profit world but are harder to find and even harder to define. The argument goes:

Yet, takeover attempts do take place, and crafting a response to these high stakes conflicts reminds us of the centrality of mission and the complexities created by the multiple stakeholders in nonprofit organizations. Thus, it is worthwhile to explore the nonprofit takeover phenomenon and to articulate the appropriate legal standard to regulate it.

Nonprofit takeover activity highlights the tension between the treasured nonprofit values of mission preservation and mission evolution. (Reiser, 2006)

In essence Reiser (2006) boils down the conflict to the differences between mission preservation (keep doing the same thing) and mission evolution (doing something else or the same thing differently). Other texts, such as Worth (2008), skip the takeover issue completely and assume that board and mission are “correct” and focus on implementation and governance given board and mission (as does, for example, the Management Control (MC) as strategy implementation literature stream).

Worth (2008) does suggest three types of boards for non-profits; the elected board (usually by a chapter meeting), the self-perpetuating board (board members elect board members\(^3\)) and hybrid boards (which in essence is any board not fully either elected or self-perpetuating).

The next paragraphs contain examples of elected board non-profit takeovers. The examples are limited to those documented in the public sphere to allow a potentially curious reader to look up details. I have found no public records of takeovers in non-profits with self-perpetuating boards, probably since defining a “takeover” in such a setting is neigh impossible since the change would happen over a longer time and potentially become indistinguishable from mission evolution.

\(^3\)According to Worth (2008) the most common non-profit board constellation in the U.S., although less common in the Internet community.
### Table 6.2: Comparison of three non-profit takeover cases

<table>
<thead>
<tr>
<th>Case</th>
<th>Board type</th>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-profit</td>
<td>Elected</td>
<td>Coup chapter meeting</td>
<td>Failed due to publicity, tried to coup</td>
</tr>
<tr>
<td>Elected youth</td>
<td>Elected</td>
<td>Coup chapter meeting</td>
<td>Failed due to publicity, succeeded and suppressed the chapter</td>
</tr>
<tr>
<td>Lobby org</td>
<td>Elected</td>
<td>Coup chapter meeting</td>
<td>Failed due to publicity, tried to coup</td>
</tr>
</tbody>
</table>

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6.4. Takeovers

This first example concerns a failed takeover. In 2005 a political party tried to take over the board of a lobby organization but ultimately failed, due to the plot rising into daylight\textsuperscript{4}. According to a newspaper article (see Malmberg, 2005) the attempt might very well have succeeded if it had not risen into the light of day since not enough people would have been at the chapter meeting to stop the coup. Ergo, the publicity of the coup foiled it. The planned takeover method was to coup the chapter meeting and take over the elected board, i.e. having members present at the chapter meeting with a different blend of opinions than all members of the organization.

My second example is similar to the first, it concerns a local chapter meeting for the same political party as in the previous example. At a 2014 small local chapter meeting with the usual handful of people and with the board all but decided beforehand by the nominating committee, twenty new members appeared and elected a completely different board than the nominated one (see the news-article, Holmström, 2014). This was a successful attempt of a coup and the political opinion of the new board of the local chapter was not aligned with the general political opinion of the national party. I define this example as a coup and not mission evolution since the new board of the local branch of the party went against the political opinions of the national party.

In this third example, also set in 2014, the youth branch of a political party intended to coup the chapter meeting of a pan-Nordic youth organization, but after the plans leaked to the press the youth branch canceled their plans (see the news-articles Normark, 2014; Quensel & Vergara, 2014). Interestingly, an additional 150 people showed up to the chapter meeting to ensure that the youth branch of the political party did not succeed in their plans to coup the chapter meeting (see Weski & Arwidson, 2014). Very similar to the first example, this coup attempt (the intentions of the youth branch of the political party was not in agreement with the mission of the youth organization) was foiled by public attention.

A fourth example, as described in Knickerbocker (2004) and Cox (2004), concerns a large pro-environment non-profit. A minority stake in the organization saw their chance at taking over the organization and their 100 MUSD annual budget by recruiting new members for the annual chapter meeting. The takeover attempt was ultimately thwarted, in part by being public (see Associated Press, 2004).

In Table 6.2, I show a summary of the cases, which I use to reason in regard to takeovers concerning Internet non-profits.

All examples have elected boards, but some of the later examples (ccTLD and IXP) have hybrid boards. From an external (that is, non-member) perspective, the notion that only non-profits with elected boards has been noted

\textsuperscript{4}According to Malmberg (2005) the objective was to politically connect immigration to higher taxes, i.e. a very political move.
as “taken over” makes sense, since defining “taken over” for either hybrid or self-perpetuating boards is tough in comparison to mission evolution.

In the case of a self-perpetuating board, the existing board elects new board members, and therefore only the sitting board is in charge of setting a new course. One way for the board to be “taken over” several board members would have to disappear simultaneously so a clear minority of board members gets to elect a majority of board members. Such a case seems very unlikely. Another is that members drastically change opinions (due to some reason, such as threats, bribes or perhaps a rational change of opinions) and through that change the direction of the board.

The hybrid board on the other hand is more complicated. A typical hybrid board is where several constituents have fixed positions on the board and then the remaining slots are filled either by the board themselves or an assembly separate from the chapter meeting. ICANN is an example of such a hybrid board, where several constituents have fixed positions on the board and several positions are “open” for applicants and the EC acts as an assembly for filling these positions.

The Internet Society (ISOC) has a similar approach where four board members are elected in total each year for a three-year mandate, bringing the board up to a total of thirteen (13) including the CEO / president. The chapters (i.e. ISOC sub-groups except the IETF) elect one board member, the members elect one board member and the IETF elect two board members (a division of positions which currently is under revision).

Also, the board of the IETF, called the Internet Engineering Steering Group (IESG), is elected according to RFC-7437 (Kucherawy, 2015) and is to govern through the procedures specified in RFC-2026 (Bradner, 1996). The IESG sets the Internet standards (they are called “Internet standards”, and are the de facto standards of the Internet as well), even though the IETF in its entirety is often stated as the standard setter.

Here follows an overview of actors and organizations with description on whether they can be taken over to change or disrupt the Internet as it functions today. The actors are divided into several main groups: the ICANN formal multi-stakeholder structure with the IANA-function at the top for maintenance of unique identifiers, the IETF (including ISOC and IESG) for producing and setting standards, infrastructure and network operators (i.e. in practice ISPs and IXPs) for maintaining the physical infrastructure, and nation states and national regulatory authorities setting the legal premise and regulation for actors.

Even though boards, chapter meetings and similar in the Internet ecology might have specific names, this text uses general terms where applicable in comparisons, such as “the board” or “the chapter meeting” instead of the organization-specific terms, such as the “Address Council” or the “Internet Engineering Steering Group”.

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6.5 The structure of ICANN

ICANN has since they changed their bylaws in 2016 incorporated a multi-stakeholder approach in their governance model (ICANN, 2016a), with the EC as an oversight organization for some of ICANN’s functions (ICANN, 2017d). EC’s powers include but are not limited to recalling the board, selling ICANN assets and rewriting the ICANN bylaws. The EC is being described as a way for ICANN’s Supporting Organizations and Advisory Committees to organize as a separate organization under California law (ICANN, 2017d), but the EC does not represent two of the Advisory Committees: Root Server System Advisory Committee (RSSAC) and Security and Stability Advisory Committee (SSAC) (see ICANN, 2017d). In essence the EC acts as a common chapter meeting, i.e. appointing and holding the board accountable.

The interviews raised the issue that the EC structure was lacking appointees which would mean that an organized group could gain disproportional influence in the EC. The EC structure itself is quite large and consists of five constituents, ASO, Country Code Names Supporting Organization (ccNSO), Generic Names Supporting Organization (GNSO), At-Large Advisory Committee (ALAC) and Governmental Advisory Committee (GAC). These constituents might have regional constituents who in turn might have national (or similar) constituents. They are summarized in Table 6.3.

The ccNSO has an elected board by all of its ccTLD constituents. Each individual ccTLD in turn might be a firm, a foundation, a non-profit or a state agency.

In comparison, the ASO, who has a hybrid board where each RIR gets three seats for a total of fifteen (15) seats, is potentially more complicated. Out of the three positions per RIR, two are selected by the RIR chapter meeting and one by the RIR board. In the case of RIPE (the European RIR) this practically means the RIPE Community with its 16000 members allow for a drawn out process if there is considerable disagreement. The other RIRs (APNIC, LACNIC, AFRINIC and ARIN) have similar situations, where AFRINIC stands out and requires voters to be physically present at a meeting5 (in general, all of these constellations mentioned in this chapter do not distinguish between types or modes of presence).

The GNSO in turn has a hybrid board with 21 members, divided into two houses, one house for contracted parties (those with contractual relations with GNSO, i.e. registries and registrars) and one house for non-contracted parties (formally further divided into commercial and non-commercial stakeholders, who in turn are further divided).

ALAC has a similar regional structure as ASO, divided into five regions who all through different processes appoint two members each and the ICANN NomCom appointing five members.

Table 6.3: Summary of EC structure. Generic terms, such as board and chapter meeting, are used instead of organization-specific vocabulary. Numbers from ICANN bylaws.

<table>
<thead>
<tr>
<th>Org</th>
<th>Board Constituents/members</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICANN</td>
<td>hybrid</td>
<td>All constituents (Decisional Participants) have equal weight in EC governance.</td>
</tr>
<tr>
<td>Supporting Organizations</td>
<td>elected</td>
<td>Elected by ICANN Nominating Committee.</td>
</tr>
<tr>
<td>ccTLDs</td>
<td>elected</td>
<td>Elected by ccTLDs.</td>
</tr>
<tr>
<td>ccTLDs</td>
<td>appointed</td>
<td>ccTLDs appoint two members to the NomCom.</td>
</tr>
<tr>
<td>ccTLDs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ccNSO</td>
<td>elected</td>
<td>Elected by ccTLDs.</td>
</tr>
<tr>
<td>ccNSO</td>
<td>appointed</td>
<td>ccTLDs appoint two members to the NomCom.</td>
</tr>
<tr>
<td>ccNSO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASO</td>
<td>elected</td>
<td>Elected by the RIRs.</td>
</tr>
<tr>
<td>ASO</td>
<td>appointed</td>
<td>RIRs appoint three members to the NomCom.</td>
</tr>
<tr>
<td>ASO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GNSO</td>
<td>hybrid</td>
<td>Hybrid, complex structure with multiple constituencies.</td>
</tr>
<tr>
<td>ALAC</td>
<td>hybrid</td>
<td>Hybrid, multiple constituencies.</td>
</tr>
<tr>
<td>GAC</td>
<td>elected</td>
<td>Elected from Global苋国.</td>
</tr>
<tr>
<td>NomCom</td>
<td>hybrid</td>
<td>Consists of 17 members, 5 from ALAC, 7 from GNSO, 1 from ccNSO, 1 from ASO, 1 from GAC.</td>
</tr>
</tbody>
</table>
Lastly the GAC consists of national governments, multinational governmental organizations and treaty organizations who elect the board of the GAC.

These five organizations together constitute the EC with one vote each. The structure is summarized in Table 6.3.

Also important is the ICANN NomCom, which appoints eight (8) out of sixteen (16) positions of the ICANN board. The NomCom is appointed by GNSO, ALAC, ccNSO, ASO and the IETF. The NomCom sets its own processes, something brought up as potentially problematic several times in interviews.

Since the board of ICANN can be overridden by the EC in terms of IANA actions, both the ICANN board and the EC need to be under control of a party wishing to force certain IANA policy. And even though there is power in the coordination function, i.e. controlling the IANA-function through the ICANN board and the EC, the processes themselves are slow and it would be possible for Internet actors to create a replacement organization before the overtaken controlling function could create longstanding harm. The coordination function here is the IANA-function, i.e. the coordination of IP-addresses, TLD-names and to some extent protocol specifications.

As stated above, one of the most important coordinating functions of the Internet, the IANA-function, is in the greater picture not that important for control purposes. The IANA-function is important as long as it is allowed to be important. With that said, it is possible to create havoc by wresting control of the IANA-function by taking over the ICANN-board, the EC and the NomCom, but the cost of doing so is greater than the rewards if the goal is to control the Internet (on the other hand, if the objective is chaos and fragmentation, it might well be worth it).

It is worth noting that the Internet is intentionally bottom up, not just emergent bottom up because planning was non-existent, as can be seen in IETF (2012) and RFC-2026 (Bradner, 1996) and described in interviews (by “Advisory Committee”; “Cryptographic Officer”). There is a philosophy built into the Internet, intentionally transcending nationality (“[the Internet] does not care for borders [...]” (“Advisory Committee”)) and organizing in a way different from governments, that should not be forgotten. Since the Internet is bottom up, it is possible to just stop listening and electing a new coordinating entity if the current one should stop working in a direction favoured by its constituents (explicitly argued by “Advisory Committee”; “Cryptographic Officer”). This makes the impact of the EC structure being infiltrated or taken over smaller, but not negligible.

There is a common misunderstanding today that ICANN does more than they do. In essence, they exist to coordinate the IANA function, and there are those who would like ICANN to do more. (“Advisory Committee”)
In short, controlling the IANA-function through the EC structure is possible but cumbersome, and ultimately controlling the IANA-function will not give long-lasting control over the Internet nor disrupt it. Even if control over the Internet was possible through ICANN, it is not clear what would constitute mission evolution (new board with new ideas) or mission disruption (board takeover).

6.6 The ICANN mission

In addition to ICANN as the administrative seat of the IANA-function, the mission of ICANN is interesting. Even though I interviewed experts on Internet Coordination, some changes in the ICANN bylaws regarding the IANA stewardship transition were not recognized during my interviews, which indicates that there is not wide recognition that the bylaws changed greatly in conjunction with the IANA stewardship transition, which further reinforces the picture than ICANN is not seen as that important by Internet organizations. Historically, ICANN has revised or amended their bylaws on average twice a year, with two major revisions so far; a rewrite in 2002 and a large amendment in conjunction with the IANA stewardship transition in 2016 (see ICANN, 2017a). In 2002 most of the bylaws were rewritten and a mission statement was added and formulated as follows:

The mission of The Internet Corporation for Assigned Names and Numbers ("ICANN") is to coordinate, at the overall level, the global Internet’s systems of unique identifiers, and in particular to ensure the stable and secure operation of the Internet’s unique identifier systems (ICANN, 2002)

Prior to that rewrite the bylaws did not contain a mission statement, but my interviews indicate that it was the implicit mission statement already. In the 2016 amendments, the mission statement was altered as follows:

The mission of the Internet Corporation for Assigned Names and Numbers ("ICANN") is to ensure the stable and secure operation of the Internet’s unique identifier systems as described in this Section 1.1(a) (the “Mission”) (ICANN, 2016a)

This, at least on paper, is possible to interpret in two ways: the limit of coordinating is removed and as such the mandate to ensure operation is clearer, or that the mission of all over coordination was removed in favor of only ensuring the operation of the unique identifier systems.

Another important difference in ICANN’s bylaws is that ICANN now has in their mission to collaborate with other bodies as appropriate (ICANN, 2016a), even though the bylaws limit ICANN’s mandate to collaboration, rather than say, signing treaties (ICANN, 2016a).
In the short term, these changes are not going to change how the Internet functions, but long term the purpose of ICANN could change, especially given the fact that there is a political and legislative need for a formal Internet governor (a role sometimes unjustly ascribed to ICANN).

6.7 The IETF structure

In comparison to ICANN, the IETF has a loose multi-stakeholder structure, and functions or boards included in the IETF structure includes ISOC (the formal organization), the IETF (a subgroup of ISOC), IAB (appoints IESG), IESG (the board of IETF using general terms) and IRTF (the research arm of ISOC). See Table 6.4 for overview.

The main product of the IETF, from an external perspective, is the RFC-stream, that is Requests for Comments published and available. The Requests for Comments handle almost all IETF matters, such as technical standards, standards for practice and internal processes. As an example, RFC-2026 The Internet Standards Process – Revision 3 (Bradner, 1996) describes the Internet standards process and RFC-791 Internet Protocol (Postel, 1981a) describes the original IPv4 standard.

To make sense of the current structure, a bit of history is necessary. In the early nineties there were no formal organizations (in a legal sense) coordinating the Internet, there was a loose organization called the IAB who had two arms: the research arm in IRTF and the maintenance (i.e. standards arm) in the IETF. The ISOC was created as a means of solving two issues: a legal and administrative seat for IETF and sister organizations, and securing financing for IETF and sister organizations.

ISOC is as of mid-2018 no longer the legal and administrative seat of the IETF; that stewardship passed to IETF LLC (in a legal, administrative and financial perspective). Worth noting is that ISOC has many chapters and groups which are not IETF and IRTF, and the IETF is to a large extent funded through ISOC (including Public Interest Registry (PIR) and domain sales).

Actual standard-suggesting work is done in working groups, who formally are organized in “areas” under the IETF. These working groups suggest RFC to the IESG for publication. Formally the working groups have chairpersons, but they only have formal roles.

6Updated by RFC-1349 (Almquist, 1992), RFC-2474 (Nichols, Blake, Baker, & Black, 1998) and RFC-6864 (Touch, 2013), as RFC-791 (Postel, 1981a) is amended to say. Imagine if academic publications were updated ex-post when theory is amended, changed or proven wrong to point to the current iterations of the theory in complete packaging.

<table>
<thead>
<tr>
<th>Org</th>
<th>Board (and IACO (continued by IESG))</th>
<th>Constituents/members</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>IETF</td>
<td>IAB</td>
<td>Everyone interested (practically present)</td>
<td>IETF is the open standards organization connected to the RFC, but also other organizations such as (e.g., ICANN) that are interested in the Internet. IETF is a formal nonprofit and has legal organizational status. The IETF board (the IETF Board of Trustees) is elected by the chapters, the IETF, and IAB. IETF operations (such as the Internet standards process) are conducted by the IETF. The IETF is less prominent than the IRTF. The IETF is in essence the board of IRTF.</td>
</tr>
<tr>
<td>IAB</td>
<td>IETF</td>
<td>Chair, chairs of research groups and at-large members</td>
<td>IRTF is in essence the board of IRTF. The IRTF is less prominent than the IETF. The IRTF is in essence the board of IRTF. The IRTF is in essence the board of IRTF.</td>
</tr>
<tr>
<td>IRTF</td>
<td>IETF</td>
<td>Everyone interested. The IRTF is less prominent than the IETF. The IRTF is in essence the board of IRTF. The IRTF is in essence the board of IRTF.</td>
<td>IRTF is in essence the board of IRTF. The IRTF is in essence the board of IRTF. The IRTF is in essence the board of IRTF.</td>
</tr>
<tr>
<td>ISOC</td>
<td>Board (and IACO (continued by IESG))</td>
<td>Mostly firms (such as Cisco, ComCast, Ericsson and Juniper) but also other organizations such as ICANN and RIPE, the European RIR</td>
<td>ISOC is a formal nonprofit, and has legal organizational status. The ISOC board (the ISOC Board of Trustees) is elected by the chapters, the ISOC, IETF, and IAB. ISOC operations (such as the Internet standards process) are conducted by the ISOC and IETF. The ISOC is in essence the board of IRTF. The ISOC is in essence the board of IRTF. The ISOC is in essence the board of IRTF.</td>
</tr>
<tr>
<td>NomCom</td>
<td>NomCom</td>
<td>Elected (at random)</td>
<td>NomCom is elected through a semi-randomized process (RFC 3797, Eastlake 3rd, 2004). NomCom nominates candidates for IESG (confirmed by IAB), IAB (confirmed by the ISOC board) and IAOC (confirmed by IESG).</td>
</tr>
</tbody>
</table>
[as a Working Group Chair] I have no more influence than anyone else [in the group] on the outcome of our work. At most, I can delay the process by fudging or missing formal deadlines [...] (“Working Group Chair”).

For the purpose of Internet control and disruption, standards are interesting, which means that three IETF groupings are of particular interest: IETF working groups, where standards are de facto created, IESG who approve and edit the RFC stream where standards are published and the IAB who handles appeals and reviews the IESG process regarding standards.

First, IETF working groups. These are open groups where participation is voluntary, making them vulnerable for takeovers. But even if a working group is taken over, any standards (or similar) suggested by that group is up for review by the IESG before publication. In essence, controlling only a working group has no decisive influence in the Internet standards process as a whole.

Second, the IESG has the editorial task of approving and publishing standards, a function which on its own can only stop the publishing of new standards rather than change existing standards.

Third, the IAB handles oversight such as appeals of the IESG editorial process. Controlling the IAB affords the capacity to deny appeals made towards the process.

By controlling the NomCom and the ISOC board it is possible to appoint IESG and IAB and through that completely control the publishing process for Internet standards. In a sense, it is significantly easier to gain control over the IETF standards process than ICANN, but the bigger issue is, does it matter?

As mentioned earlier, the IETF in full does not wield any regulatory or similar power, their standards are their products and it is voluntary to follow them. As explicitly stated in RFC-2026 (Bradner, 1996):

The Internet, a loosely-organized international collaboration of autonomous, interconnected networks, supports host-to-host communication through voluntary adherence to open protocols [my emphasis] and procedures defined by Internet Standards (RFC-2026 (Bradner, 1996))

So even though controlling or taking over the IETF-process is possible as mission disruption; infrastructure and network operator and other actors could ignore the new IETF procedures and standards and ultimately reorganize in a new IETF-like function if needed.

### 6.8 Software error

Most of the root servers use BIND (see Wikipedia Contributors, 2017b), an open source DNS software for DNS servers. In that sense it is problematic
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if the software no longer could be trusted. BIND is currently developed by the Internet Systems Consortium (ISC) through an open source process (see description in ISC, 2017), and this process is considered secure enough by many (“[the process] is good enough” (“Cryptographic Officer”)).

In a pragmatic view, a fault in BIND would allow for issues if not noticed, for example someone could introduce a problem when resolving democrats.org (the website of one of the two major American parties) and rendering the page unreachable through disrupting the name-resolution process. In that sense faults in BIND propagate to the real world. But such a fault would be noticed and addressed by someone.

With DNSSEC taken into account, it would on the one hand be hard to spoof correct domains, but on the other hand easy to fault the DNSSEC info of a DNS request, thereby making the resolved host seem fake or spoofed (see specification in Arends, Austein, Larson, Massey, & Rose, 2005a, 2005b, 2005c; Hubert, 2017). As a technical note, DNSSEC is based on encryption, and by intentionally not following the encryption standards and specifications, BIND could hamper all DNSSEC requests.

Reasonably it would be problematic if BIND was compromised but the software could reasonably easy be rolled back to a safe version if this happens and is noticed by DNS operators. Quite a few actors are involved in maintaining and running BIND, and this, in conjunction with its open-source character, makes it resilient. However, it is possible to imagine that a compromised BIND could cause quite a ruckus regarding DNSSEC until resolved.

6.9 Human error

I was given the surprising nugget of information that human error has been close to causing large issues in central registries, such as missing periods or commas in configuration files. In general, human error is not something that could be discounted as having an influence on the stability of the Internet, but not something the literature prepared for.

Figure 6.1: Comparison of zone-file contents

(a) Correct zone file, including trailing dot
(b) Faulty zone file, missing trailing dot
(c) Expanded zone file, missing dot


Although human error in the long term will not cause disruption of the Internet, it is an interesting mention of an event which would disrupt the Internet. In a technical sense, a corrupt root zone file distributed to and
unnoticed by the root server operators would cause issues once the cached DNS-entries start timing out, in effect disrupting the Internet for most use-cases.

This actually happened for a TLD zone file as described:

Due to [human error] the trailing dot was missing and the TLD was appended to all zone-file entries, which for all intents and purposes broke the system. The zone-file was fixed and [organization behind error] sent out information to flush DNS-caches. ("Cryptographic Officer")

Technically, if the trailing dot is missing from a zone file, BIND automatically adds an origin or default domain to create a Fully Qualified Domain Name (FQDN). A short illustrative example: you are the registry for ".com", which means that your default domain is "com.", and your zone file contains these two top rows in Figure 6.1 (pseudo-format). This would work splendidly since they are FQDN in BIND (i.e. with trailing dot), but b in Figure 6.1 would not, because b in Figure 6.1 would be interpreted as c in Figure 6.1 due to lack off trailing dot and BIND would add "com." (your domain) to all non-FQDN to turn them into a FQDN.

In essence, a missing dot could break the Internet, or the technically correct version, break the DNS-system.

6.10 Infrastructure and network operators

The previous discussions regarding ICANN and IETF concern core functionality such as the naming and numbering system of the Internet, but what about the infrastructure and network operators?

The infrastructure and network operators have the power to shape what the Internet is for the end user since they control the network. One mechanism keeping ISPs and IXPs in check is legislation which could regulate to which extent traffic can be modified, filtered, dropped or logged.

It seems natural to assume, since ISPs in general are commercial wholesalers, that they want to use their competitive advantage to its fullest, and provide their own services rather than a general distribution service. For example, an ISP might be more interested in selling their own streaming service rather than a general Internet based service such as Netflix. It would then be possible for them to downgrade the delivery of the competing service so it becomes useless.

However, as long as there is regulation (either structural, market or policy) in place ensuring that there is no significant packet filtering or other such activity taking place, this should not be a major concern for the future. The business end of packet filtering is usually referred to as net neutrality, and in essence often concerns particular services.
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Horizontal vs vertical integration was brought up as an issue for the future, since the Internet only works if everyone does what they are supposed to do, and actors like Facebook change how services are available since some services are available only for Facebook users. This is problematic since everyone who has access to the Internet does not have access to Facebook.

Interviewee - The important long-term issue here is vertical vs horizontal integration.

Interviewer - Explain further?

Interviewee - What I mean is both on a high service level, do we use Google or Facebook? And on a lower level concerning infrastructure, is the owner of the fiber the only one sending information over it? (“Advisory Committee”)

One issue with both ISPs and IXPs is that regulation is often not appropriate given how the Internet works. The Internet is a best-effort-based packet switching network, which is different from specialized services as is common in telecommunications (“Specialized telecom services and the Internet are very different [!]” (“Advisory Committee”)). As an example, there has recently been a push towards traffic priority for Public Protection and Disaster Relief (PPDR), which is problematic for the Internet since it would require a change in how routing and packet forwarding works, and even getting into the area of net neutrality.

[those pushing for PPDR as a specialized (i.e. not best-effort) service over the Internet] either do not understand how the Internet works, or use it to push their agenda of what they want the Internet to be like [i.e. vertically integrated] (“Advisory Committee”)

The problem is that there is a push from a regulatory perspective to make the Internet into something which can be and should be regulated, rather than the bottom-up coordinated digital end-to-end infrastructure it is today.

Infrastructure and network operators could ultimately change the Internet into something different than originally envisioned, in a sense disrupting the Internet, but would not be able to control the entire Internet.

### 6.11 The international agenda

Several of the interviews turned into forays of international politics and how different world orders are in competition today. One description is that there are two primary world views in conflict today, one promoting an order with coordinated legislation across countries and nations, and another promoting country sovereignty. A coordinated legislation would by necessity require some coordinating function, like the UN.
6.11. The international agenda

Two of the interviewees have different thoughts on the UN and its role in global Internet coordination or governance. On the one hand:

The UN is not democratic, neither are all members democracies nor is representation proportional [to population], [...] the IANA-function should not be under the ITU. (“Advisory Committee”)

And on the other:

ICANN [i.e. the IANA-function] should be under the UN [or ITU] since those are the democratic institutions we have today. (“Legislator”)

These are dichotomous views. Should the ITU (or UN) have influence over central Internet functions because they are the international arena in place today? Or should the Internet stay coordinated rather than governed through international treaties?

Using the vocabulary from non-profit organizations, mission evolution and mission disruption, a transfer from loose formalization and multi-stakeholdership to formalized inter-governmental governance would constitute a mission disruption. The Internet was intentionally not designed that way.

The ITU has previously had consensus on all their agreements [telegraph, telephony, cellphones etc], up till 1988 [WATTC-88, Melbourne], and Dubai [WCIT-2012, Dubai] was the first time all countries did not sign the agreement. Forty five [45] countries chose to not sign; these are the countries who believe in an open Internet (“Advisory Committee”)

In the context of politics, ICANN is in general seen as a good placeholder for the IANA function, since if ICANN did not exist, another organization would become the administrative seat of IANA (as a technical function, regardless of name), and the IANA function could potentially fall into the “wrong” hands. As such, one raison d’être for ICANN is ensuring that no-one else controls the IANA function.

In the context of the world today with changing and dichotomous world orders, the role of the USA is critical. Prior to the 2016 election, the USA could be seen as the de facto leader of the coordinated world order, which included concepts such as an open Internet. Since the 2016 election, the USA is no longer the leader in terms of a coordinated world order, and is in certain areas choosing a sovereign world order, prioritizing national interests over international ones. Over time, this could drastically change the possibilities of having the Internet or an Internet as it works today. Companies taking a big role in the Internet coordination or controlling large parts of a communications chain, as described in Zittrain (2008), are described as just bumps on the road.
6. **Internet social resilience**

rather than real issues. What is said about Google, Facebook, Microsoft, Apple and Netflix today was said about Yahoo and AOL previously.

The only [forces] powerful enough to permanently disrupt the Internet are [nation] states giving up on the coordinated world order and focus on their sovereignty (“Advisory Committee”)

The following is a powerful quote, said with experience from ICANN, IETF, UN, ITU, national regulatory authorities and telecommunications companies, illustrating the problems as perceived by the interviewee:

Do not assume that the Internet as we know it [a digital best-effort end-to-end network] will be around five years from now (“Advisory Committee”)

A practical illustration of the direction of the ITU is the World Conference on International Telecommunications (WCIT) 2012 treaty which intended to put the IANA-function (or similar, in practice the unique identifier coordination mechanism) under ITU and state umbrellas. As previously mentioned, 45 nation states did not sign the treaty. And consequently, the treaty has had little effect on the western world.

Table 6.5: Comparison of unique identifier systems. Illustrative in character rather than fully technically accurate, since the systems differ in implementation.

<table>
<thead>
<tr>
<th>System</th>
<th>Current DNS</th>
<th>DONA handle-system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oversight</td>
<td>EC through multi-stakeholderism</td>
<td>ITU through nation-states</td>
</tr>
<tr>
<td>Maintainer</td>
<td>ICANN/IANA</td>
<td>DONA</td>
</tr>
<tr>
<td>Technical solution</td>
<td>DNS</td>
<td>DOA</td>
</tr>
<tr>
<td>Standard setter</td>
<td>IANA and IETF</td>
<td>DONA</td>
</tr>
<tr>
<td></td>
<td>Standards, i.e. Requests for Comments</td>
<td>Software and upcoming standards</td>
</tr>
</tbody>
</table>

A similar issue was up for debate in ITU Plenipotentiary (ITU PP) 2018, except this time the discussion concerned the handle- or DONA/DOA-system. It is commonly referred to as the handle-system even though the technical name is DOA, and is the system which is intended to handle digital identifiers. As an example, the Digital Object Identifier (DOI)-system is part of the larger DOA concept.
6.12. Conclusions

In essence, DONA (a Swizz foundation) was suggested as the formal organization in charge of naming under the ITU. Rather than ICANN (i.e. as administrative home of the core naming function) under a multi-stakeholder model. Important to note is that the ITU does not recognize ICANN as a formal collaborator (see ITU, 2018). Table 6.5 gives a rough overview of the two systems.

ISOC is critiquing the handle-system and is primarily focusing on the transparency of its governance. In comparison, ICANN/IANA is coordinating rather than governing. Technically interesting is that the handle-system is available as software rather than standards. As such it is more suitable to compare the handle-system to a bundle of DNS and BIND, rather than DNS on its own.

Transparency: Management of Internet resources requires a governance model with a high level of transparency for all of its processes and policies, e.g., how are decisions made, how is its leadership selected, how are MPAs selected and what is their agreement with the DONA Foundation, how are top-level prefixes allocated? Without such transparency it will be hard to gain the trust and confidence of the system’s users. The recent transition of IANA Stewardship illustrates the crucial role that transparency plays in the operation of global Internet identifier systems. To date, this level of transparency has not been implemented by the DONA Foundation in that very little information is available on their website (Internet Society, 2016)

Neither the WCIT 2012 treaty nor the ITU PP 2018 meeting tried to take control over the Internet by using the existing coordination and multi-stakeholder structures, such as ICANN and IETF, but rather by exerting regulatory and policy authority as the arena for international governmental collaboration. An Internet governed by states and the ITU can be considered mission disruption using the previous terminology, since it is not a development but rather a drastic change in coordination methods. Undoubtedly the ITU and handle-system has the potential of altering the Internet more in practice than either a takeover of ICANN or the IETF could.

6.12 Conclusions

In its simplest form, i.e. as a means of end to end digital communication, the Internet is quite resilient, but it can be seen as troublesome that the Empowered Community (EC) structure is not fully populated at lower levels, these vacancies could be used to push policy through Internet Corporation for Assigned Names and Number (ICANN). However, this would only have
long-standing effect as long as the Internet ecosystem considers ICANN as a negotiator for all things Internet since the Internet actors themselves are usually quite clear that they are not contractually bound to ICANN. But since the bylaws for ICANN offer a greater leeway now than earlier for negotiating and collaborating with other organizations, this possibility should not be discounted.

With that said, I argue on the one hand, the short term, that the social resilience of the Internet is high in that no constellation of people or organizations in a short time frame could redefine what the Internet is. But on the other hand, there are long-term pressures which could possibly change how the Internet is organized and coordinated. For example, the bylaws of ICANN have changed from being explicitly just coordinating in its mission (see ICANN, 2016b) and later dropped the explicitness for coordination and rather focus on ensuring a stable Internet function and collaborations (see ICANN, 2016a). Not to be forgotten is that the Internet, given that it is the possibility of end-to-end communication using standards agreed upon by the users, stops being the Internet as soon as it is regulated rather than coordinated.

The reason for the Internet’s basic resistance is that coordination is based on mutual acknowledgments, i.e. that power in some sense only exists if recognized and no central authority exists, and that if malicious actors appear, they can be ignored if their maliciousness is recognized. Even if someone assumes the power in ICANN, it should be possible to reorganize basic Internet coordination in another forum, although ICANN could possibly retain its political standing with non Internet actors which would create long-term issues as just mentioned.

Neither should BIND nor other Internet infrastructure-essential software, although reasonably resilient, be considered non-problematic since it might be possible to manipulate the software to serve someone’s purposes.

The larger issues, from an Internet resilience perspective, are international policy pressures, such as sovereign world orders and members of the International Telecommunications Union (ITU) pushing for increased influence and control over central naming functions.

To answer the initial research questions in an orderly fashion:

**How can the Internet be controlled through social means?**
There are no existing entities in control of the Internet, and as such a venture into controlling the Internet by taking over an existing organization will not succeed.

As such, an actor controlling the mission evolution of the Internet is improbable.

**How can the Internet be disrupted through social means?**
Takeover of ICANN would ultimately cause hick-ups in Internet opera-
tion, mainly through Internet Assigned Numbers Authority (IANA) and its position as Domain Name System (DNS)-root, but permanent disruption is unlikely. In comparison, a takeover of the Internet Engineering Task Force (IETF) would have less practical impact, and the processes done under the IETF umbrella could simply be done elsewhere.

The larger issue arises from external pressures, in a sense pressures which do no want the Internet to be Internet but rather a regulated entity under, for example, ITU, state or other multilateral governance. This can be illustrated by the World Conference on International Telecommunications (WCIT) 2012 treaty and the suggested handle-system at ITU Plenipotentiary (ITU PP) 2018.

As such, mission disruption is possible by external pressure since the intrinsic values can change over time.
7 Internet and net neutrality

*The Internet lives where anyone can access it.*

— Vint Cerf

Notes

An earlier version of this chapter was discussed at the 13th PhD Seminar at ITS 2018 in Trento as a standalone paper (not publicly available). The chapter ends with remarks from a conference contribution to net neutrality and business models (in the sense of how business do business).

This chapter shows general website use of the Internet and how that potentially can change under different net neutrality regimes. The chapter also suggests a matrix for identifying different net neutrality regimes for digital communications networks.
Abstract

Net Neutrality, a highly debated topic both in academic and public settings, is often neither defined nor nuanced, and neither is the Internet. This paper bases the Internet on its base coordination and technical aspects, and offers a definition for Net Neutrality given these technical and coordination dimensions of the Internet: "traffic perceived as de facto treated according to agreed standard absent potential harm to networks or their users." This definition differs from the common view of Net Neutrality as a last-mile concept of price discrimination, since packet discrimination can happen anywhere on the Internet and not just at the last-mile. The Internet today is best-effort end-to-end, where the network itself, mostly, does not add or capture value of the traffic, a notion which is challenged today with concepts such as price discrimination. A deep look into one website and an overview of websites is used to illustrate the end-to-end notion of the Internet in practice, in essence that the business ecologies in place today are not probable without the notion of the end-to-end principle (i.e. a best-effort “stupid” network).

This text further argues that the issue with Net Neutrality for the Internet is not regulation for or against, but rather regulation and policy as such since the Internet in general is coordinated by other means than policy. Any policy not emanating from the coordination mechanisms of the Internet itself will ultimately challenge and potentially change the notion of the Internet as it is today. This paper, based on Net Neutrality literature, Internet governance and coordination literature and a technical overview of the Internet, suggests a typology for digital communication networks with four distinct quadrants based on coordination and de facto Net Neutrality: “early Internet” for end-to-end net-neutral networks devoid of government policy, “regulated Internet” for networks upholding net neutrality with the help of government policy, “regulated telecom” for networks without de facto net neutrality supported by government policy and “market Internet” for networks dominated by market forces. According to this typology, the Internet started out as “early Internet”, and in the EU with BEREC guidelines today, has moved into the “regulated Internet” quadrant. Comparably, in the US, moved into “regulated Internet” and took a turn towards “market Internet” with the recent deregulation. China fits into “regulated telecom”, where policy guides and controls the network, in essence without the end-to-end principle intact in that the network concerns itself with that which is transferred on the network (such as filtering, dropping or modifying traffic). Also important is that the Internet is not coordinated to elect representatives to act on behalf of the Internet for political purposes, and therefore it should not be expected that the Internet is represented in policy debates concerning Internet policy at state or international level.
7.1 Introduction

The Internet is often assumed or implicit, both in scientific contexts and in our daily lives. But can we really take it for granted? And how does net neutrality affect what the Internet is?

A literature overview shows the Internet and its coordination mechanisms in a governance or policy lens, i.e. how should regulation, policy and laws govern the Internet, rather than looking at the Internet as an intentionally bottom-up coordinated digital communications infrastructure for end-to-end communication. This framing (or thought collective as this text argues, see Fleck, 1935) is in direct conflict with the notion that the Internet is governed in a regulatory or policy sense.

In this text I start with the ideas behind the Internet and its coordination mechanisms, propose a definition for net neutrality, show parts of the Internet involved in browsing the web, frame the current net neutrality debate, go through a selection of net neutrality literature and sum up the differences between the web as it works, the debate and the literature and reason about consequences.

Unbeknownst to many, the International Telecommunications Union (ITU), a multilateral telecommunications organization coupled with the United Nations (UN), proposed a treaty at the World Conference on International Telecommunications (WCIT) at Dubai in 2012 suggesting, simplified, a nationalization of the Internet. A majority of ITU members (most of them UN members) signed the treaty. In short, Western Europe and North America did not sign the treaty, so the context or the norm of this text is a world where our heads of state did not want the Internet under the influence of the ITU (and in the end sovereign states), but rather that the governance structure stayed a multistakeholder model.

Technically the suggestion at WCIT 2012 implied that the central naming function (i.e. the Internet Assigned Numbers Authority (IANA) function) under the supervision of Internet Corporation for Assigned Names and Number (ICANN) should be under the umbrella of the ITU, a notion contrary to the multi-stakeholderism ideas behind ICANN.

The ITU Plenipotentiary (ITU PP) conference in Dubai the fall of 2018 continued partially on the track of WCIT 2012. The focus was on which organizations the ITU was to formally collaborate with. In short should either the existing Internet naming structures (i.e. ICANN, IANA, Domain Name System (DNS) and top-level domain (TLD) systems) or the proposed handle-system (i.e. Digital Object Numbering Authority (DONA) and Digital Object Architecture (DOA)), both of them or none. ITU has since the birth of the Internet become less relevant in terms of influence (i.e. wired phones and telegraphs are used less), and the handle system can be seen as a way to make the ITU relevant again (see Farhat, 2017, important to note is that even though cellphone usage is increasing, cellphones are often using the Internet
rather than provider specific services). In the end neither group was added to the formal documents describing the path forward for ITU members.

Table 7.1: A comparison of the competing naming systems.

<table>
<thead>
<tr>
<th>System</th>
<th>ICANN/DNS</th>
<th>DONA/DOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>“multi-stakeholder”</td>
<td>ITU</td>
</tr>
<tr>
<td>Naming</td>
<td>ICANN via IANA</td>
<td>DONA</td>
</tr>
<tr>
<td>Technology</td>
<td>DNS</td>
<td>DOA</td>
</tr>
</tbody>
</table>

The ITU is an intergovernmental treaty organization (i.e. nation states are members) while ICANN has a wider approach where most entities, organizations or people can have input in a formalized multi-stakeholder process. This has led to the Internet community quite explicitly condemning the DONA/DOA/handle-system, as can be exemplified by

there is concern that the system will be captured by governments and subject to geopolitical concerns (Internet Society, 2016)

in a recent Internet Society (ISOC) report. At a technical level DNS is the de facto standard for Internet resources such as domain-names, while DOA is used for some resources and is mainly known through the use of doi as academic article identifiers.

Recently in what can be seen as a step in the same direction, the United States commission for among other the Internet, the FCC, voted for the repeal of the net neutrality regulation put in place 2015. In practice this meant reclassifying the Internet as a "Title I Information Service" (such as cable TV) rather than a "Title II Common Carrier" (such as telephony) in accordance with American\(^1\) regulation. There are texts, such as Coldeway (2017) and Electronic Frontier Foundation (2017), which argue that this reclassification does not make sense, and I will in this text join them, given how the Internet works and as I describe it with my web-page examples, it does not make sense in that the Internet as such is rather a network of carriers than a cable service provider. This text goes further and suggests that the important issue is not net neutrality vs not-net neutrality in the regulatory sense, and instead suggests that regulation as such is the issue given the coordination of the Internet.

This text aims to answer and describe net neutrality in the perspective of the bottom-up-coordinated constellations of networks that is the Internet, and provide guidance for treating the Internet, regardless of the goal (such as keeping the coordination voluntary bottom-up or if tougher top-down regulation is required).

\(^1\)I.e. US regulation
Conclusions include that the last-mile centered view on net neutrality prevalent in both public debate and current academic literature illustrates one dimension of the larger issue of the best-effort network that is the Internet, but leaves the larger issue of all parts of the Internet which are not last-mile untouched.

I end this text with stating that the problem might not be of the character “we should regulate with X” or “we should regulate with Y” but rather whether the current implementation of policy and regulatory systems is at a high level compliant with the current Internet Coordination mechanisms in place today. Perhaps we need to look in other directions for internationally viable solutions?

7.2 Terminology, background and agenda of the researcher

This text puts light on multiple thought collectives\(^2\) and arguments. And to make those as clear as possible, I include both the terminology I use, my background and the context in which this text was written.

Where applicable, I use the technical terminology to avoid confusion. One such example is the technical term Autonomous System (AS), which for most intents can be translated to Internet Service Provider (ISP), but in an Internet perspective, routing involves ASs, not ISPs.

I also avoid the ambiguous term “bandwidth”, due to its ambiguity with a part of a frequency spectrum or throughput, but for example Wu (2003) does not discriminate between throughput (bit/s) and bandwidth (Hz). To avoid confusion, I will use throughput to indicate the magnitude of data transferred per time-unit, and reserve bandwidth for representing a part of a frequency spectrum.

I refer to the term “bit (rate) distance product” once in a throughput argument in this text, it refers to the product of distance and bit rate for a transmission technology, which often is constant (i.e. longer distance means slower throughput and vice versa). In Table 7.2 I present numbers from Farjadrad (2014) which show the problem of “technology neutral” policy since fiber solutions are three to four magnitudes better in technical sense (i.e. an optic fiber can carry the same data a thousand to ten thousand times faster over the same distance as copper).

This text is written in a Western context, with the Internet typically being packet neutral. I have been practicing software engineering in a Swedish context, where net neutrality is part of the norm (and regulation), which can be seen both as Sweden is part of the EU with the BEREC-guidelines, and as the local legislation the Swedish electronic communication regulation (see “SFS 2003:389”) charges network operators with delivering electronic

\(^2\)Roughly perspectives, see explanation later in this text.
7. Internet and net neutrality

Table 7.2: Comparison of digital communication technologies regarding bit rate distance product. Data from Farjadrad (2014).

<table>
<thead>
<tr>
<th>Technology</th>
<th>Gbit m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper ethernet</td>
<td>500</td>
</tr>
<tr>
<td>Coaxial</td>
<td>1000</td>
</tr>
<tr>
<td>Single mode fiber</td>
<td>10 000 000</td>
</tr>
</tbody>
</table>

communication to the best of their ability, and that there are exemptions to this rule only when traffic can be considered harmful to users or networks. In comparison, US no longer has net neutrality specific interpretation for the Internet. There, the Internet can, in a policy perspective, be compared to cable-TV.

This text uses the vocabulary of Fleck (1935) to describe and reason regarding perspectives and viewpoints. Fleck (1935) introduces two terms, thought style, how an individual reason and create facts / reality / truth, and thought collectives, how collectives such as scientific fields agree on how scientific fact is created. Kuhn (1962) draws upon the changing thought collectives of Fleck (1935) to describe paradigm shifts.

This text, in a semi-controversial manner, starts off with my thought style and the respective thought collective or perspective of the Internet, its governance and relation to net neutrality, and from there goes on to contrast my thought style with that of the academic literature, which is commonly framed in a telecom perspective, and with the public debate.

Do note that thought styles are not opinions per se, but rather the construct of how fact and context is created. As an example, a legal scholar might find a scientific endeavor on how to interpret a certain law passage meaningful, while a management scholar might consider the same endeavor much less interesting since laws and regulatory frameworks are just one factor influencing organizational behaviour. Fleck (1935) also puts emphasis on what is necessary to create that which can be considered scientific fact. For example, quantitative behavioral sciences using frequencist methods require a \( 2\sigma \) cutoff for rejecting the null hypothesis, while particle physicists require \( 5\sigma \), a five thousand times tougher cutoff value, while a qualitative business scholar might consider them both to be nonsense since numbers cannot represent the actual inner workings of an organization.

I use thought collective as a stronger expression than perspectives, opinions or views. I consider the latter expressions to be temporary, i.e. “I used to have Opinion X, but now I have Opinion Y”, but thought collectives and thought styles are fixed in their nature and describe the entirety of one’s process of

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\(^3\)\(2\sigma\) corresponds to a 5% cutoff for rejecting the null, while \(5\sigma\) a \(3 \times 10^{-7}\) cutoff.
creating or validating opinions, perspectives, facts and views. A thought style can be described as “this is how I make sense of the world”, and it does not change without need (cf. paradigm shift in Kuhn, 1962).

Fleck (1935) also discusses the concept of incommensurability, at its core the notion that different thought collectives cannot agree on what is fact, which can be understood as that it is very possible that even scientific fields cannot agree on what is true (fact) or not. Compare to the earlier $2\sigma$ vs $5\sigma$ vs “numbers are not relevant” example, even though different methods might create fact within thought collectives that fact might not be fact in other thought collectives. Then that fact is incommensurable in those thought collectives.

7.3 The Internet

As mentioned in my earlier work (i.e. Chapter 5) the Internet is seldom described in detail, which can lead to demarcation issues when discussing what the Internet is and is not. For the purpose of this text I am using my previous description (see Chapter 5):

a set of protocols for digital end-to-end communication affected by its users (Chapter 5)

There are two important explicit parts of this: first, the Internet is not only an infrastructure but also has a notion of its coordination, and second, the Internet is governed, or affected, by its users, i.e. explicitly bottom up.

In this text the Internet is used as above, which means it is different from the web (a service on the Internet). Also important is that my description is devoid of technical specification, which would not be meaningful since it would boil down to technical hairsplitting (i.e. is a device which cannot route to the entire Internet part of the Internet or not?) and not add anything meaningful to the discourse (see Lehr et al., 2018, who draw similar conclusions on the futility of seeing the Internet as only technical). The duality of my perspective describes the Internet as the concept of a bottom-up-governed digital communications network, of which our current digital communications network stemming from the IANA root can be considered one instance among many possible incarnations.

Also, for my argument, the technical structure of the Internet is not terribly interesting (but important to understand); the coordination mechanisms on the other hand are. As an example, the management of the entirety of the dot-se domain is delegated to a Swedish organization by a document of a handful of pages which explicitly states that the parties are not bound by any liability (see the agreement itself, Aerts, 2007).

4I.e. every address ending with .se
7.4 Net neutrality in practice

In most western countries net neutrality is the norm, and my experience from asking people is that many have not considered an Internet with such limitations, but from time to time the concept has been challenged. In Europe net neutrality is regulated (by EU directives, see Berec, 2017, and often in national law, such as the case in Sweden), in the United States net neutrality has never been in the law, but rather under the supervision of the FCC, who from early 2015 until late 2017 had rules with regard to net neutrality.

According to Seward (2014), a journalist, who hints at being an inside source, and collaborated by other sources such as Morran (2014), Comcast started to “slow” down Netflix’s traffic in 2013 into the Comcast network, therefore lowering the quality of Netflix’s streams for Comcast customers. In March 2014 a deal signed by Netflix to pay Comcast for not slowing down traffic (Morran, 2014; Seward, 2014).

Netflix is supposed to have similar arrangements in place with Time Warner Company, AT&T and Verizon, i.e. Netflix paying the network operator to not intentionally slow down their traffic, which is supported by Seward (2014) and Erickson (2014), both journalists.

The conflict between Netflix and Comcast is said to have been one of the main reasons behind the FCC 2015 ruling enforcing net neutrality in the United States, which meant reclassifying ISPs as common carriers under Title II (see Wikipedia Contributors, 2018, for overview). The FCC 2015 ruling in turn was abolished in late 2017 by FCC, and at the time of writing the net neutrality regulation is repealed in the US at a federal level but enforced in several states by state law.

In general terms, net neutrality violations are said to affect one in five Internet users in Europe (Berec & European Commission, 2012; Karr, 2017), usually noticeable in services such as VOIP, P2P and gaming. Karr (2017), a journalist, presents a comprehensive list of mostly U.S.-centered net neutrality violations, and insinuates that the same behaviour could be considered normal in a western context, insinuations which the findings of Molavi Kakhki et al. (2015) back up.

My personal experience is that violations of net neutrality occur much more frequently on cellular connections than wired access. As an example, I often unscientifically experiment with YouTube on a computer and a cellphone with a hotspot (vast majority of cases mainland Europe, in essence a layman’s version of Molavi Kakhki et al., 2015, who conducted rigorous scientific testing on the subject). The results are usually as shown in Table 7.3.

In Table 7.3 “Connection” refers to either cellular, which is using my cellphone as a hotspot for my computer, or wired which refers to some kind of wired connection for Internet access (i.e. my connection might be Wi-Fi, but I know that from the other end of the router the connection is wired). With “Service” I refer to either watching an HD-stream on YouTube or downloading
7.4. Net neutrality in practice

Table 7.3: Net neutrality and cellular throughput

<table>
<thead>
<tr>
<th>Connection</th>
<th>Service</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular</td>
<td>website</td>
<td>As expected</td>
</tr>
<tr>
<td>Cellular</td>
<td>YouTube</td>
<td>Lower than expected</td>
</tr>
<tr>
<td>Wired</td>
<td>website</td>
<td>As expected</td>
</tr>
<tr>
<td>Wired</td>
<td>YouTube</td>
<td>As expected</td>
</tr>
</tbody>
</table>

a website in full to my computer. And for avoidance of doubt, my cellphone contract does not specify any clause regulating different throughput for different services, neither at home nor abroad. “Throughput” is relative, either as expected or lower than expected, and measured as the raw data throughput on my computer.

The results can be interpreted as I always get the same throughput for YouTube and website browsing when on wired connections; such as at home, office, cafés and other public Wi-Fi spots. But when using my cellphone as a hotspot, I get different throughputs depending on application, i.e. YouTube gets throttled. Important to note for this experiment is that I am watching a high quality stream on high resolution on my computer and forcing a high bit-rate by setting the YouTube-video quality to high manually.

These results are similar to Molavi Kakhki et al. (2015) and an indicator that it is not impossible for the interested Internet user to detect net neutrality infringements.

Logically it makes more sense for an ISP to throttle video data than any other kind of data on cellular devices due to the displays being quite small. Ergo the lower quality might not be noticed by the end user, and many of the European net neutrality violations mentioned by Karr (2017) and measured by Molavi Kakhki et al. (2015) are of this kind, which indicates that the average user might not notice the infringement.

The curious reader might want to try the app Wehe, an app for detecting net neutrality infringements. The app measures differences between certain services, such as YouTube, Skype and Spotify, and compares it to raw throughput, in essence like Table 7.3.

These examples are of last-mile throttling or blocking, and technically it is possible to throttle or congest traffic in transit as well, i.e. between networks in the Internet when transferring data over long distances. A couple of years ago when I was working as a software engineer, I needed some data, roughly 30 GiB, to my laptop when I was travelling in the U.S. and the data was at our server location in Sweden. Fetching the data directly (with either SFTP or HTTPS) gave me throughputs in the vicinity of 1 Mbit/s, i.e. a complete transfer time of almost three days (!). I solved this by uploading
the compressed (and encrypted) file to Google-drive from the server, and then downloading it from Google-drive to my laptop in the U.S., and then averaged upwards of 1 Gbit/s upload to the server, and a download of closer to 100 Mbit/s. Ergo I could by using the parallel (transit) network of Google transfer my file across the Atlantic in an hour rather than three days. In this case, congestion did not occur at the last-mile, but somewhere closer to transit across the Atlantic ocean. This type of congestion remain untouched in non-technical literature. This is also part of the reason organizations transfer large amounts of data with services such as the AWS Snowmobile\(^5\), which literally is a large truck full of drives, since transferring data over the Internet is too time-consuming.

Previous examples have been centered around throttling throughput, i.e. in practice often limiting quality for video-streams, but there are other ways to infringe net neutrality, such as blocking traffic entirely, delaying traffic or setting data caps\(^6\), which I will discuss further.

A current data cap example: Tesla. Currently, their vehicles regularly communicate with central servers to both upload and download significant amounts of data (such as diagnostic data and firmware). In others words their business model is based on a working Internet connection without caps. A repeal of net neutrality, ergo that ISPs might charge differently for packets to and from different destinations, as well as setting data caps, would hamper such business models. And in this case, a net neutrality repeal might not only lead to lower quality video-streams but to vehicles on the roads with potential vulnerabilities since they do not receive the intended patches and firmware upgrades. As an example, Xfinity (Comcast’s ISP brand) has an 1 TiB/month cap (Xfinity, 2018), and Tesla cars are reported to upload above a GiB per day after a patch in the fall of 2017 according to forum posters Dakine1 (2017) and Balance~ (2017). An illustrative quote regarding Tesla cars and net neutrality:

What percentage of $100K car owners have data caps at home

[...]

Owners in a Comcast area... (Balance~, 2017)

In a world where net neutrality is not the norm, it would be probable that Tesla would have to enter into contractual agreements with ISPs in all countries where their cars are legal to ensure proper firmware version and security patching. One notion here is that they should, like any business transaction, pay for what they need explicitly. The other notion is that the Internet should be sender and receiver agnostic and therefore neither Tesla nor their customers should be required to enter into specific agreements. Also,

\(^5\)See https://aws.amazon.com/snowmobile

\(^6\)In general data caps are not thought of as net neutrality infringements, but the formulation of my net neutrality definition suggest that they are.
creating these agreements would take time and effort so it is also probable that firms bundling and/or brokering access will pop up. I.e. instead of having to enter into agreements with infrastructure and network operators directly the device manufacturer could enter into an agreement with a proxy partner.

Or, as later shown with the automated advertisement ecology surrounding websites, perhaps the buy and sell sides of network access become automated. For example data consumers such as Tesla and Netflix go together and organize an automated buy side which buys traffic when prices are the lowest, much the same as the electricity spot-market.

From a personal perspective I have routinely asked firms I have come into contact with what would happen if net neutrality would be abolished in practice. And surprisingly, even high level managers for firms selling cloud services lack good answers. For avoidance of doubt, cloud service providers are dependent on that reaching the cloud is not more complicated than reaching an in-house server, as it probably would be if agreements were needed to reach the cloud provider.

To build on the last paragraph, a concrete example of where the value capture for ISPs and networks depend on net neutrality: Internet-of-Things (IoT). Not all IoT devices are dependent on high throughput and low latency, but still add significant value to the operator which the network operator might be inclined to capture part of in a non-net neutrality world.

7.5 Net neutrality in literature

The majority of well cited net neutrality research is anchored in an economics perspective, as can be discerned by a Google Scholar search on “net neutrality” (Google Scholar ordering is roughly comparable to number of citations). In this case Google Scholar proved harmful by implicitly hiding non-economic literature on net neutrality due to the high amounts of citations for the economic net neutrality literature.

As earlier mentioned, literature on net neutrality mostly focus on economic aspects of net neutrality in general and the economics for network owners and operators in particular. Common terms are “investment incentives”, “two-sided markets”, “vertical integration” and “price discrimination”. Examples of such literature is Choi, Jeon, and Kim (2015), Hahn and Wallsten (2006), Lee and Wu (2009), Litan and Singer (2006), Musacchio, Schwartz, and Walrand (2009), Peitz and Schuet (2016), Pil, Kim, and Choi (2010), Wallsten and Hausladen (2009). These articles do not explicitly differentiate the Internet from other networks, but implicitly acknowledge that the Internet is a unique network.

I have found no literature on relations between net neutrality and Internet Coordination, i.e. on the topic of coordinating and controlling the Internet (except one of my earlier conference papers, i.e. Lindeberg (2017b) (which
became Chapter 5), in which I touch net neutrality briefly, although there is literature on the subject of Internet Governance and net neutrality, in which the Internet is portrayed as a technical (but undefined and unexplored) phenomenon governed by regulation and government policy, a thought style I disagree with. Examples in this literature stream are Musiani (2012) and Mueller, Cogburn, Mathiason, and Hofmann (2007) who discuss net neutrality as an Internet Governance issue, although not differentiating Internet Governance from any other policy issue and is similar in reasoning to texts such as Cheng et al. (2011) and Litan and Singer (2006), much as is argued by van Eeten and Mueller (2012) (that literature which concerns the governance and coordination of the Internet often does so implicitly).

Nor have I found explicit literature on net neutrality and its impact on organizations; the closest I have found is literature such as Litan and Singer (2006) who quite broadly state that the Internet has been beneficial to economic growth but that net neutrality is harmful for the Internet (and broadband penetration) and therefore would hurt firms, without explicit reasoning on how and why it would hurt firms. Searches on "Internet business model" and similar give large sets of academic texts on the subject of how firms can use the Internet to improve their business, but in general these articles do not discuss nor problematize the Internet in detail, but assume the Internet to be the same regardless of location (for example Amit & Han, 2017; Berman, 2012; DaSilva & Trkman, 2014; de Reuver et al., 2017; Hagberg, Sundstrom, & Egels-Zandén, 2016; Jesse, 2018; Porter, 2001; Subramanian, 2017; Zott, Amit, & Massa, 2011).

In my reading, the economic literature tends to agree that a repeal of net neutrality would benefit infrastructure and network operator (in practice ISPs) and hurt content middle men (such as Netflix and YouTube), but I can find no agreement on consequences for Internet users. The conclusions of texts such as Cheng et al. (2011) and Economides and Hermelin (2012) boil down to differently formulated versions of "it depends", since net neutrality and what a repeal of net neutrality would entail is in practice not well-defined.

Interestingly not explicitly mentioned is the progress of time, which should be of interest in a world affected by Moore’s law, and the natural increase in throughput over time should be mentioned. In general, by looking at the specifications of access technologies such as copper Ethernet, fibre Ethernet, DOCSIS and xDSL, possible throughput increases in the vicinity of 50 percent year-on-year. Of particular importance is that copper technologies (such as Ethernet and DOCSIS on coaxial (cable TV)) have reached their practical ceiling in terms of throughput over a meaningful distance (i.e. more than a couple of meters) due to the nature of attenuation (see Farjadrad, 2014, and earlier bit-rate distance product table, Table 7.2).

None of the above mentioned texts reasons that the Internet should be considered to be anything else than a service offered by a network operator (c.f. Berghel, 2017; Cheng et al., 2011; Choi et al., 2015; Cook, 2014; Economides
7.5. Net neutrality in literature

Figure 7.1: A representation of the models of Cheng, Bandyopadhyay, and Guo (2011) and Economides and Hermalin (2012). The middle node represents the networks owner (i.e. the ISP), the top right (yellow) represents and Internet user connecting to a service with potential competitors (the other three nodes). These models are used as a simplified model of the Internet.

The literature (Hahn & Wallsten, 2006; Hylton, 2017; Kourandi, Krämer, & Valletti, 2015; Lee & Wu, 2009; Litan & Singer, 2006; Musacchio et al., 2009; Peitz & Schnett, 2016; Pil et al., 2010; Reggiani & Valletti, 2016; Tan et al., 2018; Wallsten & Hausladen, 2009; Wu, 2003), which is a vastly different perspective than the primary perspective in this thesis, and in turn does not take into consideration that very few Internet-based services in practice consist of traffic between one sender and one receiver, but rather, as shown with examples later in this text consist of a “starting point” for a service (such as a website) but for actual service the user connects to different networks and hosts to fetch different parts of the service.

One such example is Netflix, the website is not at the same server as the video-data. Another, online-gaming; for many games to function properly the user often needs to be able to connect to several networks because the other gamers might not be on the same network. This is important since the net neutrality-debate and literature assumes that traffic starts at specific services, and it is meaningful to categorize which service a packet came from. But in reality if a user visits both dn.se and svd.se (two competing Swedish news agencies), the user would get traffic from hosts providing services for both dn.se and svd.se and the ISP would have to work backwards to find out if one particular image belongs to an ad served on behalf of svd.se or dn.se. This is problematic for ISPs who favor price differentiation, since today there is no readily accessible way for the ISP to discern whether traffic coming from Host X who serves both Service A and Service B is from Service A or Service B. And as shown later in Table 7.5, the majority of data from a normal news-
site does not come from the site itself, but rather other hosts presumably providing auxiliary services such as ad distribution, as Host X in the previous example.

There are three articles of particular interest, Wu (2003) as the origin of net neutrality and the issue, Economides and Hermalin (2012) as a well-cited net neutrality and economics paper and Hylton (2017) for a legal perspective.

Wu (2003) is seen as the first mention of net neutrality, and although there are significant technical shortcomings in the article, the conclusion, that net neutrality should be considered a goal and not a regulation is something I can relate to and discuss in greater detail. He also clearly points to the dangers of not using well-defined terminology and suggests that his paper is merely a foundation which to use for further discussion. In my view the technical shortcomings are severe in that the article uses bandwidth in three different senses, where one is vaguely technically accurate. The article also notes contractual differences between xDSL (i.e. “telephone-line based”) and DOCSIS (i.e. “cable-tv based”) subscriptions without realizing that the differences are all based on the technical nature of the connection. DOCSIS-subscribers share their throughput (and bandwidth in this case) while xDSL subscribers have their own wire and do not share their throughput. In general terms, Wu (2003) suggests the following net neutrality regulation formulation:

absent evidence of harm to the local network or the interests of other users, broadband carriers should not discriminate in how they treat traffic on their broadband network on the basis of inter-network criteria. (Wu, 2003, p. 168)

Economides and Hermalin (2012) uses the model in Figure 7.1 to reason in regard to effects of net neutrality or no-net neutrality. As shown later in Figure 7.2, I think that model is too simple to properly illustrate the complexity of a network such as the Internet. Interestingly, the text assumes that ISPs do not produce their own content and implicitly compete with the Internet offer, which is contrary to the situation experienced in for example the US where cable-owners are offering competing services such as cable-TV and phone services, but the text does not go deeper into whether the network owner and the ISP are the same. Economides and Hermalin (2012) also assumes congestion, i.e. that the network normally is full in some sense.

Economides and Hermalin (2012) briefly states some actors and their stance on net neutrality (presumably net neutrality as regulation in the US rather than a wider concept or norm) which conforms with the notion that firms considered Internet firms are pro net neutrality (examples given are Google, Skype, Amazon, eBay and Microsoft) and firms considered telecommunications companies are against net neutrality (Cisco Systems, and telecom and cable companies). Later texts often use YouTube and Netflix as examples of pro net neutrality and cable companies as no net neutrality. Hylton
(2017) concludes in a law perspective that in theory the net neutrality norm might be socially desirable, but in practice there are better solutions which are, interestingly, not explicitly mentioned in the paper. His conclusions are in part based on inaccurate assumptions of Internet function and ISP pricing. For example, he compares net neutrality with a bridge where cars and trucks have to pay the same price even though they cause different levels of maintenance, i.e. cross-subsidization. But net neutrality more accurately is whether all trucks have to pay the same price regardless of origin to access all roads (i.e. not only one bridge), because net neutrality more than well allows for different price levels depending on wanted throughput (i.e. car vs truck). I will restate the last sentence, net neutrality allows different price levels for different consumption levels, what net neutrality does not allow is different price levels for the same consumption for different services. Net neutrality is service or use agnostic, not throughput agnostic. As an example, an ISP might very well charge €~30/month for 100Mbit/s while charging €~50/month for 1000Mbit/s. Another problematic statement is that Hylton (2017) uses that Netflix on average have a financially stronger userbase than the average American as an argument that net neutrality in general is a transfer of wealth from the poor to the rich, where there is a significant problem with the first part; he is proxying the entire Internet via Netflix, one service provided by one actor. This in essence only is a meaningful comparison if the only thing you could do with the Internet is watch IPTV and all ISP subscriptions fees are the same regardless of promised throughput.

Neither Wu (2003), Economides and Hermalin (2012) nor Hylton (2017) define or describe the Internet concisely, even though they all argue for the need of good and usable definitions and descriptions. Mansell (2012) argues that such lack of definition and conciseness stems from the technical and domain-specific nature of the Internet, and that it is not reasonable to assume that lawmakers or academics in non-technical fields should wield such expertise.

In particular, the mentioned literature is interesting in how network (i.e. AS) peering (i.e. interconnectivity) is mentioned and used, and as argued in Choi et al. (2015):

To the best of our knowledge, we are the first to explore implications of net neutrality in the framework of two-sided markets with interconnected and competing ISPs. Choi and Kim (2010) analyze the effects of net neutrality regulation on investment incentives of a monopoly ISP [...]. Economides and Hermalin (2012) derive conditions under which network neutrality would be welfare superior [...]. As these papers consider a monopolistic ISP, the interconnection and competition issues do not arise. (Choi et al., 2015, p. 108)
### Table 7.4: Comparison of networks (technically AS and entities used or accounted for by different sources)

<table>
<thead>
<tr>
<th>Source</th>
<th>Nr of AS</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economides and Hermalin (2012)</td>
<td>&gt;1100000</td>
<td>Routing relevant entities</td>
</tr>
<tr>
<td>Choi, Jeon, and Kim (2015)</td>
<td>&lt;64000</td>
<td>All assigned VS</td>
</tr>
<tr>
<td></td>
<td>&lt;1500</td>
<td>Weekly use</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>Visiting a news site and reading two articles requires almost twenty networks.</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Reading two articles as Internet addresses almost seven networks.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>The model includes peers between two networks for content delivery.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Does not include peers; i.e., one ISP is the entire network.</td>
</tr>
</tbody>
</table>

The Internet according to BGP-announcements. See Table 3.6 for more detail. The model includes peers between two networks for content delivery. A week of Internet use at home required in the ballpark of one hundred. Ad-blocking is based on networks which devices on my home network tried to resolve and not necessarily successfully resolved.

RFC-6793 (Vohra & Chen, 2012) for more detail. The model includes peers between two networks for content delivery. The model includes peers between two networks for content delivery. The model includes peers between two networks for content delivery. The model includes peers between two networks for content delivery. The model includes peers between two networks for content delivery. The model includes peers between two networks for content delivery. The model includes peers between two networks for content delivery.

IPv4 address (32-bit unsigned integer) is the same as the maximum number of ISPs or ASNs. Today the maximum number of ASNs is the same as the maximum number of IPv4 addresses (32-bit unsigned integer) in the ballpark of four billion. See Table 3.6 for numbers and Figure 3.5 for graphical illustration.
This is interesting from an Internet perspective since the whole idea of the Internet is peering between networks, or as RFC-2026 (Bradner, 1996) frames it; “The Internet, a loosely-organized international collaboration of autonomous, interconnected networks, supports host-to-host communication through voluntary adherence to open protocols and procedures [...]”. In Table 7.4, I compare the number of networks used for various models and tasks. As seen, during an average week at home I needed roughly a thousand more networks than the model of Economides and Hermalin (2012) accounts for. I suggest that the assumptions of Economides and Hermalin (2012) and Choi et al. (2015) are not without contention, in that normal Internet use needs significantly more networks than the contemporary models account for. From where I stand, it plausible that the models of Economides and Hermalin (2012) and Choi et al. (2015) would become too complicated when modelling the entire Internet with its several tens of thousands of networks (or millions of networks including routable entities such as prefixes), which might be one of the reasons for the focus on last mile congestion and price differentiation for last mile.

This is an inaccurate simplification, and ad real-time bidding implementations might prove a fruitful exercise in what a price-differentiated Internet could look like.

Real-time bidding for online ads is a “catch-all” umbrella for automated online advertisements and their actors, mostly condensed into browsers (the customers), supply side platforms (those who supply the customers), ad exchanges (where supply meets demand) and demand side platforms (those who have the ads) (see Stange & Funk, 2014, for an extended overview). When a user through a browser tries to access a website, the server, will while the user is loading the page, contact a supply side platform and say something along the lines of “I have a client here with Facebook cookie XYZ, Google cookie ABC, IP: this and that, etc”. The supply side platform will then format this information with the information required to put this on the exchange such as floor price, blacklists (such as no travel ads or no sex toys) and whitelists (i.e. requiring for example a travel or taxi ad). This information is then put on an ad exchange with a timer on roughly a hundred milliseconds which works as any normal auction, the highest bidder gets the ad slot and can display their ad to the user. The demand side platform will then transform the information in the bid into financially viable information such as the socioeconomic status of the area of the IP-address, check history for Google and Facebook cookie, cross-reference with data management platforms (platforms that store user profiles and similar on web-users) and decide how much this ad slot is worth to them. All in all the process takes a couple of hundred milliseconds, i.e. not noticeable to the user due to all the other resources needed to display a web-page. Wang and Yuan (2015), Yuan, Wang, and Zhao (2013) and Stange and Funk (2014) all go through the process in greater detail.
Online advertising is not a “two-sided market” but a very complicated heavily automated beast. And it is worth noting, as a recent Msc thesis does, that the automation and marginalization of the employees who used to manage ad inventory for publishers has caused discontent (Gårdh & Amnäs, 2017), indicating that peering departments at current ISPs might not appreciate the changes a non-net neutrality regime might bring.

It is probable that a non net neutrality regime would develop similar characteristics as real-time bidding for online ads. As an example with Tesla in a non net neutrality Internet: A user wants to update the firmware in his car. He opens the Tesla app, presses update. Then the Tesla servers go to a demand side platform which they tell how much they are willing to pay to transfer X data to address A within time T, and then the demand side platform (or Tesla themselves, depending on whether they outsource or not) goes to an exchange to find the cheapest supplier for this data transfer. This requires competition at all stages of the transfer, and not veritable monopolies on bottlenecks of the transfer (such as last-mile access for cable-TV subscribers). As can be seen by the FCC broadband map, FCC (2018), large parts of the rural US lack ISP competition, and veritable monopolies are common.

I have tried to collect DNS-resolution data for other constellations than my home (for Table 7.4), such as universities, hospitals or ISPs, but I was denied access to or not given such data due to General Data Protection Regulation (GDPR). This means that 1500 AS is a ballpark figure for networks used or contacted by an average household rather than a formal average.

In general, the mentioned literature treat net neutrality as a last-mile issue, i.e. whether the ISP can / should / want to filter / block / delay / otherwise shape traffic at the last stretch of cable connecting a paying subscription, in effect framing the question in the telecom perspective. This can be compared with a more general net neutrality approach in which, for example, transit operators start charging differently (i.e. Atlantic-cable operators refusing or throttling certain services) in a more Internet perspective influenced net neutrality setting.

I do not pretend to know why the literature focuses on last-mile, but I can speculate that from an economics perspective, issues arise at the last-mile where there are veritable monopolies, whereas the more “central” areas, such as transit could be compared to functioning markets.

But what is really last mile? The mentioned literature frames it as the last-mile between an ISP and a private consumer, and as shown later in Figure 7.2 are not all hosts (blue nodes) connected to networks (red nodes) via last-mile

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7. This was the formal answer to my requests, practically I assume no one wanted to take the time to clean such data in a GDPR-compliant way, assuming that the data they have is for debugging purposes and normally contains enough information to identify individual devices, and in extension their users.

8. Using the word central in a technical sense is inaccurate, but I use it for lack of a better word.
7.5. Net neutrality in literature

in some form? Does last-mile as a term need a definition? Or is it perhaps more fruitful to stop using the term as it is not that meaningful in an Internet perspective with hundreds and thousands of hosts and networks involved?

Given the journalistic overview of new or upcoming US state-level regulation regarding net neutrality by Brodkin (2018) there are significant state level regulatory frameworks being put in place to replace the previous FCC net neutrality regulation. In particular Washington state in mentioned as one of the stricter states, as described:

The Washington state law prohibits home and mobile Internet providers from blocking or throttling lawful Internet traffic and from charging online services for prioritization. (Brodkin, 2018)

This has a clear focus on consumers and private Internet users rather than on firms or other organizations.

Another assumption or non-mentioned characteristic is network owner vs ISP, and I assume that when the models only include ISPs and not network owners, they consider them the same (i.e. no open access regulation).

Net neutrality as congested last-mile resource where the network owner and the ISP are the same, is framed in a telecom perspective. In an Internet perspective, the network owner and the ISP should not be the same since all Internet actors should do one thing and one thing only, i.e. in this case an actor operating fibres or cables and their infrastructure should not also sell different kinds of services to consumers or businesses (according to Chapter 5 and I further elaborate in Section 9.1). Also, in an Internet perspective, congestion can happen anywhere, and is an integral part of routing, many routing protocols are designed to work around congestion and routes passing through congested networks are considered “longer” or more expensive so other routes are chosen. Congestion is not something that only happens at last mile but is an integral part of the Internet.

The models I have found in the net neutrality-literature do not agree with my thought style and understanding of the Internet. And surprisingly, no text mentions that it is easier for an ISP to control traffic by meddling with DNS-resolutions, such as ensuring that users are being redirected to far away Netflix servers, which would be very hard for end-users to spot. As an example, instead of setting up your own filtering and blocking to go from Figure 7.2 to Figure 7.3, an ISP could provide the same service (or disservice depending on viewpoint).

As previously mentioned, academic net neutrality literature in general can be said to assume:

1. Network owner and ISP are the same.
2. Congestion happens in last mile.
3. Services have a producer and a consumer.

These assumptions are revisited later in this text after an overview of a collection of websites and their Internet use.

7.6 One website in detail

In the coming paragraphs I will briefly go through how the web functions, exemplified with data on how many hosts, networks and requests are needed to fully load and display a website. I am here using the web, one Internet service, as a proxy for how the Internet works, which from a technical perspective is an oversimplification but still a powerful example. The later portions of this text refer back to this description, in particular Figure 7.2 and Figure 7.3.

This section focuses on one website, www.dn.se, a major Swedish news outlet. There are two main factors for using www.dn.se, it is Swedish, so I should get the intended experience, and all the hosts on the route to www.dn.se answer, which made testing easier. The visit is based on a filtering / privacy setup and visiting with default browser settings.

The results are shown in Table 7.5. The browser which does not block or filter content (the first two line in the table) downloaded four times as much data, contacted six times as many hosts and in total traversing over three times as many networks (ASs) as the filtering setup (lines three and four). In this particular case, browsing two articles while enabling DNS and ad-blocking (line three) used fewer ASs than just loading the front page (line four), illustrating the fickleness and dependence of modern websites on contextual and “randomized” behaviour. The expected behaviour was that browsing two articles would involve more networks than just browsing the front page, as happened without filtering, line one and two.

Table 7.5: Varying front page versus reading two articles with and without filtering for www.dn.se.

<table>
<thead>
<tr>
<th>Type</th>
<th>MB</th>
<th>Hosts</th>
<th>ASs</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP + 2 art</td>
<td>38</td>
<td>189</td>
<td>67</td>
</tr>
<tr>
<td>FP</td>
<td>13</td>
<td>140</td>
<td>53</td>
</tr>
<tr>
<td>filtering + FP + 2 art</td>
<td>9.5</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td>filtering + FP</td>
<td>5.6</td>
<td>24</td>
<td>21</td>
</tr>
</tbody>
</table>

Browsing the front page and two articles is illustrated in Figure 7.2 and Figure 7.3. As can be seen, a vast array of host and networks are used when browsing without intentional blocking and filtering on the client side. In this particular case around 15 hosts are necessary for loading the “core”-page.
Figure 7.2: Graph for an unfiltered visit to a news agency including reading two articles. Note that blue blobs represent individual hosts and the blue clouds are large collections of these hosts, and none of the big clouds are under control of the news agency, they all belong to the ad-ecology. Also note that this network is vastly more complex than Figure 7.1.

Figure 7.2, Figure 7.3 and Figure 7.1 all use the same coloring schema: a yellow node represents the starting host (my computer), red nodes represent networks (technically ASs, but can be thought of as ISPs and other network owners) and blue nodes represent hosts (such as servers and other computers). The length of the edges has no meaning, and their lengths are purely a consequence of trying to organize the graphs meaningfully.

Note that the edges (i.e. lines) between ASs (red nodes) represent some kind of IXP, i.e. simply put a large switch, while the ASs (red nodes) represent networks and cables. This is contrary to the edges being the network cables, which might be the intuition looking at the graphs.

Neither Figure 7.2 nor Figure 7.3 show the host dn.se since it adds no additional value when illustrating the distributed nature of a news website.

In Table 7.6, Table 7.7 and Table 7.8 I list all AS involved with www.dn.se in any way. I have manually divided the network into categories for an easier overview, and I want to point out that I tried to illustrate the main point of an AS. As an example, the Microsoft ASs are categorized as “Ads and
7. Internet and net neutrality

Figure 7.3: Graph for a filtered (i.e. ad-blocking and aggressive DNS-blocking) visit to a news agency including reading two articles. Note that compared to Figure 7.2 much fewer hosts and networks are used, since ad providers are blocked.

tracking”, even though their cloud also could be used as a CDN. But in the context of loading www.dn.se, these ASs acted closer to “Ads and tracking” than a more passive “CDN”. The primary distinction made between “Ads and tracking” and “CDN” is that “Ads and tracking” where involved in which CDNs to contact, rather than providing content themselves. In total, ASs registered in eleven (11) different countries in Europe and North America were used, which can serve as a very rough estimation that infrastructure in eleven (11) countries was needed to view a Swedish news-site in Sweden, something which no academic literature touches as far as I know, and rather conveniently assumes that “everything happens” in one jurisdiction.

Transit

These are those ASs who are mostly concerned with sending traffic along. In a road network analogy, they could be considered the main owners of highways and longer connections. Both CDN:s and players in the ad ecology try to be as close to the highways as possible.
Table 7.6: ASs (transit and unknowns) visited to properly display www.dn.se

<table>
<thead>
<tr>
<th>Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASN</td>
</tr>
<tr>
<td>174</td>
</tr>
<tr>
<td>1299</td>
</tr>
<tr>
<td>1653</td>
</tr>
<tr>
<td>2603</td>
</tr>
<tr>
<td>2843</td>
</tr>
<tr>
<td>3356</td>
</tr>
<tr>
<td>5588</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASN</td>
</tr>
<tr>
<td>12552</td>
</tr>
</tbody>
</table>

Ads and tracking
These are networks concerned with advertisements and similar activities such as tracking users. In the www.dn.se case, very little data was fetched from these networks, but rather information of where to get the content of the ads, i.e. referencing CDNs. Revisiting Stange and Funk (2014) these are the networks with the actors involved in the bidding process, although they do not contain the actual ads themselves.

CDN
These are networks containing content, and in our case the majority of the DN controlled content is at Akamai (i.e. ASN 166625 and 20940), whilst the content of advertisers and other dynamic content is spread over the other CDNs. Note that these CDNs are not actively participating in the ad bidding process, but rather just contain the ads themselves and serve them when needed.

Others
IPO-EU is the “European Intellectual Property Office”, who apparently have their own network, and they did not fit neatly into the other three categories.
7. Internet and net neutrality

Table 7.7: Content Delivery Networks (CDN) visited to properly display dn.se

<table>
<thead>
<tr>
<th>ASN</th>
<th>AS owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>8523</td>
<td>BASEFARM-SE-ASN, SE</td>
</tr>
<tr>
<td>12516</td>
<td>WEBORAMA, FR</td>
</tr>
<tr>
<td>13335</td>
<td>CLOUDFLARENET, US</td>
</tr>
<tr>
<td>14061</td>
<td>DIGITALOCEAN-ASN, LLC, US</td>
</tr>
<tr>
<td>15133</td>
<td>EDGECAST - MCI, US</td>
</tr>
<tr>
<td>15830</td>
<td>TELECITY-LON, GB</td>
</tr>
<tr>
<td>16245</td>
<td>NGDC, DK</td>
</tr>
<tr>
<td>10276</td>
<td>OVH, FR</td>
</tr>
<tr>
<td>16625</td>
<td>AKAMAI-AS, Inc., US</td>
</tr>
<tr>
<td>20940</td>
<td>AKAMAI-ASN1, US</td>
</tr>
<tr>
<td>24940</td>
<td>HETZNER-AS, DE</td>
</tr>
<tr>
<td>24961</td>
<td>MYLOC-AS, DE</td>
</tr>
<tr>
<td>27357</td>
<td>RACKSPACE, US</td>
</tr>
<tr>
<td>29791</td>
<td>VOXEL-DOT-NET, US</td>
</tr>
<tr>
<td>29990</td>
<td>ASN-APPNEXUS - AppNexus, Inc, US</td>
</tr>
<tr>
<td>30633</td>
<td>LEASEWEB-USA-WDC-01, US</td>
</tr>
<tr>
<td>35220</td>
<td>SPOTX-AMS, NL</td>
</tr>
<tr>
<td>42622</td>
<td>DCSTO-AS, SE</td>
</tr>
<tr>
<td>42995</td>
<td>CNHAB, SE</td>
</tr>
<tr>
<td>43948</td>
<td>GLESYS-AS, SE</td>
</tr>
<tr>
<td>48173</td>
<td>UNBELIEVABLE-AS, DE</td>
</tr>
<tr>
<td>53340</td>
<td>FIBERHUB - VegasNAP, LLC, US</td>
</tr>
<tr>
<td>54104</td>
<td>AS-STACKPATH - netDNA, US</td>
</tr>
<tr>
<td>54113</td>
<td>FASTLY - Fastly, US</td>
</tr>
<tr>
<td>56396</td>
<td>TURN, GB</td>
</tr>
<tr>
<td>57367</td>
<td>ECO-ATMAN-PL ECO-ATMAN-, PL</td>
</tr>
<tr>
<td>60068</td>
<td>CDN77, GB</td>
</tr>
<tr>
<td>197541</td>
<td>VIDEOPLAZA-AS, SE</td>
</tr>
<tr>
<td>197595</td>
<td>OBENETWORK, SE</td>
</tr>
<tr>
<td>201979</td>
<td>TAPAD-AMI, NL</td>
</tr>
</tbody>
</table>
7.6. One website in detail

Table 7.8: **AS:es (ads and similar) visited to properly display** www.dn.se

<table>
<thead>
<tr>
<th>ASN</th>
<th>AS owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>8068</td>
<td>Microsoft Corporation, US</td>
</tr>
<tr>
<td>8075</td>
<td>Microsoft Corporation, US</td>
</tr>
<tr>
<td>13414</td>
<td>TWITTER - Twitter Inc., US</td>
</tr>
<tr>
<td>14618</td>
<td>AMAZON-AES - Amazon.com, Inc., US</td>
</tr>
<tr>
<td>15169</td>
<td>GOOGLE - Google LLC, US</td>
</tr>
<tr>
<td>16509</td>
<td>AMAZON-02 - Amazon.com, Inc., US</td>
</tr>
<tr>
<td>18568</td>
<td>BIDTELLECT - Bidtellect Inc., US</td>
</tr>
<tr>
<td>25751</td>
<td>VALUECLICK - Conversant, Inc., US</td>
</tr>
<tr>
<td>26667</td>
<td>RUBICONPROJECT, US</td>
</tr>
<tr>
<td>30419</td>
<td>MEDIAMATH-INC - MediaMath Inc, US</td>
</tr>
<tr>
<td>32934</td>
<td>FACEBOOK - Facebook, Inc., US</td>
</tr>
<tr>
<td>33419</td>
<td>TRIBAL-FUSION, US</td>
</tr>
<tr>
<td>34010</td>
<td>YAHOO-IRD, GB</td>
</tr>
<tr>
<td>44788</td>
<td>ASN-CRITEO-EUROPE, FR</td>
</tr>
<tr>
<td>62713</td>
<td>AS-PUBMATIC - PubMatic, Inc., US</td>
</tr>
<tr>
<td>198622</td>
<td>ADFORM, DK</td>
</tr>
</tbody>
</table>

Also, as previously mentioned, playing a large role selecting resources for the website to show are real time bidding actors\(^9\) which broadly can be categorized as an automated (i.e. algorithm and data driven) aggregated buy side and an automated aggregated sell side. In effect when a user visits an ad sponsored website the user sends meta-data (such as IP-address, location (Rich neighbourhood? Poor neighborhood? Country? Ice-hockey-interested suburb?), resolution, cookies among others\(^10\)) and then the sell side with the help of that meta-information holds an auction through a trading platform where the winner is the buy side ad-owner or ad-aggregator willing to pay the most to show the user the ad. In effect, there is an entire automated ecology surrounding online advertisements.

\(^9\)See previous argumentation and for example Stange and Funk (2014) and Yuan et al. (2013) for a more detailed overview of these actors and processes.

\(^10\)The interested reader might want to have a look at https://panopticlick.eff.org, a service which shows identifiable information in browsers.
7. **Internet and net neutrality**

All of Table 7.6, Table 7.7 and Figure 7.2 are based on the unfiltered version of the website. Table 7.7 contain all the content-related ASs visited to fully display the web-page including the two articles. Do note that this might not be all ASs, but rather the ones who made themselves known. I have shortened the names in Table 7.6 and Table 7.7 for a better table fit, as some AS-names are quite technical in their nature.

As can be seen in Table 7.7, a visit to www.dn.se requires data from networks owned by Facebook, Twitter, Microsoft, Akamai, Amazon and Google, to name a few.

As can be seen in the differences between Figure 7.2 and Figure 7.3, the use of an adblocker drastically lowers the amount of needed hosts (as shown in Table 7.5).

Figure 7.2 and Figure 7.3 are not meant to be analytically useful, but rather are meant to serve as a comparison to the common net neutrality models as shown in Figure 7.1. Visiting a website is by all accounts a bit more complicated than most (all?) current net neutrality models account for.

This complexity also explains the common appearance of malware online. Since no one actor is in charge of managing the entire website experience, it is possible for a bad actor to buy into the ad ecology and show malicious ads to end users. Note that all ads have the possibility of executing code (for example JavaScript) in the visiting browser. This is how over 2500 sites became infected back in 2017 (see Goodin, 2017) with a JavaScript snippet that used the visiting computers resources for mining cryptocurrency. In 2018 the problem continued and was focused around the cryptocurrency Monero (see Goodin, 2018). I would argue that there are two main solutions to this problem; the Internet perspective solution of users (or even ISPs) using software to block malicious hosts and content, and the telecom perspective solution of forcing service providers such as news sites to be in complete control of the entire page (which incidentally also would alter the online ad ecology drastically).

To put the number of hosts in perspective, at my home all my devices in total requested exactly 4786 different hosts (note that from a host perspective dn.se is different from www.dn.se) during a normal week. This means that many of the hosts visited are reused for several websites and other Internet services.

Comparing with the Title-classification of FCC, the Internet here is the carrier of all the resources required to present a web-page, but the Internet does not decide what to show in a specific web-page, as the “Title I Information Service”-classification implicitly assumes. The Internet acts as a common carrier for packets, much like Electronic Frontier Foundation (2017) argues.

In this section I intentionally used a news site to show the distributed nature of websites, since news sites normally have ad-revenues and therefore use a larger number of networks and hosts than a static page such as the Google entry-point (i.e. google.com). I have not shown that all Internet services are
as distributed as news web-pages, but rather illustrated the complexity of the ad-financed ecologies surrounding a selection of sites.

### 7.7 A portfolio of websites

The previous section dived into a single website to show the complexity of a website ecology today. This section carries on with a thinner analysis of a selection of websites.

For website selection, I used the Alexa website ranking for the ten thousand most popular hosts, looked at the results, cleaned it from duplicates (example: I merged google.com, google.jp, google.se, google.dk etc into google.com as they gave similar results), and then in the interest of reducing the number of hosts to a paper format manageable number, removed sites which I thought would not be recognized. In the end, I had the websites presented in Table 7.9 representing the broader web. I made sure I had several Swedish, German, British and American news sites. I chose Swedish because I live in Sweden, German news because they are the biggest economy in Europe, British and American news to compare two English-speaking contexts, and all of these presumably part of the Western context. I also kept Amazon and DealExtreme (dx.com) as examples of online stores, Twitch as an example of a streaming site\(^{11}\) and Reddit because of its popularity as an Internet forum.

I ran my scripts for all hosts, but filtered out a countable number of hosts with comparable behaviour to the rest to show as examples here in the paper\(^{12}\).

Both Table 7.9 and Table 7.10 contain data collected by visiting several websites over a period of a week.

The first column, in Table 7.9 and Table 7.10, is the host, or the start of the website. The second column is the number of requests, on average, required to fully load the website (i.e. different resources, such as images, ads, javascript files and other services). The third column is the average number of contacted hosts to display the page fully. The fourth column, AS:s, are the number of AS we need to visit to fully load the page, an approximation of the number of network owners involved to load the page fully\(^ {13}\). In the fifth and final column, AS:s r, I show the total amount of involved ASs, including those who only routed traffic and did not per se have any of the website resources.

Also important to point out is that the automation did nothing except visit the page, so this data does not include logging in and for example browsing a Facebook feed.

What is the point of this example (i.e. Table 7.9 and Table 7.10), you might ask? It is to show that looking at the Internet as a content provider

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\(^{11}\)From a network perspective, the main page of YouTube is very similar to the main page of Google without logging in.

\(^{12}\)For further technical detail, see https://github.com/flindeberg/internet-tools

\(^{13}\)Important to note that this refers to infrastructure operators rather than server operators.
### Table 7.9: Data for hosts queried and resources with no intentional filtering.
Average values.

![Table 7.9](image-url)
7.8. Revisiting the literature

delivering a service to a content consumer over one discrete pipe or “a series of tubes” is quite a simplification. Have I proven that those models fail? No, but there should be reasonable doubt to consider whether they hold given that the Internet can not be thought of as a “pipe” with one entity per side. And therefore the complexity of regulating the whole become greater. The current debate is often in terms of last-mile access and what the providers of last mile access are allowed to do, but looking at Figure 7.2, there are hundreds of blue nodes, i.e. hosts, and leading up to each one of them is a last-mile (or similar) operator.

But what are the differences between Table 7.9 and Table 7.10 then? As can be seen in the tables, those websites affected the most by DNS-based adblocking are news sites, which have a greater reliance on ad revenues and other from an Internet end user viewpoint unwanted content (i.e. the ads themselves, users seem to enjoy ad-financed websites as long as they do not have to be bothered by the ads). For example, thesun.co.uk uses 157 hosts spread over 47 networks when unfiltered, but uses 47 hosts spread over 16 networks when filtering. In an Internet perspective, the notion that the user is in charge and can select which parts of the service is of interest and block or filter the rest is central, even though it entails problems since many sites are financed by showing ads. In a telecom perspective this behavior is a bit more contentious, as this would be similar to programmatically skipping the ads on a cable-TV show.

In Table 7.11 I show the total number of unique hosts and AS:s used for visiting the page during a week. The reason this is different from Table 7.9 is that many website change dynamically over time. For example, if you sell advertisement space on your website, it is usually not you as the website owner who dictates which advertisements appear, but rather the advertisement-provider who dynamically gives ads based on your browsing history through the use of cookies. This is the reason those Google Ads with track shoes always appear and seem to haunt you after you have been googling for track shoe reviews. In this case I am not sending any interesting cookies but rather start from a clean slate for each request, and of course there are other ways to track users than cookies, but I can with reasonable accuracy say that the ads I received were randomized to a large extent.

Also of importance here is Table 3.6 and Figure 3.5 which beyond any doubt show the enormous potential complexity of services utilizing the entire Internet, both in terms of actual technical complexity and in terms of legality and responsibility.

7.8 Revisiting the literature

As previously mentioned, academic net neutrality literature in general can be said to assume:

1. Network owner and ISP are the same.
Table 7.10: Same hosts as Table 7.9 but with intentional blocking of domains (i.e. using pi-hole). Average values.

<table>
<thead>
<tr>
<th>News</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>nytimes.com</td>
<td>269</td>
<td>63</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>washingtonpost.com</td>
<td>71</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>theguardian.com</td>
<td>163</td>
<td>28</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>thesun.co.uk</td>
<td>160</td>
<td>47</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>svd.se</td>
<td>174</td>
<td>39</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>dn.se</td>
<td>157</td>
<td>51</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>spiegel.de</td>
<td>177</td>
<td>28</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>sueddutsche.de</td>
<td>95</td>
<td>25</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>tribunnews.com</td>
<td>151</td>
<td>27</td>
<td>9</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Search / Social</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>google.com</td>
<td>17</td>
<td>6</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>yahoo.com</td>
<td>193</td>
<td>31</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>reddit.com</td>
<td>89</td>
<td>22</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>facebook.com</td>
<td>41</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Retail</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>amazon.com</td>
<td>334</td>
<td>16</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>amazon.de</td>
<td>289</td>
<td>9</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>dx.com</td>
<td>236</td>
<td>19</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>twitch.tv</td>
<td>158</td>
<td>30</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>wikipedia.org</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>livejasmin.com</td>
<td>42</td>
<td>13</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
7.8. Revisiting the literature

Table 7.11: Same hosts as Table 7.9 and Table 7.10 but the size of the complete set of unique hosts and AS:s visited in total.

<table>
<thead>
<tr>
<th>News</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>nytimes.com</td>
<td>N/A</td>
<td>155</td>
<td>44</td>
<td>56</td>
</tr>
<tr>
<td>washingtonpost.com</td>
<td>N/A</td>
<td>32</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>theguardian.com</td>
<td>N/A</td>
<td>205</td>
<td>38</td>
<td>50</td>
</tr>
<tr>
<td>thesun.co.uk</td>
<td>N/A</td>
<td>360</td>
<td>79</td>
<td>97</td>
</tr>
<tr>
<td>svd.se</td>
<td>N/A</td>
<td>103</td>
<td>27</td>
<td>37</td>
</tr>
<tr>
<td>dn.se</td>
<td>N/A</td>
<td>295</td>
<td>68</td>
<td>89</td>
</tr>
<tr>
<td>spiegel.de</td>
<td>N/A</td>
<td>179</td>
<td>36</td>
<td>50</td>
</tr>
<tr>
<td>sueddeutsche.de</td>
<td>N/A</td>
<td>48</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>tribunnews.com</td>
<td>N/A</td>
<td>394</td>
<td>70</td>
<td>90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Search / Social</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>google.com</td>
<td>N/A</td>
<td>8</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>yahoo.com</td>
<td>N/A</td>
<td>177</td>
<td>56</td>
<td>75</td>
</tr>
<tr>
<td>reddit.com</td>
<td>N/A</td>
<td>157</td>
<td>47</td>
<td>61</td>
</tr>
<tr>
<td>facebook.com</td>
<td>N/A</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Retail</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>amazon.com</td>
<td>N/A</td>
<td>37</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>amazon.de</td>
<td>N/A</td>
<td>35</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>dx.com</td>
<td>N/A</td>
<td>122</td>
<td>9</td>
<td>21</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th>Requests</th>
<th>Hosts</th>
<th>ASs</th>
<th>ASs r</th>
</tr>
</thead>
<tbody>
<tr>
<td>twitch.tv</td>
<td>N/A</td>
<td>58</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>livejasmin.com</td>
<td>N/A</td>
<td>21</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>wikipedia.org</td>
<td>N/A</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
2. Congestion happens in last mile.

3. Services have one producer and one consumer.

Item 1: as previously noted, this seems a typical telecom perspective approach, while an Internet perspective approach would see the ISP as a wholesaler of services on someone else’s infrastructure. Practically true (i.e. network owner and ISP the same) in some settings but not universally true from a global perspective.

Item 2: as previously argued, only bandwidth and throughput sharing technologies such as DOCSIS have this phenomenon. Also, as previously mentioned, for single mode fibers the bit rate distance product is 3 to 4 orders of magnitude higher than that for any wireless or copper-based digital communication technology. The future implications of this (assuming exponential growth of throughput utilization) is that for any distance longer than inside a server cabinet, you will sooner or later need fiber-optics infrastructure.

From a technical standpoint, I argue that congestion at last-mile is rather ISP-induced than technology induced. This Cheng et al. (2011) agrees with, only the ISPs stand to gain from throttling services, either artificially through traffic-shaping or due to technical limitations.

As mentioned earlier, the packet is the natural base for a net neutrality discussion from an Internet perspective, since the Internet is supposed to be application agnostic. This can be compared to Wu (2003) who argues that net neutrality can mean different things, and argues that it might be more reasonable to discuss application neutrality rather than net neutrality (or packet neutrality), but from an Internet perspective the whole idea is the neutrality of the IPv4 or IPv6 packet (or whatever protocol happens to be the standard and accepted norm), and if that hurts low-latency applications, the solution is not to enforce application neutrality but rather increase network throughput with the intention to keep the network stupid.

Item 3: that services have one producer and one consumer, is also a problematic assumption. As shown in Figure 7.2, Table 7.5 and Table 7.7 you might very well need to fetch resources from up to forty or more networks just to browse a website. In a non-scientific text, Gianpietro-Zago (2018) explains, or argues, that the Internet is centralizing and decentralizing in waves. The first wave was the initial Internet with distributed services, which paved the way into the content producer / content consumer majority (i.e. YouTube, Netflix, Facebook etc, models comparable to telecom perspective models) where large organizations have a central role. Gianpietro-Zago (2018) argues that a new wave is coming, with more distributed services, such as Storj and IPFS instead of Dropbox, and Essentia one and EOS replacing traditional operating systems, and I would add distributed IoT applications as well. And all of these offered over the Internet, mostly between users on equal footing rather than large producer with a subscription model for subscribers, such as
7.9 Net neutrality and Internet Coordination

Netflix, YouTube, Facebook or most non-Internet services. The Internet, or even the web, is not reasonably describable in all its shapes as a relationship between a producer and a consumer, even though it would be easier to model it that way.

As mentioned previously, the terminology is not always well-defined, and Gianpietro-Zago (2018) uses “the web” to signify both what I would call “the web” and what I call “the Internet”.

7.9 Net neutrality and Internet Coordination

The Internet is coordinated through an explicit bottom-up process, mainly through the organizations the Internet Engineering Task Force (IETF) and the ICANN and the fora they provide (Chapter 5). Neither ICANN nor IETF have a history of getting involved in political debates but rather try to behave as a neutral executor of a multi-stakeholder process, with ICANN focusing on coordination and maintenance issues while IETF focus on technical issues, although the distinction sometimes is hard to make (see argument in Chapter 5).

Do note that not everyone agrees directly with the previous paragraph. In particular not policy literature. And as hinted in the introduction, the UN and the ITU would prefer a nation-state-based multilateral approach to Internet Coordination (i.e. Internet Governance) rather than the current model.

The importance of the Internet as a concept, compared to traditional telecommunications networks, lies in its coordination mechanisms, and I see IPv4 and IPv6 as products or consequences of how the Internet is coordinated rather than the standards as the Internet itself. In Table 7.12 I show how this description compares to that of DeNardis (2012), and note that it is not black and white but rather a spectrum. For example texts such as Chapter 5 and Zittrain (2008) are explicit in the importance of coordination while van Eeten and Mueller (2012) is more implicit and texts like Economides and Hermalin (2012) and Cheng et al. (2011) do not in any way imply that the Internet is something else than a technical phenomenon (albeit a unique one).

On the one hand in short, the IETF focuses on maintaining, improving and setting standards for the Internet. Their mantra can be summarized as:

We reject kings, presidents and voting. We believe in rough consensus and running code. (IETF, 2012)

This mantra still efficiently describes the thoughts behind the IETF (Chapter 5). And as exemplified in Chapter 5, many formal leading positions (such as chair positions in groups and committees) are ceremonial in character and wield little to no power above that of an ordinary group member.

ICANN on the other hand focus more on the practical delegation of domain names (such as icann.org), numbers (i.e. IPv4 and IPv6 addresses) and some
Table 7.12: Comparison of Internet and Internet Coordination.

<table>
<thead>
<tr>
<th>Coordination component</th>
<th>Source</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 5, Zittrain (2008), van Eeten and Mueller (2012), DeNardis and Raymond (2013), etc</td>
<td>Explicitly mentions that the Internet is more than the physical manifestation of a digital network.</td>
<td></td>
</tr>
<tr>
<td>ITU, DeNardis (2012), Economides and Hermalin (2012), Cheng, Bandyopadhyay, and Guo (2011), etc</td>
<td>Does not consider the Internet to have coordination component, i.e. only the IT-artifact in sociomateriality.</td>
<td></td>
</tr>
</tbody>
</table>

protocol standards (such as DNS using port 53), technically referred to as the IANA function. To clarify, ICANN is an organization, IANA is a function administratively placed under ICANN (technically via an organization called Public Technical Identifiers (PTI)). ICANN was incorporated in 1998 as a replacement for Jon Postel who previously ran the IANA function on his own. Back then it was implicitly assumed by many that ICANN would change into the same governance schema as the IETF (Gillett & Kapor, 1997), i.e. users in charge and a loose multi-stakeholder structure, but instead ICANN transformed into a formalized multi-stakeholder model (see fuller argument in Chapter 5). Not everyone is happy with the ICANN formal multi-stakeholder model; just as ITU agreed on more involvement of nation states in Internet Coordination, others thought the multi-stakeholder model is too formalized compared to the looser coordination model of the IETF.

Table 7.13: Illustrating the dimensions of the Internet according to and from Chapter 5

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>coordination</td>
<td>Explicitly loose bottom up with focus on empirically motivated decisions.</td>
</tr>
<tr>
<td>technology</td>
<td>End-to-end best effort digital communication.</td>
</tr>
</tbody>
</table>

Important to note is that all decisions and standards in ICANN and the IETF are not enforceable and policy does not play a role (although in later

---

14See for example the reporting of Masnick (2012) and Lee (2012).
years the Governmental Advisory Committee (GAC) at ICANN has increased in prominence), nor does national regulatory authorities, but rather following standards is a way of being able to play with the others, i.e. voluntary participation in a sense (as argued in RFC-2026, see Bradner, 1996). As an example, no one could sell a smartphone or router which does not do Internet Protocol (IP) or Internet Control Message Protocol (ICMP)\textsuperscript{15}. Not following agreed standards means that you can not play, there are no legal repercussions, i.e. regulation and regulatory enforcement does not play a part.

Net neutrality is usually used in the telecom perspective, i.e. neither the IETF nor ICANN use the term net neutrality explicitly, but the political debate does. As an example from an IETF-context, Handley (2009)(in an IETF keynote) argues that net neutrality is mostly an economic matter and the IETF should not get involved (i.e. pick sides), but rather help in providing tools and standards for the users involved (i.e. ISPs and their customers). However, the opinion of Handley (2009) is not fully compatible with RFC-2026 (Bradner, 1996) as the Internet implies end-to-end communication, i.e. that the networks should be “stupid” and do best-effort delivery and all “smartness” should be at the edges (i.e. servers and clients in practice); i.e. the argument of Handley that the IETF should provide tools which potentially undermines the best-effort aspect of the Internet can be seen as incommensurable with RFC-2026 (Bradner, 1996).

ICANN is also quite quiet on the subject, and as an example the CEO of ICANN stated that the repeal of net neutrality in the U.S. would not impact ICANN’s work (see reporting in Saez, 2017). Another interesting detail is that their wiki on the topic has not been updated since 2016 (see ICANNWiki, 2016).

It is worth reiterating that both ICANN and the IETF are not representational in that they elect individuals to represent parts of the technical Internet (as for example countries elect representatives to represent them in the UN), but rather as the fora where actual governance happen. And as previously noted, Internet-lobbyists are few and far between (see Chapter 5).

It should not be forgotten that the Internet is best-effort (see Table 7.13), in a sense that there is no guarantee that packets reach their destination. However, there is a difference between trying to deliver packets but failing, and intentionally dropping or throttling packets.

The above paragraphs are not exhaustive, but rather exemplify how the political term net neutrality intermingles with Internet Coordination. For a deeper insight into Internet Coordination I recommend both Jonson (2010) and my earlier Chapter 5. There are other texts which focus on Internet Governance (i.e. a formalized top-down version of Internet Coordination) and net neutrality, such as Mueller et al. (2007), although texts in the governance

\textsuperscript{15} Broadly, if comparing IP with mail envelopes; ICMP would be notifications of non-delivery, handling of faulty addresses and so on, i.e. a diagnostic or meta protocol.
and regulation stream are set in a different thought collective where other notions are important, such as in law and policy where the importance of formal government policy is assumed.

See “The Internet and its Governance: A General Bibliography” (2012) for another list of governance and policy perspectives on the Internet from the perspective of global governance looking at the Internet (even though the companion glossary manages to avoid the Internet term, see “Glossary of Key Terms and Notions about Internet Governance” (2012)).

7.10 Net neutrality revisited

Given the literature, the website examples and connection to Internet Coordination I suggest to view net neutrality as:

\[ \text{traffic perceived as de facto treated according to agreed standard} \]
\[ \text{absent potential harm to networks or their users} \]

Using this description or notion, net neutrality can be seen as the political side of the notion that the user should be in control. A lack of net neutrality would imply that the user is not in charge since the users are not free to use the Internet as they see fit since upstream network operators are allowed to modify and drop traffic as they see fit due to among others business or political reasons. Also important to note is that I see net neutrality as traffic de facto treated according to standard, not de jure treated to standard (i.e. regulation or policy), so it is indeed possible to have net neutrality without net neutrality-specific regulation as well as possible not to have net neutrality even under net neutrality-specific regulation, as my YouTube example in Table 7.3 shows ISPs can ignore net neutrality regulation seemingly without repercussions. I.e. see this definition as “practical neutrality” rather than “absolute neutrality”.

Both perceived and standard require a more nuanced description. With perceived I refer to that which can be noticed or felt by either the sender or receiver of traffic, for example the perceivable throttling of video streams, such as causing a downgrade in resolution. In this definition I do not consider the YouTube example in Table 7.3 as a breach of de facto net neutrality: it is not supposed to happen, but it practically does not matter.\(^{16}\) With absent potential harm I want to point out that there are scenarios where traffic could be affected or modified according to standards and norms, for example if the traffic is potentially spoofed.\(^{17}\) I also avoid the terms Internet and packet in the definition and use the non-implementation-specific traffic to ensure an

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\(^{16}\)Or can be seen as reasonable technical management of the network, even though that would serve as an indicator of a sub-dimensioned network.

\(^{17}\)See for example the Best Current Practice (BCP)-38 debate with regards to the present issues with IP-packets with spoofed sender addresses.
implementation agnostic definition, which could be applied to all manner of networks.

And to summarize, net neutrality is complicated in an Internet Coordination lens since it can be seen as both a necessary consequence of core values (user in charge) and as irrelevant (economic and regulatory issue, not an “Internet” issue), and in the end the different coordination mechanisms of formal regulation and those of the Internet do not conform.

7.11 Regulation and coordination

Throughout this text I refer to the Internet as being coordinated rather than governed and contrast that with a formally governed network or Internet. In Table 7.14 I suggest a parsimonious model for illustrating the different versions of a digital communications network given these axes. The vertical axis signifies type of regulation, i.e. the primary type of regulation, regulated policy vs market policy, and the horizontal axis describes de facto net neutrality as defined previously. Table 7.14 describes four distinct regimes, the early Internet, the regulated Internet, regulated telecom and market Internet. Note that these regimes concern the Internet itself, rather than what the Internet is used for. It is possible to have a regulated telecom network used for market purposes, and those market purposes would influence the network but government policy and regulation still sets the rules of engagement, such a network is classified as regulated telecom.

Table 7.14: Taxonomy of digital communication networks differentiated by de facto net neutrality and source of regulation, either policy (government) or structural (such as markets).

<table>
<thead>
<tr>
<th>Regulatory policy</th>
<th>Market policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>de facto net neutrality</td>
<td>Market Internet</td>
</tr>
<tr>
<td>no net neutrality in practice</td>
<td>Regulated Internet</td>
</tr>
</tbody>
</table>

The early Internet has bottom-up coordination and de facto net neutrality through its end-to-end principle, that is, the purpose of network operators is to propagate traffic in a packet-neutral except if said traffic can be deemed harmful to the network or its users. The net neutrality does not have to be “full net neutrality” but rather “good enough net neutrality” as in the example of re-scaled YouTube videos. The earliest Internet is characterized by net neutrality through technical standards and later through market policy as foundations and non-profits kept firm grip on core functions.
7. Internet and net neutrality

The regulated Internet behaves much as the traditional Internet with the difference that net neutrality is regulated instead of structured bottom-up as is the case with the end-to-end principle. For the Internet edge user, the regulated and the traditional Internet behaves the same, the difference lies in the coordination dimension, whether it is run by states through policy or by other actors through voluntary coordination.

Regulated telecom goes back to traditional state-coordinated telecom-standards, such as the telegraph and telephony, in essence a digital communications world where the operator is in charge of everything available to the end customer/consumer. The traditional Internet pushed into this corner would imply heavy if not total state oversight of naming and numbering functions. The handle-system can be seen as such a state-controlled naming function (even though DONA say they are not state controlled, almost all board-member have backgrounds in or are current members of international, regional or national regulatory authorities).

Last is the market Internet where market forces, i.e. revenue and profit generation, drives Internet operation. This regime allows for net neutrality by a set of actors as a means of business offer differentiation, but net neutrality would not be considered the norm or the de facto standard.

Europe has, in broad strokes, gone from the early Internet without government policy to the regulated Internet, where government-enforced policy dictates net neutrality. In comparison, the USA has gone from early Internet to a regulated Internet, regarding net neutrality, and now could either go towards regulated telecom (policy “against” net neutrality) or a market Internet where the business case of network operators define what the Internet is and can be used for.

7.12 Conclusions

There is reason to care for net neutrality and Internet Coordination. Without de facto net neutrality several of the assumptions behind the Internet falls, and it is up to the infrastructure and network operator to decide what the Internet is. Today most of Western Internet is in the early or regulated Internet regime, with some forces pushing towards government policy and other forces towards market regulation of net neutrality issues.

Problems would arise for the users if the market does not function for last-mile access (i.e. lack of ISP competition as is the reality for large parts of the rural US) under a market Internet regime.

From a technical standpoint, there are no considerable issues with a net neutrality repeal, the network would still function as such, but as illustrated by my web examples (Figure 7.2, Figure 7.3, Table 7.9 and Table 7.11) the Internet is complicated, and discriminatory routing even more so, clearly putting
today’s Internet in the early or regulated Internet categories. Since the current Internet Standards were not made for arbitrary traffic pricing models but rather best-effort packet delivery, a rewrite and re-acceptance of many Internet Standards is required to foster a packet-discriminating Internet. An N-sided market where N is in the vicinity of a couple of thousands, price negotiation would quickly become costly and a turn in the direction of automation and/or aggregated brokerage is probable, a possible behavior in the market Internet quadrant of the matrix.

Also, as shown in Figure 7.2, Figure 7.3, Table 7.7 and Table 7.6, today there is wide ecology of actors who create value together in network-like constellations. These probably would not exist if net neutrality had not been the norm, specifically as in regulated telecom but also possible on the market Internet if the largest actors were not to capture value by providing packet neutral services (since value capture is, in some limited sense, the purpose of for-profit organizations).

As previously argued, issues such as net neutrality are problematic in a regulatory sense, since state regulation does not fit either the coordination of the Internet or the technical workings of the Internet. Regulation for net neutrality or against net neutrality is not the issue, net neutrality as regulation is the issue, in essence the forces pushing into the upper two quadrants of Table 7.14.

As is illustrated in Table 7.14, I suggest four different possible defining quadrants of a digital communications network. The horizontal dimension signifies de facto net neutrality, i.e. how traffic is treated in essence on the network, while the vertical dimension signifies the role of regulation in governing the network (i.e. the Internet). Historically, in a Western context, the Internet has been in the bottom left early Internet corner, that is unregulated but de facto net neutrality since the end-to-end principle has held, meaning that the network itself did not add or capture value beyond that involved in content neutral propagation of traffic.

Forces today push up in Table 7.14. Regardless of net neutrality or no net neutrality, the public debate calls for regulation, regulation which is coordinated different than Internet core functions and standards. In short, the debate assumes regulation in the top half instead of the more nuanced Internet approach in the bottom part of Table 7.14.

My probing suggests that many organizations are not prepared for that the Internet might change into something which no longer can be black-boxed even if their core business rely on the Internet as best-effort. For them, the importance is not ultimate or pure net neutrality, but rather a reasonably neutral network for practical purposes. Just as Handley (2009) mentions that the Internet has never been really neutral. I.e., in practice, absolute net neutrality is not that relevant for organizations and has never been the norm, but rather that it should be possible to update car-firmware when-ever and
7. **Internet and net neutrality**

where-ever without pre-existing deals pertaining to that particular task. And in the future, the same is true for IoT-devices no matter the location.

Ultimately, **net neutrality** is not only an issue right now for the Western world, but rather an important norm on concerning how the world in the future should look at digital communication; can the service provider treat traffic at his own discretion or should norms, ethics or even regulation affect traffic operators and (not?) protect users? This is important in the sense that low-quality Netflix or YouTube might not cause permanent harm, but what if network operators blocked sources with different political views?

Recently, the ITU PP 2018 Dubai conference chose not to go closer to either the DONA or the ICANN systems of unique identifiers, as such not clearly pushing either up or down in Table 7.14 and keeping the status quo.

### 7.13 Net neutrality and business models

This end of this chapter is a short summary of a conference submission (i.e. extended abstract and presentation) done in a marketing thought collective, as such the framing was different from the rest of this chapter. The extended abstract is available in the proceedings as follows:


The abstract was written and presented together with roughly equal distribution of labor, done by me and a PhD candidate colleague.

The abstract (i.e. Brege & Lindeberg, 2018) add on the notions and concepts of this chapter. The idea behind the abstract was, roughly, “what about **net neutrality** and businesses (and/or business models)?” (i.e. a combination of our topics). We frame the Internet as I defined it in Chapter 5 and consider **net neutrality** a part of the practical Internet regime in place today (i.e. the Internet would not be the Internet without practical **net neutrality**). We only problematized practical **net neutrality**, and did not discuss the nuances of **net neutrality** as earlier in this chapter (for example differentiating *de facto net neutrality* from *de jure net neutrality*).

There are two interesting points made in the contribution (in the context of this thesis):

- The scientifically interesting point; the Internet is rarely problematized in business literature as a business issue (i.e. fields of marketing, management, information systems, etc. In economics and policy the Internet is problematized as a telecommunications service), nor defined. The
7.13. Net neutrality and business models

consequences are two-fold; first, similarly to platforms in de Reuver et al. (2017), digital platforms (such as the Internet) present an interesting research opportunity, and second, assuming Internet-function in a black-always-existing-box gives similar issues with results as those mentioned in Orlikowski and Iacono (2001) on the problematization of the IT-artifact.

- The practically interesting point; we tried to identify firms especially vulnerable should the Internet change drastically, as through hard net neutrality or non-net-neutrality regimes. Concisely, we noticed that there are few firms especially vulnerable (such as Netflix and YouTube) because their business model is based on the existence of net neutrality. The vast majority are vulnerable to some degree due to reliance on simple digital services (such as email, Skype or similar, corporate VPNs, etc). Perhaps the interesting object of study should rather be those not vulnerable to a change in what the Internet is. We could not identify any such firms employing more than a couple of people.

One particular purpose of having a reference to this conference submission here is to ensure that there is no plagiarism when I discuss content and ideas made for a particular submission outside the scope of that submission. Plagiarism is a very gray area, so I chose to stay close to the brighter side. By noting the conference submission, I also acknowledge that the coming chapters are influenced by the work Brege and I did for that conference.

The main influence is the notion that the Internet is used almost everywhere in a western business context, and even when central to the business model often not toted as such. As an example, Tesla is relying more on the Internet for car maintenance and updates than other car manufacturers, yet the Internet is not explicitly mentioned as a part of their business model. It is, though, mentioned as something included in the car (i.e. cellular), but not that the Internet is essential for Tesla to get diagnostic data back (see for example Tesla’s FORM 10-K annual report in which the business idea is described).

As such, business in general need practical net neutrality rather than any specific legislation. As such the notions in Brege and Lindeberg (2018) are in line with this chapter as a whole.
8 Revisiting the context

The Internet works because a lot of people cooperate to do things together
— Jon Postel

This chapter serves as a contextual empirical summary of this thesis so far. And will shortly go over the technical setting together with insights from data such as interviews, but with a considerable emphasis on empirical additions outside the scope of Chapter 5, Chapter 6 and Chapter 7, such as the 2018 ITU Plenipotentiary (ITU PP) and further discuss the Internet as a case of least possible coordination.

8.1 Defining the Internet

The Internet definition in this thesis (from Chapter 5) stems from literature reviews, interviews and documents such as bylaws and meeting minutes available at the start of this process. The purpose of this section is to revisit this definition in the light of recent events, and in particular the Swedish Internet-access definition report (referenced as Netnod, 2019). Remember, the first interviews were done two years ago and things change, particularly since Section 3.11 argues that digital paradigm shifts should happen every seven years or so.

The Internet definition as suggested in Chapter 5 is “a set of protocols for digital end-to-end communication affected by its users” (Chapter 5).
This definition (which I consider the vital principles behind the Least
Common Internet), rather than specify exactly and precisely what the Internet
is at a technical level, focuses on defining design characteristics of the
Internet. According to Chapter 5, the Internet is a digital end-to-end network
and protocols which are controlled by the users (and not, for example, a cen-
tral governing organization, the importance being that the Internet epistemic
community itself can coordinate rather than work their agendas towards those
in charge), i.e. the Internet can still be the Internet even without Internet Cor-
poration for Assigned Names and Number (ICANN) and Internet Engineering
Task Force (IETF) if similar principles are upheld.

Figure 8.1 illustrates the technical and infrastructure part of the Internet
which is based on the idea that is the Internet.

The Internet-access definition report (see Netnod, 2019, in Swedish) has
the explicit purpose of defining Internet-access in legal settings, such as proc-
curement, to be used as the one all-encompassing definition of what Internet-access is, including its lowest bounds (i.e. rules of engagement at the
edges of the Internet, illustrated by Figure 8.1 blending into the white background). And as such it is relevant to account for the actual organizations, standards and jurisdictions in play. My Internet definition and the Swedish Internet-access definitions are on different meta-levels. Paraphrasing from the definition report:

The purpose of this report is to propose a common perception of Internet access and to define important related terminology to be used by all market participants. (Netnod, 2019, p. 5, translation from Swedish)

The report does not define the Internet but rather the contractual and measurable aspects of accessing the Internet. In the order of the report, Table 8.1 lists the areas and how they map to my suggested Internet definition (in Chapter 5). Fragmentation (a technical implementation issue), accessibility and support do not relate to my suggested Internet definition, and are rather service issues than Internet issues.

Netnod (2019) acknowledges the problems with defining Internet access due to the lack of Internet centrality, i.e. a similar argument as in Section 3.10, since the Internet consists of multiple networks and does not have a central node or network per se, cf. Markus (2006) and Request for Comments (RFC)-2026 (Bradner, 1996).

However, Netnod (2019) does not define Internet access outside a “one site and one cable” scenario, which is an explicit choice by the project group to keep the first iteration of the definition simple, and possibly extend it in the future if the definition is proven useful1. As an example; the suggested Internet access definition is not explicitly2 applicable to mobile broadband, Wi-Fi roaming services, and other similar services.

As can be seen in Table 8.1, most aspects map well onto my suggested Internet definition, except for service-level aspects, which naturally fall in contractual rather than ideological aspects of (accessing) the Internet. My definition also maps well back onto the Internet access definition in the “one site and one cable” case, i.e. as a definition of what is needed to access an incarnation of the Internet as this thesis defines it from one site with one cable.

Another recent text on the Internet is “Contract for the Web” (in references as World Wide Web Foundation, 2019, and is authored, by among others, the Electronic Frontier Foundation (EFF) and many Internet activists, so should not be considered neutral and rather a representation of the Internet epistemic community) which indirectly defines the Internet (bundled with

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1Verified by a short conversation with a project member.

2As an example, the Internet access definition assumes that the same network is used all the time, and does not, for example, take height for Internet access in different jurisdictions as can / will happen with mobile broadband and similar scenarios.
### Table 8.1: Internet-access properties and Internet definition aspects, order from Netnod (2019), areas translated

<table>
<thead>
<tr>
<th>Area</th>
<th>Access report (Netnod, 2019)</th>
<th>Interpretation of definition (Chapter 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td></td>
<td></td>
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<tr>
<td>Policies and security at hand-over</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside shaping agreed on standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service level issue not required at the Internet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School policy agreed on terms</td>
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<td></td>
</tr>
<tr>
<td>(the separation of concerns and that the service)</td>
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<td></td>
</tr>
<tr>
<td>The decision that packets should be treated equally</td>
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<td></td>
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<tr>
<td>Describes separation of shaping at the Internet</td>
<td></td>
<td></td>
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<tr>
<td>The Internet is not service level but best-effort, etc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policies for service level agreements, resolution</td>
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<tr>
<td>Transient layer implementation and filtering of windows and information processes</td>
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<tr>
<td>Name server (&quot;the DNS resolver&quot;)</td>
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<tr>
<td>Service level issue not required at the Internet</td>
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<td></td>
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<tr>
<td>Internet could (should) be separated from the Internet</td>
<td></td>
<td></td>
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<tr>
<td>Separation of concerns at Internet access service</td>
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<td></td>
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<tr>
<td>Internet option, such as the ISP should not multiply</td>
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<td></td>
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<tr>
<td>(reconfiguration)</td>
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<tr>
<td>DNS option, such as the ISP should not multiply</td>
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<td></td>
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<tr>
<td>Technical is more or a variety check</td>
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<tr>
<td>Delivery a minimum MTU of 1500 bytes, which</td>
<td></td>
<td></td>
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<tr>
<td>according to users</td>
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<td></td>
</tr>
<tr>
<td>Delivery of II address information, both IPv4 and IPv6</td>
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<td></td>
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<tr>
<td>Policies for II address information, both IPv4 and IPv6</td>
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<tr>
<td>Requirement the Internet should at least follow the standards</td>
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<tr>
<td>Requirements for handing over IP and TCP and</td>
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<td>Requirement for handing over IP and TCP and</td>
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<tr>
<td>Client, i.e., user, should have influence to choose their equipment</td>
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<tr>
<td>Client and ISP equipment, where there are DHCP, where there are DHCP</td>
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<td></td>
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<tr>
<td>Security</td>
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<td>Policies and security at hand-over</td>
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<td>Service level issue not required at the Internet</td>
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<td>(the separation of concerns and that the service)</td>
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<tr>
<td>The decision that packets should be treated equally</td>
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<tr>
<td>Describes separation of shaping at the Internet</td>
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</tbody>
</table>
8.2. The Internet organization(s) revisited

In Chapter 3 and Chapter 4, I went through previous thoughts and studies on and around the Internet and its actors. Here I will reiterate those thoughts in the light of my empirical contributions.

As Chapter 5 argues (see updated Figure 8.2), there are three particularly important agents or actors of the Internet, without regard for ordering: the Internet standards and similar Requests for Comments, the Internet Assigned Numbers Authority (IANA) function (i.e. naming and numbering) and the infrastructure and network operators (ISPs, Internet Exchange Points (IXP) and similar actors).

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3See specifically https://www.w3.org/TR/webarch/
8. Revisiting the context

Figure 8.2: Central concepts in the Internet Coordination ecology

Internet standards

The Internet Standards, Best Current Practices (BCP) and Requests for Comments, set through IETF and Internet Engineering Steering Group (IESG) according to procedures specified in RFC-2026 (Bradner, 1996) are important in that they are (mostly) being followed. They are the core of the minimum coordination needed for the digital communications network the Internet to function.

Although the Requests for Comments more and more seem to be considered recommendations than actual standards, one such example is BCP-38 (RFC-2827, see Ferguson & Senie, 2000), which concerns spoofing IP source address for nefarious purposes. Had RFC-2827/BCP-38 been followed some of the most common distributed denial of service (DDoS) had been mostly a non-issue. Unavoidably following BCP-38 would be “good” for the larger ecology, but there is little to no incentive there for the smaller infrastructure and network operators to implement proper edge controls. As pointed out in Chapter 5, it is important to understand the difference between idea and implementations, i.e. in practice the Internet Standards themselves (such as

\footnote{Technically, it is only possible to detect spoofed source packets at the edge of an Autonomous System (AS), since then it is possible to detect which packets do not have a source address in the delegated prefix of the AS. If the packet came from another AS, you cannot judge its authenticity based on source address.}
8.2. The Internet organization(s) revisited

Requests for Comments and BCPs) and their implementations at infrastructure and network operators.

The Internet Standards are set through a mostly adhocratic process with few fixed steps until the actual accept or reject of the suggested Internet Standard by the IESG (or RFC to another track than the standards track).

Noteworthy is that the epistemic community itself is present in IETF settings, and produces and accepts Requests for Comments, rather than the normal democratic procedure where epistemic communities influence democratically elected leaders who themselves are not part of the epistemic community.

ICANN and IETF are treated further in Section 8.5.

Naming and numbering

Continuing on from the organizations themselves towards the core coordinated functions of the Internet for day to day operation (at a large scale), we have the naming and numbering of the Internet. These are handled by the IANA function and are built on technical and legitimate consideration rather than legal consideration. Similar results is shown in Mueller and Chango (2008) who notes that the WHOIS service is in 2008 contrary to many data privacy laws (i.e. illegal) but prevails, firmly in the legitimate side of the trespassing matrix (see Table 4.2) in the Internet community.

As mentioned in both Chapter 6 and Chapter 7 there are significant forces in play for other ways of handling both naming and numbering. One such force is pushing for the Digital Object Architecture (DOA)/Digital Object Numbering Authority (DONA) system, often referred to as the handle-system, to replace, or at least complement, the DNS/IANA system in place today. At a technical level the handle-system and DNS are quite similar, a central root or node which can delegate further naming authority, but at a coordination level vastly different in terms of involved parts. The handle-system is meant to specifically coordinate with the International Telecommunications Union (ITU) (as per their statutes) and several of their current board members have decade long careers from the ITU. In practice the MPAs (the DOA version of a top-level domain (TLD)) are selected by an opaque process by the board (i.e. the board has full discretion, as per the statutes), and most MPAs themselves are state connected (such as the Saudi Arabian “Communications and Information Technology Commission”, Russian Rostelecom, the Smart Africa Alliance headed by Paul Kagame⁵, the Tunisian Internet Agency and Misadi of the South African government). As argued in Chapter 6 by an interviewee; “it is possible to say bad things about ICANN, but they are transparent [paraphrased]”. Even though ICANN are not considered perfect, they are (in this case) the known devil.

⁵The president of Rwanda.
8. Revisiting the context

However, *ITU PP* 2018 did not decide to replace, remove or alter the role of DNS. Neither did the *ITU PP* continue in the direction of vying for control over the IANA function. See further discussion in Section 8.4.

**Infrastructure and network operators**

As mentioned earlier, the infrastructure and network operators play a vital role in deciding what the Internet is for the user at the edge. In this thesis, they have not been given the attention they deserve, and should be researched further. Throughout this thesis, I argue that the Internet in general is not governed by regulatory policy, but infrastructure and network operators can be directly affected by such policy, as the net neutrality regulation in the US shows (see Chapter 7).

For an infrastructure and network operator optimizing on value capture (i.e. revenue generation in the case of a firm) it is natural to bundle services and integrate vertically to capture as much value as possible. Such a proposition contradicts the earlier reasoning in Section 4.11 that the Internet is based on separation of concerns.

The question then becomes, can infrastructure and network operators be motivated to follow standards and design principles to allow their value capture processes to be agnostic to data transferred over their networks? Section 8.7 digs further into this in a net neutrality lens.

8.3 Standard setting

On the notion of standard setting in a more general sense, it seems that standards are set and accepted in manners which seem explicitly constructed to avoid issues such as those mentioned in Shapiro and Varian (1998), especially intellectual property rights, and as described in RFC-2026:

If patented or otherwise controlled technology is required for implementation, the separate implementations must also have resulted from separate exercise of the licensing process. [...] this indicating a strong belief that the specification is mature and will be useful.

The requirement for at least two independent and interoperable implementations applies to all of the options and features of the specification. In cases in which one or more options or features have not been demonstrated in at least two interoperable implementations, the specification may advance to the Draft Standard [the next stage in the standards process] level only if those options or features are removed. (Bradner, 1996, p. 12)
This highlights two concerns, firstly, for something to be considered bumped to formal standard (in the perspective of the IETF/IESG) two independent and interoperable implementations need to exist. In practice, this often means two competing firms. And secondly, open standards (that is non-proprietary or patented) are chosen over other forms of standards. A complete read of RFC-2026 shows awareness of patent and proprietary issues.

Anecdotally, I have in discussion regarding the IETF heard comments similar to “I remember the first time Firm X brought lawyers to an IETF-meeting”, indicating that there is now money on the table in the standards setting environment.

Another highlight from interviews and discussion is the marketing aspect of standards. Several firms have been noted to publish and suggest Internet standards to gain a competitive advantage by noting their standards adherence. I.e. “buy backbone routers from us, we follow RFC-xxx and RFC-yyy (which we also incidentally wrote ourselves to be able to say we follow them)”, which can work since suggested standards (i.e. drafts) can get published as Requests for Comments as well, not only the Internet Standards (i.e. the formalized standards by the IETF and IESG which require at least two working implementations to pass the review process)\(^6\).

Using the notion in Santos (2012) for value creation and value capture, the IETF standards process seems to balance the sometimes dichotomous forces of value creation for the ecology and value capture of the firm/organization quite well. Although there are indicators of a slowdown of innovative standards and progress in the IETF due to the nature of their consensus based approval methods, it is (now) hard to pass standards and suggestions which can be considered problematic.

Table 8.2 is a context-updated version of the suggested Internet design principles in Table 4.5. It contains a cursory overview of core protocols such as IP, DNS, BGP, UDP, TCP, ICMP, HTTP and maps them to suggested design principles. In the general sense, core Internet protocols (i.e. the technical Internet) follow the design principles mentioned in Section 4.13 and Table 4.5 and can be said to follow separation of concerns by design.

### 8.4 ITU Plenipotentiary

In November 2018 there was an ITU PP, which is an ordinary chapter meeting for the ITU (except being quad-annual rather than the common annual cycle). This means that ITU PP 2018 was business as usual from the perspective of the ITU.

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\(^6\)To me this assumption is similar to several misconceptions about ICANN as well, both the IETF and ICANN are regularly assumed to have more power and be more formal than they are. IETF (and IESG) by assuming that all Requests for Comments are standards and should be treated as such and therefore enforced in some “magical” way, and ICANN in that they govern the Internet in a policy sense.
Table 8.2: Internet design principles revisited (see Table 4.2) for the technical Internet: its standards and infrastructure.

<table>
<thead>
<tr>
<th>Design Principle</th>
<th>Technical Internet Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle (1)</strong></td>
<td>Low coupling, high cohesion</td>
</tr>
<tr>
<td><strong>Principle (2)</strong></td>
<td>Program to an interface, not an implementation</td>
</tr>
<tr>
<td><strong>Principle (3)</strong></td>
<td>Composition over inheritance</td>
</tr>
<tr>
<td><strong>Principle (4)</strong></td>
<td>Interface segregation</td>
</tr>
<tr>
<td><strong>Principle (5)</strong></td>
<td>Open closed principle</td>
</tr>
<tr>
<td><strong>Principle (6)</strong></td>
<td>Liskov substitution</td>
</tr>
<tr>
<td><strong>Principle (7)</strong></td>
<td>Single responsibility</td>
</tr>
<tr>
<td><strong>Principle (8)</strong></td>
<td>Dependency inversion</td>
</tr>
</tbody>
</table>
With that said, some interesting things were expected to be discussed, such as the DOA/DONA issue and a potential upcoming World Conference on International Telecommunications (WCIT). I did two interviews on ITU PP specifically; one surprisingly short with a senior representative from the Internet-sphere, which essentially said “whatever they would have decided, it would not have mattered [...] they have tried before and it did not work then”, and a longer interview and discussion with a delegate to ITU PP (who had also been at WCIT 2012). Both are firmly in the Internet epistemic community. None of the ISPs or telecommunications firms I contacted wanted to discuss ITU PP with me, and some did not know of the ITU PP, as such indicating that these matters are not that important to ISPs. But considerably more important in the Internet epistemic community.

Prior to the meeting, the delegate expected in essence three issues of special importance to the Internet to be brought up at ITU PP 2018:

- Potential need for a new WCIT
- The issues of new technologies (such as the buzzwords AI and blockchains)
- DOA/DONA

A potentially new WCIT is important since the last WCIT went in a direction against the Internet. The issue of new technologies is important since it concerns how the ITU should face developing technologies (and possibly changing their own purpose/mandate). And DOA/DONA is important as a competing naming system to DNS (as discussed briefly in Chapter 7).

In short, it was considered necessary (by the ITU PP meeting) that there should be a new WCIT in the future and one could be announced in the next four years. On the topic of new and emerging technologies nothing changed, i.e. the mandate did not change (in this sense, the ITU conformed to the Internet design principles by not extending their mandate).

But, surprisingly enough, DOA/DONA did not specifically get added to the managing document of the ITU. I was told that it boiled down to horse-trading, the Internet epistemic community wanted IETF and ICANN added formally, while others wanted DOA/DONA added, and in the end nothing got added. The delegate further explained that the working group for those particular documents9 could not agree on a final form in terms of which organizations to explicitly mention, which meant that none were suggested to

7The difference between a WCIT and a ITU PP is that a ITU PP has to take place every fourth year as a chapter meeting with all members (i.e. nation-states), while a WCIT is only called for when new treaties are needed. The two last WCITs are Melbourne in 1988 and Dubai in 2012, where Dubai was unique in that not all members signed the treaty.
8Adding IETF and ICANN would entail that the ITU should consider the opinions of ICANN and IETF on matters which concern the Internet.
9Specifically Resolution 101 (“Internet Protocol-based networks”) and Resolution 102 (“ITU’s role with regard to international public policy issues pertaining to the Internet.

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the plenary session. However, as was pointed out to me, if the plenary session had brought it up to a vote, the proponents of DOA/DONA are likely to have been in the majority.

Also of particular interest is that the delegate suggests that the participants of ITU PP do not agree on what the Internet is, yet try to agree on its future. Historically, the ITU has had little impact on what the Internet behaves in a coordination sense (such as handling of unique identifiers). However, technically the Internet uses policies coordinated by the ITU, such as spectrum allocation policies for Internet-access in cellphones (which gives the members of ITU the possibility to argue that since most actual networks are coordinated indirectly, in some sense, by the ITU, it is to be expected that the ITU is responsible for all coordination between those networks as well).

There are other ideas in the works in places which do not like the idea of an open Internet which is not under control of the ITU, United Nations (UN) or other association of nation states. I have not been able to procure referable material in an ethically acceptable way (I have been shown internal documents and presentations) on any other suggestions than WCIT going for IANA/ICANN in 2012 and the very recent DOA/DONA at ITU PP 2018, the thoughts are there outside of the ITU setting.

8.5 The organizational context

Tying the Internet as an ecology or organization back into organization literature (and thought collective) few planned and hard values are present in the coordination of the Internet. There is little central control (i.e. the agency often given ICANN is not visible), there are no planning and cybernetic controls (in the by authors Malmi & Brown, 2008, sense), and the main controls are rather culture (as a common understanding of meaning) and administrative (as in the coordination structure of the Internet including recruiting staff to ICANN and Internet Society (ISOC) and nominations to representational duties).

This is in line with the arguments in Mintzberg (1993) (a changing environment creates agile and adhocratic constellations) and Simon (1997) (rationality plays a smaller role than often implied in what actually happens) as well as the more general notions in Meyer and Rowan (1977) and DiMaggio and Powell (1983) that isomorphism and formalization is a consequence of socialization rather than efficiency requirements. For example, according to Meyer and Rowan (1977) and DiMaggio and Powell (1983) it is to be expected that ICANN is more formal than the IETF since ICANN has less reason to change.

and the management of Internet resources, including domain names and addresses”), final version is available as ITU (2018).
8.5. The organizational context

It is prudent to look at the Internet as something wider than a concept in need of governance, or a strategy in need of implementation, and rather something living and changing and to that extent hard to define in an organizational or coordination context. Therefore, the technical context is also of interest, which Section 9.1 digs deeper into. I found little to no formal management in place for the Internet in coordination terms, which is not surprising given that the Internet is dynamic and changing, although it was a surprise that there is so little coherence and overarching strategy for the Internet as a whole in what the Internet is or should be. Even within the Internet epistemic community there are clear nuances at play when looking deeper.

As an example, in a discussion on principles I was told that layer violation “is bad” and should be kept at minimum, but a couple of minutes later that same person described the technical details and promoted a service which violates layers. My understanding of the situation is that no one else should violate layers for their own value capture, but “it is okay if we do it”.

However, ecologies (as discussed in Olve et al., 2013; Westelius & Lindh, 2016; Westelius & Westelius, 2018) proved useful for understanding the not always formal relationships between organizations and their reasoning towards each other. In particular the MARC model (Westelius & Westelius, 2018; Westelius et al., 2013) and its “soft”-values better explained core Internet thoughts than the rational optimal market approach. I perceive that people partake in IETF and ICANN processes for two reasons; either because their employer wants it (“hard”-side, for example promoting standards which could be adopted generating revenue) or because it gave them meaning (“soft”-side, for example partaking in coordination processes of a global common to fulfill a higher calling).

There is a problem with competence supply in leading ideological roles (see Chapter 5), which according to one interviewee was solely (the interviewee’s opinion) dependent on that the salaries for the “good guys” were not high enough. The full argument being that for a young technically gifted and governance interested individual it makes rational sense to go into industry and earn three or four times of what a job at an Internet Coordination non-profit would get you. The meaning of working with Internet Coordination was not considered enough to outweigh the rationality downside (in MARC terms).

In terms of ecologies, Table 8.3 shows the identified actor types in the Internet ecology. Important updates include clarified roles for the regulators as responsible for contract adherence and not explicit telecommunications regulation (in the Internet perspective). In terms of actor types, I added “squatter” as a role for an organization which changes the overall behavior in an ecology by existing passively rather than acting. In this case ICANN, through interviews, seems to affect the behavior of ITU and UN meetings by
### Table 8.3: Internet-actor types, based on the typology in Olve, Cöster, Iveroth, Petri, and Westelius (2013), reworked version of table in Chapter 5.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Roles</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICANN</td>
<td>society, policy, squatter</td>
<td>ICANN in practice acts as the lens where society and politicians exert pressure on shaping and defining the Internet</td>
</tr>
<tr>
<td>IETF</td>
<td>standardizer, innovator</td>
<td>The IETF produce unenforced Internet Standards through Requests for Comments</td>
</tr>
<tr>
<td>infrastructure and network operators</td>
<td>distributor, financier</td>
<td>Provides Internet-access as a service, and to a lesser extent stakeholders in the standardization process (most are passive stakeholder, but few participate in the process)</td>
</tr>
<tr>
<td>CDNs</td>
<td>customers and suppliers</td>
<td>Suppliers of content and customers of infrastructure and network operators and IXP, much of web-content is centralized in CDNs</td>
</tr>
<tr>
<td>Govts, the UN and the ITU</td>
<td>regulators</td>
<td>Regulatory power, in many aspects trying to regulate the Internet as a cable-TV-like streaming service rather than a generic digital communications platform. Also the ITU, in what could be a move to stay relevant, is trying to take a more active Internet Governance role as the governor (rather than participating in Internet Coordination). In practice regulate contractual agreements, such as end-user or service agreements.</td>
</tr>
<tr>
<td>Users</td>
<td>customers and suppliers</td>
<td>There seems to be no clear innovators or idea marketers for innovating the Internet itself in the Internet ecology today. Innovation seems to be centered on services on the Internet rather than the Internet or the coordination of the Internet today. Depending on perspective, the ITU can be considered an innovator (or disruptor).</td>
</tr>
<tr>
<td>??</td>
<td>marketeers</td>
<td></td>
</tr>
</tbody>
</table>

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Table 8.4: An interpretation of software design principles as organizational design principles in the case of the Internet.

<table>
<thead>
<tr>
<th>Design principle</th>
<th>Organizing Internet design</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Low coupling, high cohesion” (1)</td>
<td>The Internet originally had two entities in need of coordination specific to the Internet, Internet Standards and unique identifiers, separated into two arenas (ISOC and IANA) with a minimum of coordination. Also note that the infrastructure and network operators (the ones actually running the Internet) are separate from both IETF and ICANN. Just as ISPs and IXPs often are separate. A contrary example, an ISP bundling its services with a content provider and discriminates traffic from competing services. See above, ICANN and IETF depend on descriptions of what the other does rather than how it does it. In practical terms infrastructure and network operators do not depend on the implementations of each other, and rather assume that all other infrastructure and network operators (and ASs) follow Internet Standards. As such infrastructure and network operators depend on the dissipation and acceptance of standards rather than direct agreements with other infrastructure and network operators. Proposition 2 is in Internet terms more important to the running of the network than the coordination of the standards themselves.</td>
</tr>
<tr>
<td>Program to an 'interface', not an 'implementation' (2)</td>
<td>One the one hand, IETF has working groups, areas, arenas and so forth to spread out rather than concentrate function. One the other hand, my empirical material shows that ICANN is rather consolidating itself with how the EC is practically run. In practice, at least in the West, ISPs outsource the IXP to separate entities, rather than running an in-house Internet-exchange operation. Thus, composition is favored over inheritance, but not in all cases.</td>
</tr>
<tr>
<td>Composition over inheritance (3)</td>
<td></td>
</tr>
</tbody>
</table>
Table 8.5: An interpretation of software design principles as organizational design principles in the case of the Internet

<table>
<thead>
<tr>
<th>Design principle</th>
<th>Organizing Internet design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single responsibility principle</strong></td>
<td>Requirements for changing standards go through ICANN (and the ICANN Board). Changing customer requirements go to the ICANN. Requirements for different name and number policies go through the IETF. Requirements for different service and product policies go through the IETF.</td>
</tr>
<tr>
<td><strong>Liskov substitution principle</strong></td>
<td>Infrastructure and network operators, ISOC, ICANN etc do not have to rely on each other. Services can extend their services, such as triple-play, and long as that agreed on values, such as non-discrimination of packets, is upheld. See Section 8.7 for further discussion.</td>
</tr>
<tr>
<td><strong>Open closed principle</strong></td>
<td>Infrastructure and network operators, ISOC, ICANN etc do not have to rely on each other. All interested parties have the possibility of participating in IETF and ICANN processes (given funds and time). Regardless of type of party.</td>
</tr>
<tr>
<td><strong>Dependency inversion principle</strong></td>
<td>Internets-access providers can extend their services, such as triple-play, and long as that agreed on values, such as non-discrimination of packets, is upheld. See Section 8.7 for further discussion.</td>
</tr>
<tr>
<td><strong>Interface segregation principle</strong></td>
<td>Internet-access providers can extend their services, such as triple-play, and long as that agreed on values, such as non-discrimination of packets, is upheld. See Section 8.7 for further discussion.</td>
</tr>
</tbody>
</table>

The IETF and ICANN processes are separate and modular processes compared to the EC process. Requirements for changing standards go through the IETF, ICANN and IANA. Requirements for different service and product policies go through the IETF. Requirements for different name and number policies go through the ICANN Board. Changing customer requirements go to the ICANN. Services can extend their services, such as triple-play, and long as that agreed on values, such as non-discrimination of packets, is upheld. See Section 8.7 for further discussion.
just existing and prevents actors from claiming the \textit{naming} and \textit{numbering} functions of the Internet.

Table 8.4 and Table 8.5 compare Table 4.4 with the empirical organizational Internet found in Chapter 5 and Chapter 6. In the general sense, the Internet central organizations have at one time, followed the suggested organizational design principles in Table 4.4, but the waters are muddied today with the inclusion of generic top-level domains (gTLD), increasing ICANN mandate (and implicitly the formal structure of the EC) which all increase the size of ICANN. Similar issues as noted with ITU in the interviews, could be applied to ICANN, such as bloating mandate and mission to become the arena for all issues (concerning Internet for ICANN, and telecommunications for ITU). Of particular note is the ICANN NomCom (nominating committee) which can\(^{10}\) set their own processes, and as such can practically change their own purpose within the larger ICANN ecosystem.

\textbf{IETF}, in my empirical data, lies considerably closer to the design principles suggested in Table 4.4. There are clear distinctions and descriptions regarding the tasks and processes of particular groups. In particular, RFC-2026 (Bradner, 1996) envisions both organization and protocols to follow separation of concerns and to embrace and tolerate change, as quoted:

> From its inception, the Internet has been, and is expected to remain, an evolving system whose participants regularly factor new requirements and technology into its design and implementation. Users of the Internet and providers of the equipment, software, and services that support it should anticipate and embrace this evolution as a major tenet of Internet philosophy. (Bradner, 1996, p. 3)

It is possible to explain the differences between ICANN and the IETF by normative isomorphic forces as argued in Meyer and Rowan (1977) and DiMaggio and Powell (1983). In the meaning that isomorphism comes from engineers\(^{11}\) and similar thought collectives into the IETF, while ICANN might attract another blend of policy people, economists and engineers and therefore is more isomorphic to policy organizations than engineering firms or skunk-works. My interviews hint that the normative isomorphic pressure from engineers is declining (in ICANN specifically, but also in IETF sub-groups) and other thought collectives and epistemic communities are pushing in (such as policy and economics, where integrating into a monolithic governing organization is not a given wrong). In a sense, this can be seen as different streams or epistemic communities vying for Internet Coordination power in their own perspectives of what the Internet is.

\(^{10}\)At the time of writing, there are political forces which want to change this.

\(^{11}\)Using engineer as an umbrella term for technically knowledgeable.
8. Revisiting the context

In this clash of perspectives, one extreme is the separation of concerns version, with Internet Coordination as the minimum coordination necessary for an international digital communications network. The other extreme is an integration of concerns single monolithic institution setting the rules of engagement in full-stack digital communications.

8.6 Revisiting net neutrality

Chapter 7 problematizes Internet Coordination in a net neutrality lens and suggests a matrix (see Table 7.14) for identifying digital communication networks. In Table 8.6 I suggest an updated and more nuanced version of the same matrix. Whereas Table 7.14 in Chapter 7 focused on the extremes of coordinating a digital network, Table 8.6 adds a nuanced middle ground.

Table 8.6: Typology of digital communication networks revisited

<table>
<thead>
<tr>
<th>Policy logic</th>
<th>Net neutrality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>de facto net neutrality</td>
</tr>
<tr>
<td>Regulartory policy</td>
<td>Regulated Internet</td>
</tr>
<tr>
<td>Mixed policy</td>
<td>Mixed Internet</td>
</tr>
<tr>
<td>Market policy</td>
<td>Early Internet</td>
</tr>
</tbody>
</table>

Specifically by adding a mix category (mixed policy) for policy, indicating that neither market policy nor regulatory policy on its own can be said to dictate rules of engagement vis-à-vis the digital network, and a “mixed” net neutrality column indicating that net neutrality is upheld by some actors but not by all (i.e. neither net neutrality nor no-net neutrality can be considered the norm).

This updated typology (Table 8.6) better illustrates events than the original typology. For example, Internet-access in the U.S. can be described as going from early Internet to mixed Internet to market Internet with the deregulation of net neutrality. Whereas in the European Union (EU) the Internet can be described as going from early Internet to mixed Internet to regulated Internet, with the EU copyright directive Article 15 and 17 pushing the Internet into clearer regulatory waters.

The original Internet values, as described, for example, by RFC-2026 (Bradner, 1996) and RFC-6722 (Hoffman, 2012) (“the Tao of the IETF”),
are best envisioned in the bottom left corner of the matrix, where markets set rules of engagements and net neutrality is a de facto norm for network operation. Perhaps not net neutrality due to market reasons, rather due to ethical reasons or an ideology of the perfect digital network.

The right-hand side of the matrix (Table 8.6) illustrate regimes where infrastructure and network operators can capture value at will in accordance with regulation. As is the case with cable-TV service (not Internet access over DOCSIS, but programmed cable-TV service).

8.7 Net neutrality as a design principle

In Chapter 7, I briefly covered net neutrality, and treated it similarly to how it is treated in telecommunications policy (see for example Economides & Hermelin, 2012; Economides & Tåg, 2009, for net neutrality in telecommunications) but in the light of what this thesis considers to be the Internet. As the next chapter, Section 9.1, shows, net neutrality is part of a much bigger concept in the Internet sense, and is in essence a core of the distributed perspective. Net neutrality can be seen as much broader than just a “packet-over-network” issue and rather a way of doing business. Do note that my broader view of net neutrality as practical rather than a regulatory issue is not accepted in the scientific fields concerned with policy and regulation.

And it should be explicitly noted the issues we had when researching Brege and Lindeberg (2018) (as summarized in Section 7.13), that finding firms which are not at all dependent on the Internet to do business (whether it is in internal or external processes) was quite hard in the Western context. Ergo a lack of net neutrality in practice would imply that infrastructure and network operators have great control/power over their customers (i.e. firms and people, if lack of net neutrality mean that infrastructure and network operators have the legal and legitimate right to capture value on their networks).

Net neutrality is often portrayed as a political only issue, particularly in policy and economics fields (see for example Economides & Hermelin, 2012; Economides & Tåg, 2009, again), and even in an IETF keynote (see Handley, 2009), but that is not the end of the story. Section 4.11 and Section 4.13 argue that there are certain design principles for software design. Table 8.7 and Table 8.8 compare those design principles with the Internet (as portrayed in Chapter 5 and Chapter 6) and net neutrality (as portrayed in Chapter 7).

The design principles in Section 4.13 directly translated to the Internet, in such a manner that the Internet can be said to uphold software design principles in its coordination, technology and structure. Net neutrality though, does not directly map onto all selected software design principles, although it can be said that net neutrality can be seen as a design principle of the Internet, as it fits neatly on concepts such as separation of concerns. Note that if all Internet design principles are upheld, net neutrality is upheld (indirectly).
Table 8.7: Comparison of design principles for the Internet and net neutrality

<table>
<thead>
<tr>
<th>Design principle</th>
<th>Technical Internet example</th>
<th>Net neutrality aspects</th>
<th>Technical Internet example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition 1</td>
<td>&quot;Low coupling, high cohesion&quot;</td>
<td>Network protocols can be added without affecting other network protocols</td>
<td>The Internet is layered and independent layers can be added, and the network should be &quot;low coupled&quot;</td>
</tr>
<tr>
<td>Proposition 2</td>
<td>&quot;Program to an interface, not an implementation&quot;</td>
<td>The Internet is designed to not care about implementation and rather care about specification</td>
<td>Standards are separate and non-monolithic, and depend on the IETF to coordinate standards, not the actual implementation and use of standards</td>
</tr>
<tr>
<td>Proposition 3</td>
<td>&quot;Composition over inheritance&quot;</td>
<td>As an example, the Internet is not monolithic, and care should not be given to the same, as such does not limit conflict (no conflict between layers)</td>
<td>Net neutrality stipulates that the network should not care what is being sent over it, in essence low coupling with different protocols, and ICANN should not be given to the same, as such does not limit conflict (no conflict between layers)</td>
</tr>
</tbody>
</table>

Not explicitly applicable since net neutrality is not explicitly applied to secure network protocols.

Table 8.7: Comparison of design principles for the Internet and net neutrality.
Table 8.8: Comparison of design principles for the Internet and net neutrality

<table>
<thead>
<tr>
<th>Design principle</th>
<th>Technical Internet aspects</th>
<th>Internet Coordination aspects</th>
<th>Net neutrality aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition 4, Single responsibility principle</td>
<td>Protocols should only have one reason to change.</td>
<td>As an example, IANA should only change if the coordination of unique identifiers changes.</td>
<td>Not explicitly applicable since net neutrality is not intended to change and rather describes an ideal.</td>
</tr>
<tr>
<td>Proposition 5, Open closed principle</td>
<td>Protocols should where possible be extendable.</td>
<td>Upheld by the IETF and (to a lesser extent) ICANN</td>
<td>Core tenet of net neutrality, i.e. that functionality cannot be removed, that is the neutrality of the network</td>
</tr>
<tr>
<td>Proposition 6, Liskov substitution principle</td>
<td>Datagram-layer protocols work with all Internet-level protocols.</td>
<td>All parties treated the same, regardless of being governments, individuals, non-profits or firms.</td>
<td>All packets should be treated the same, no matter the sender or receiver, content or anything else.</td>
</tr>
<tr>
<td>Proposition 7, Interface segregation principle</td>
<td>Protocol specifications are spread out into functional categories.</td>
<td>For example separation of work into working groups in the IETF.</td>
<td>Not directly comparable.</td>
</tr>
<tr>
<td>Proposition 8, Dependency inversion principle</td>
<td>Protocols do not depend on implementations of other protocols.</td>
<td>Internet organizations do not rely on each others implementations but rather each others descriptions.</td>
<td>Not directly comparable, but aligned in such a sense that net neutrality is one way to uphold Proposition 8, i.e. treating all packets neutrally.</td>
</tr>
</tbody>
</table>
Important to note in Tables 8.7 to 8.8 is that Proposition 2 and Proposition 8 in the coordination sense implies that organizations should be defined by their contracts, products or interfaces rather than their implementation, which in the case of ICANN and the IETF means that the implementation (i.e. the organizations themselves) might change or be replaced and that the importance lies in their contracts or understandings with the surrounding ecology (and in this case that the coordination of unique identifiers should be done separately from the coordination of Internet Standards, and it might well be argued that numbering and naming should be coordinated separately).

As such, practical net neutrality is a pre-requirement for the Internet as designed, and the pertinent question is rather how net neutrality should be upheld. As argued in Chapter 7, what net neutrality is might not be as important as how it is coordinated. In Chapter 5, I show that the Internet is explicitly not governed by regulatory policy but rather by bottom-up coordination and market forces, which leads to that net neutrality itself should be upheld by market forces (see taxonomy table in Chapter 7), ergo regulation ought to be designed in such a way that net neutrality can become a practical market outcome. Or rephrased differently, regulation should not force net neutrality, regulation should rather create a market where packet-neutral services are a part of the complete set of offerings (and make market sense). This can be compared to how the Netnod (2019) Internet-access definition threads two worlds in bringing together the technical Internet with service level aspects of Internet-access.

The actual design of such policy is outside the scope of this thesis, but as an example, several countries have separated the infrastructure and service side of the markets to better foster competition at a service level. In Sweden, my local market, regulation has led to a virtual monopoly for the public of owning fiber optic cables (i.e. infrastructure) and forces competition at a service level instead. One such service might be Internet-access, even though net neutrality as a concept is not limited to the Internet but rather digital communications networks.

The downside of the design argument is that this selection of design principles does not represent the set of all possible design principles, and in a scientific sense shows that it is likely that the Internet is designed similarly as software design principles (i.e. there is correlation but the hypothesis of causality cannot be proven). And that if these design principles are upheld, there is net neutrality.

In general terms, the academic net neutrality debate has changed the last years (i.e. since Chapter 7 was written), and gone from putting the Internet in a US context into either common carrier (i.e. regulatory and in some sense enforced net neutrality due to common good and utility argument) or information service (i.e. no regulation regarding net neutrality at either service or infrastructure layer, since the Internet is entertainment rather than a need or utility) to a more nuanced debate more in line with Chapter 7. In particular
Glass and Tardiff (2019) gives a nuanced view of the US situation; firstly by admitting that more than the last-mile\(^{12}\) is interesting (i.e. the entirety of the network should be looked at), and secondly, the question whether regulation is the right way to go or not (i.e. instead of asking which box the Internet should be squeezed into, the question changes to if the Internet should be squeezed into a box at all).

There are other nuanced texts which are not part of Chapter 7, such as Thorngren (2006), principally only because I did not find them (an illustration of how university libraries, Web of Science and Google Scholar influence research).

### 8.8 Internet threats

As mentioned in Section 2.7 (in Table 2.4, static questions) a common theme and question during interviews was “What is the most significant threat to the Internet today?” The answers to this question generally were in two categories; political and “technical and market”-related.

Political threats included a changing world order where world coordination is no longer the norm, and in such a world order, a free and open digital communications network is not an obvious want or need. Examples of this include the notion of DONA and DOA where nation states would have a more pronounced role in the governance of the digital communications network.

On the technical and market level issues, such as Internet-of-Things (IoT) and BCP-38-related consequences are often brought up. These are intertwined but can in their extremes be said to concern how a society can become vulnerable by placing too much trust in a best-effort network such as the Internet (due to misconceptions of what the Internet is). As with IoT dependent smart cities and smart societies where a lack of Internet-function would prevent essential services from working. As an illustrative example, there is something wrong with the door and you can not open it, even though you need to get through the door to start your daily commute. In reality, there is an issue somewhere with the network, could be an ISP, or an IXP, having issues. But who is to blame? And how should the issue be solved? The Internet is best-effort, so situations like this are to be expected and handled (in comparison to avoided through service level contracts and agreements). That is, handled so that devices at the edge can function without the Internet, since the Internet should not be relied on to work all the time.

BCP-38 issues in general concern the dynamic nature of the Internet and how to create incentives to at a technical level work for the common good rather than personal (or organizational) gain, which can be compared with

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\(^{12}\)In the american debate, last-mile is commonly referred to as BIAS (Broadband-based Internet Access Subscription), i.e. a service perspective (integrative perspective in Section 9.1).
the value creation versus value capture argument (see Santos, 2012, for further argumentation). Another way of framing it: how should technical standards look so that for-profit actors create excess value for the common good in their hunt for value capture. As argued in Chapter 5, the Internet is driven by for-profit actors reined in by morals, ethics and market regulation.

Here it is prudent with a reminder that the IETF can be seen as the place where markets meet technology to set standards, against the common perceived enemy the state. As stated in an interview:

Simplified a bit, [...] the IETF, especially the Americans [i.e. US people], do not trust governments to do anything properly [...] and that markets never can do anything wrong

As such “the Americans in the IETF” are the opposite of the states pushing for ITU control over the Internet (later in this thesis I argue that the classic market vs bureaucracy perspective is not enough, and that technology rationality or meaning adds understanding to the development of the Internet and its ecology). And both can be considered threats to the Internet in their own way: the ITU (UN) by changing the coordination mode into multilateralism (breaking Internet organization design principles). Firms ultimately by de facto integrating and bundling all services (breaking Internet technical design principles).

These threats are those which concerns the Internet itself och quite directly. In the broader societal perspective there are other factors which can influence, for example, public distrust of the Internet.

This demarcation of actual Internet and surrounding Internet issues is core to the different suggestions and conclusions of texts such as this text and, for example, DeNardis and Raymond (2013). Let us take public trust as an example, public trust of the Internet can be diminished if illegal or illegitimate actors use the Internet for nefarious purposes.

In the view of the Internet community this is not an Internet issue, as long as the network itself works as intended (i.e. as a sort of infrastructure for digital communication), and that other entities should deal with such behavior, for example the police in the jurisdiction where the offenders are located. And, again according to the Internet community, the Internet will continue to exist even if distrusted in a negative spiral.

In the view of DeNardis and Raymond (2013) (and Liu, 1999; Raustiala, 2016; van Eeten & Mueller, 2012, to name a few) Internet misuse and illegal use are Internet issues and should be treated by Internet institutions, therefore implicitly saying that such institutions should exist (i.e. institutions for Internet use). I do not know how the legality of such an institution would work, and such change might incur greater geographical limitations on the Internet. I.e. existence of such institutions might very well turn the Internet into a telecommunications network (as defined in this thesis). Therefore, such
institutions would be a greater threat to the Internet than the misuse itself. Quite a conundrum.

8.9 Lobbyism

An interesting observation on the notion of “Internet lobbyism”; few Internet lobbyists consider themselves lobbyists. As put in an interview:

- Do you consider yourself an Internet lobbyist?
  - Yes. [...] Even though [names of people] do not consider themselves lobbyists, they are Internet lobbyists. [...] There is] nothing inherently bad with being a lobbyist. (first quote)

This can be put in comparison with another quote:

- Are you / your organization involved in lobbying?
  - No, [organizational groupings] are not lobbyists. [...] We want to provide knowledge so those in power can make educated decisions [in the sense of how the Internet technically operates]. (second quote)

This ties a bit into the argument of “the Internet has no champions” in Chapter 7 in different clothing, i.e. that no-one will speak on behalf of the Internet if needed, since that is not how the Internet is coordinated. Also interesting is that the interviewee in the second quote was mentioned by name by the interviewee in the first quote (the Internet epistemic community is quite small, at least the epistemic community talking to me).

Further questioning into the “lobbyism” issue led me to believe that the general perception of lobbyist by Internet-people is that of someone pushing an agenda not anchored in reality (i.e. as second quote) whilst a minority (of those I talked to) had a broader less negative view of lobbyist (i.e. as first quote) which rather resembled that of a thought leader in a thought collective or an epistemic community.

Also, the Internet thought collective is clearly larger than the Internet epistemic community in that not all members of the thought collective consider lobbying or affecting those in power necessary.

Fleck is with thought collectives on the side of the first quote on this issue, that the creation of fact is a social process (i.e. not objective, if such a thing exists) and that the distinction made in the second quote is not feasible. Although neither Adler and Haas (1992) or Haas (1992) is explicit on whether it is possible to implicitly be part of an epistemic community, I make the distinction here that you are not part of the epistemic community if you do not play an explicit and intentional role.
This chapter generalizes from the previous chapters in order to synthesize two perspectives which can be generalized to almost any setting involving coordination and technology. The first perspective, the distributed perspective, is based on Internet design principles (such as separation of concerns and avoiding layer violations) generalized to a wider context, and the second perspective, the integrative perspective, is generalized from principles of integrating functionality and services as an all-in-one solution (as seen and experienced by the user), often by business logic.

The chapter starts off with discussion and synthesis of the perspectives, and end with a reflection and revisit of the sources which led to these perspectives (see Section 9.11).

I use coordination and technology as related and intertwined, rather than two separate, in technical terms orthogonal, perspectives.

9.1 Perspectives on the Internet

As previously alluded to I argue that it is possible to view the Internet as different animals depending on where you are standing. In this chapter I elaborate on these thoughts with particular emphasis on two perspectives,
9. Discussion

the integrative perspective and the distributed perspective, where the difference is in the dimension of coordination and the dimension of technology is kept fixed in the sense that Internet Standards can be used in a different coordination regime. To clarify, the first example in this chapter is the Internet in an Internet Corporation for Assigned Names and Number (ICANN) and Internet Engineering Task Force (IETF) regime compared to an International Telecommunications Union (ITU) and Digital Object Numbering Authority (DONA) regime. In short, the technical implementations are similar.

Where the integrative perspective focuses on policy and top-down governance for standards and sovereign-state-based enforcement, the distributed perspective focuses on explicit bottom-up coordination where actors are only bound by the agreements and standards they agree to.

One major difference between the integrative perspective and the distributed perspective is separation of concerns (see earlier description in Section 4.11), in that in the distributed perspective, separation of concerns is key for distributing power and function.

These perspectives build on the contents and argumentation of Chapter 5, Chapter 6, Chapter 7 and Chapter 8. In particular Chapter 5 describes how Internet Coordination functions are distributed, Chapter 6 goes through their social resilience and Chapter 7 puts net neutrality in the perspective of the Internet by comparing different typologies of the Internet. Chapter 8 puts the Internet in a design viewpoint.

9.2 The distributed perspective

A distributed perspective, the Internet is both a technical and a coordination phenomenon. Important lodestars are concepts such as “running code and rough consensus” (see IETF mantra), voluntary participation and separation of concerns (see Section 4.11). In Table 9.1 I present the Internet from a distributed perspective.

Table 9.1: Dimensions of the Internet in the distributed perspective

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination</td>
<td>Explicitly loose bottom up with focus empirically motivated decisions.</td>
</tr>
<tr>
<td>Technology</td>
<td>End-to-end best-effort digital communication.</td>
</tr>
</tbody>
</table>

An important coordination mechanism, as mentioned, is the voluntary participation in settings standards and future governance (or coordination) principles. The distributed perspective also clearly distinguishes between the Internet and other applications on top (such as the web), in that the IETF
(and Internet Engineering Steering Group (IESG)), ICANN (and Empowered Community (EC)) etc are only concerned with the digital best-effort infrastructure that is the Internet and its coordination. That which is run on top of it is “somebody else’s problem”.

Figure 9.1: Technology dimension of the Internet in the distributed perspective

One example of this is the net neutrality debate in the US. I discuss it in detail in Chapter 7 and the short version is that from a distributed perspective, the notion that network operators should differentiate traffic other than directly harmful traffic is not congruent with the ideals and views of what the Internet should be.

Figure 9.2: Coordination dimension of the Internet in the distributed perspective
9. Discussion

I consider ICANN to be of a more formalized hierarchical character since the revised bylaws in 2016 (see Chapter 5 and Chapter 6 for argumentation) but prior to 2016 ICANN was more akin to the IETF governing model. Currently, the EC model is hierarchical and strict compared to IETF. The IETF processes are more haphazard and adhocratic in the organization of the working groups (WGs in Figure 9.2b) and effective power is distributed and not, for example, given to chairs. Working groups normally number in the hundreds without formal hierarchical structure, although all working groups belong to an area. The IETF does have a gatekeeper for Requests for Comments (RFCs), the IESG, although my interviews suggest that the workings groups are the ones coordinating and doing all the work up to the formal gate instance. The relationships are comparable to research groups and editors of journals in terms of producing product and quality assuring product.

9.3 The integrative perspective

The integrative perspective grew from that which was once the telegraph community. This meant vertical integration of services, even at a device level where the telecommunications operator could own edge devices (such as phones or routers). In essence, the integrative perspective can be considered opposite to the distributed perspective in many ideological and governing matters. Just like integration of concerns (Section 4.12) and separation of concerns (Section 4.11) are two different models of solving a problem. In Table 9.2, I give a summary of the integrative perspective. In this perspective, Domain Name System (DNS) is replaced with the suggested Digital Object Architecture (DOA) and DONA constellations for naming, while numbering (and routing) stays the same.

As such the coordination dimension has changed (Figure 9.4 compared to Figure 9.2) while naming and numbering in the technical sense behaves similarly (see Figure 9.3 compared to Figure 9.1).

Table 9.2: Dimensions of the Internet in the integrative perspective

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination</td>
<td>Through telecommunications governance bodies such as the ITU and national regulatory authorities, in a sense classical governance.</td>
</tr>
<tr>
<td>Technology</td>
<td>End-to-end digital communication.</td>
</tr>
</tbody>
</table>

In Table 9.2, note the difference in the technical dimension to the distributed perspective (Table 9.1), the integrative perspective is not explicit in
that the technology is best-effort rather than service level, which comes from that at a telecommunications service level contracts are usually in the form of service level agreements (i.e. could be a bad business decision to admit that the technology is best-effort and not service level) rather than what the technology does. And since the integrative perspective values vertical integration, additional layers can make the Internet seem service level, even though the technology at its core is not.

<table>
<thead>
<tr>
<th>ITU</th>
<th>ITU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>Germany</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Regulation (b) Standard setting

Figure 9.4: Coordination dimension of the Internet in the integrative perspective

Recently Telia (a Swedish telecommunications firm, i.e. mostly infrastructure) made a bid for TV4 (one of the bigger Swedish content producers for TV) which can be seen as a typical move in an integrative perspective, i.e. integration of concerns or vertical integration.

In both Chapter 6 and Chapter 7 I elaborate a bit on the handle-system and its position on challenging the DNS-system on being the de facto digital resource naming system. The handle-system fits better in the gover-
nance model of the distributed perspective since all “nodes” would be either sovereign states or international treaty organizations such as the ITU (practically). The DNS-system model is hierarchical in essence but actors can be essentially anyone, whereas the handle-system in practice involves state entities and international treaty organizations.

9.4 Comparing the perspectives

The two previous section described the Internet from two perspectives, the distributed perspective and the integrative perspective, in a nuanced way. Going forward I will use the distributed perspective and integrative perspective as dichotomous opposites or extremes to illustrate differences rather than nuanced tools. As such the realm of possibilities lies between the perspectives as well as within them, a notion I elaborate more on in Section 9.11.

In Table 9.3 I give an overview of the perspectives and how they interpret terms or events differently. Do note that I here present the extremes of the perspectives and most members of the perspectives would probably agree that the reality lies somewhere between the two extremes. As such the Least Common Internet is a concept or a design for how to build digital communications networks, rather than an actual manifestation. Simply and a bit naively put, the distributed perspective is designed and optimized for change, while the integrative perspective is optimized for value capture of existing actors.

As can be seen in Figure 9.1, Figure 9.3, Table 9.1 and Table 9.2 these perspectives do to a large extent agree on what the Internet is from a technology perspective, even though telecommunications tend to skew towards service level rather than a best-effort mechanism in terms of describing the technical function of the network.

An interesting difference is how technical trust should be handled. From the integrative perspective, it is possible to trust the network (in technical error) to deliver and not misbehave concerning the traffic, but in a distributed perspective it is fundamental that the Internet cannot be trusted, the entity at the edge is responsible for ensuring delivery and resending packets. This ties significantly into best effort vs service level on packet delivery. And the upcoming discussion on Articles 15 and 17 in the EU copyright directive which explicitly tasks infrastructure and network operators with responsibilities which requires the infrastructure and network operators to inspect traffic (Section 9.5).

On the topic of trust I want to mention the issues in the US regarding the AT&T case and Snowden revelations (as mentioned in Chapter 5). Before the revelations there were people who suggested that the (Internet) network (practically) cannot be trusted in a privacy sense since it could be of the interest of many parties, including states, to spy on traffic. The court case (see Markus, 2006, for central testimony) started processes which ended up
Table 9.3: A comparison between extremes of the distributed perspective and the integrative perspective.

<table>
<thead>
<tr>
<th>Topic</th>
<th>A distributed perspective interpretation</th>
<th>An integrative perspective interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISP</td>
<td>An actor selling Internet access to end-users and buys capacity from network capacity wholesalers.</td>
<td>Typically one of the many roles of a cable and network company.</td>
</tr>
<tr>
<td>last-mile</td>
<td>It should work, but not that particularly interesting.</td>
<td>An opportunity for n-sided markets. The last-mile owner and operator has a right to capture value from traffic flowing on the last-mile.</td>
</tr>
<tr>
<td>the Internet</td>
<td>The notion of a bottom-up governed digital network without central power.</td>
<td>A telecommunications service.</td>
</tr>
<tr>
<td>congestion</td>
<td>A natural part of a distributed and interconnected network, that is why BGP exists and TCP has built in mechanisms for handling congestion and dropped packets.</td>
<td>A last-mile phenomenon, for example when many customers watch Netflix or YouTube at the same time.</td>
</tr>
<tr>
<td>ICANN</td>
<td>A stiff and formal organization which preferably should follow the tao of the IETF with fewer kings and more consensus.</td>
<td>A rogue organization without regulatory oversight. The IANA-function should be with the ITU, else we can always use the handle-system.</td>
</tr>
<tr>
<td>packet delivery</td>
<td>best-effort</td>
<td>agreed on through service level agreements</td>
</tr>
<tr>
<td>trust</td>
<td>You cannot trust the Internet, encrypt important traffic at the edge</td>
<td>It depends on your service level agreement</td>
</tr>
</tbody>
</table>
as the FISA Amendments Act of 2008 which retroactively gave AT&T and others immunity to intentionally spying on traffic on their networks on behalf of the state (i.e. National Security Agency (NSA)). In effect, this proves, beyond a doubt, that trusting the network fully is a bad idea. The distributed perspective says that you should not trust the network to not spy on your traffic, while the integrative perspective states that such behavior should be possible to prevent through contracts and service level agreements.

I use these perspectives as two examples that the Internet can be perceived quite differently depending on viewpoint and context. Also, I show that both a technical understanding and a coordination understanding is necessary to make sense of the differences between them, highlighting the confusion which can arise when for example a telecommunications company discusses particulars of the Internet compared to when IETF does the same. In essence, they are discussing different Internet phenomena, at least in the coordination dimension in general and in particular what the Least Common Internet is.

9.5 Internet examples

The following paragraphs list several examples of the perspectives in conjunction with Internet design and function.

Examples of Internet-routing and -naming

On the Internet, naming and routing are separated into different layers, where it is technically stipulated that the ISP takes care of routing (since routing takes place on a lower layer closer to the infrastructure) and naming (i.e. DNS) could technically be handled by someone else. For most private Internet-subscribers, the ISP takes care of DNS as well, but the ISP does not have to. See the argument in Netnod (2019) that it should be possible for the end-user to choose another DNS service than the one provided by the ISP.

There are a multitude of corporate offers on DNS-services, OpenDNS by Cisco and Cloudflare to name a few, where organizations are thought to lessen risk by filtering and washing DNS-queries through a validation service to avoid phishing\(^1\) and similar attempts. These are services which would not have been available against the explicit will of the ISP, had the Internet been completely integrative perspective in its function, since then the ISP would dictate naming and routing.

Going to routing from naming, i.e. all the way back to Section 3.7, the Internet is based on the notion of best-effort packet delivery, and as such you cannot assume that your traffic is not being re-routed, inspected or modified, as a quite recent BGP-hacking incident shows. Demchak and Yuval (2018) shows a significant misuse of BGP-configurations to route massive amounts

\(^1\)For example stealing login-information through false portals.
of packets through state controlled infrastructure, presumably to gather intelligence. To cite the most telling part of their article:

Building a successful BGP hijack attack is complex, but much easier with the support of a complicit and preferably largescale ISP that is more likely to be included as a central transit point among a sea of ASs. As a result, today most BGP hijacks are the work of government agencies or large transnational criminal organizations with access to, leverage over, or control of strategically placed ISPs. For example, in 2008, Pakistan Telecom – the tier 1 AS for Pakistan – accidentally hijacked all Youtube traffic for several hours as administrators made mistakes in using routing to censor a clip considered non-Islamic. Two years later, on April 8th, 2010 China Telecom hijacked 15% of the Internet traffic for 18 minutes in what is believed to be both a large-scale experiment and a demonstration of Chinese capabilities in controlling the flows of the internet. (Demchak & Yuval, 2018)

As a technical note, all (public) BGP-announcements are in one way or another recorded, publicly, and can be access both in user-friendly ways or as raw data. As such China Telecom (as described in Demchak & Yuval, 2018), Pakistan Telecom (see reporting in Brandom, 2017) and Rostelecom (see reporting in Noction, 2018; Toonk, 2017, for BGP-hijack on financial institutions) undoubtedly BGP-hijacked parts of the Internet, even if the narrative also fits the Western agenda of the evil East. I use similar data to draw the technical representation of the Internet (see Figure 1.1 and similar).

Demchak and Yuval (2018) goes on further and argues that BGP-hijacking is commonplace for certain industries, such as banking, where traffic routinely get routed the “wrong” way to allow an attacker to look at traffic. Stories similar to the events in Demchak and Yuval (2018) are surprisingly commonplace, and I have been entrusted with several stories which, if I could decide, should see the light of day. But it seems there is a lack of public arenas to discuss serious IT-infrastructure breaches (here considering BGP-hijacking as an IT-infrastructure breach). My standpoint, given my formal interviews and informal feelers and discussion, is that there are a lot similar issues going on which never see the light of day, and possibly never will, due to lack of incentives for doing so. For example the Rostelecom case (see Noction, 2018; 2017).

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2For example https://stat.ripe.net/widget/routing-history.
3For example ftp://archive.routeviews.org or http://data.ris.ripe.net/rrc00/.
4As an example, I have been told that the Swedish Civil Contingencies Agency had a project to “get the right people to talk to each other” but it failed due to some participants using information in the meetings for political gain. This should be taken with a grain of salt, since I have not been able to verify it, but it plays well with the larger narrative of experts wanting to communicate but lack the place to do so without possible political repercussions.
9. Discussion

Toonk, 2017) it seems that VISA (and other financial institutions) was specifically targeted, I can imagine that VISA does not like the thought of telling all VISA customers that their payments went through an actor with probable nefarious intent.

**Internets and splinternets**

Another example of distributed perspective and integrative perspective is the notion of “one Internet”, or its opposite, “Splinternets”, in how the Internet should be vertically or horizontally segregated. As argued in this thesis, the Internet is vertically separated into layers, but horizontally integrated in the sense that different services on different layers should be agnostic to each other.

The concept of “Splinternets” was popularized in Lundblad (2002), and plays on the notion of not “one Internet” but rather many splintered Internets. As The Economist puts it:

> THE word—and the concept—is not new. An entire book has been written about it [i.e. Lundblad (2002)]. But it is likely to find greater currency in the coming years: “splinternet”, or the idea that the internet, long imagined as a global online common, is becoming a maze of national or regional and often conflicting rules (The Economist, 2016b)

Examples of Splinternets include how China and Russia are controlling and filtering both DNS and routing for their own purposes, in effect creating similar but different networks. Russia started blocking IP-ranges affiliated with Google and Amazon in an attempt to block Telegram, who used their cloud computing resources. At the opposite end of the spectrum, from the policies of China and Russia, are ICANN who promote “one Internet” in the sense of one coordinating mechanism for naming and numbering (i.e. the IANA function).

Also, supposedly (encountered during discussions, and publicly reported online in McCarthy, 2017), in the works is a BRIC-root-zone, with the explicit purpose of securing a working Internet if the (supposedly) US controlled IANA function decides that the BRIC countries to not get to play ball anymore. As previously mentioned, such a root-zone switch is very possible if the state controls the infrastructure and network operators (and specifically those providing DNS service).

**Article 15 and Article 17**

Both Articles 15 and 17 are upcoming directives in European Union (EU) legislation and are commonly dubbed “the link tax” (Article 15) and “the meme

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5 An end-to-end-encrypted messaging service.
9.5. Internet examples

ban” (or “upload filter”, Article 17). An article by The Verge summarizes the intention neatly:

Article 11 [now 15] is intended to give publishers and papers a way to make money when companies like Google link to their stories, allowing them to demand paid licenses. Article 13 [now 17] requires certain platforms like YouTube and Facebook stop users sharing unlicensed copyrighted material. (Vincent, 2018)

There is considerable resistance against these Articles from Pirate Parties and Internet epistemic communities, with considerable emphasis put on Article 17 as the greater evil. See, as an illustrative example, the argument in Cerf et al. (2018):

By requiring Internet platforms to perform automatic filtering all of the content that their users upload, Article 13 [17] takes an unprecedented step towards the transformation of the Internet from an open platform for sharing and innovation, into a tool for the automated surveillance and control of its users.

[...]

We support the consideration of measures that would improve the ability for creators to receive fair remuneration for the use of their works online. But we cannot support Article 13 [17], which would mandate Internet platforms to embed an automated infrastructure for monitoring and censorship deep into their networks. For the sake of the Internet’s future, we urge you to vote for the deletion of this proposal. (Cerf et al., 2018)

Article 15 is harder to categorize as an Internet issue than Article 17, since Article 15 concerns applications and services (such as the web) rather than the Internet itself. Article 17, though, goes clearly against the distributed perspective in that platforms are suggested to violate layers and check content for infringements. This is comparable to asking the postal service to go through all mail to ensure that a specific kind of content, such as copyrighted material, is not sent by mail. It is a clear layer violation, a separation of concerns issue and a violation of Internet design principles.

Although it should be noted that in the Internet Coordination formulation of texts such as DeNardis and Raymond (2013) it is not a violation in the same manner. In that sense, DeNardis and Raymond (2013) includes more into Internet Coordination than many of the Internet pioneers do (who in general agree with RFC-2026 (Bradner, 1996), that is in line with that which should be coordinated is the Least Common Internet).

6The Vint Cerf (“legendary Internet pioneer”) and the Tim Berners-Lee (“father of the web”) are among the signatories. However, weight should be put on ideas rather than people, and as such it should not matter who is behind it (even though it clearly does).
9. Discussion

9.6 Examples other than the Internet

The two perspectives, integrative and distributed, can be generalized outside the Internet-context as well, in a way touching on vertical and horizontal integration, such as whether concerns (functions or tasks) should be separated (outsourced) or integrated (inhouse). Section 9.8 and Section 9.9 put the perspectives in the context of technology and organizing (Section 9.8) and technology and society (Section 9.9).

Tesla

Tesla (formerly Tesla Motors) has a business model both reliant on aspects of a distributed perspective and an integrative perspective, depending on when it suits them. This is to be expected since the purpose (in a semi-naive tunnel vision sense) of a firm is to generate profit to owners.

As an example of their distributed perspective approach, they use the Internet for updating car firmware, sending diagnostic data and other software-related tasks (see for example O’Kane, 2018, and how they pushed firmware updates to improve braking in the spring of 2018). I.e. they are relying on a platform out of their control in a typical separation of concerns strategy.

At the same time, Tesla is preventing workshops to refurbish and repair old cars, and users from connecting to the software of the cars themselves (see, as an example, Tesla Motor Club forums on how Tesla owners have tried to reverse-engineer parts of the communications protocols to interface with their cars).

In essence, Tesla is integrating their production and maintenance side but are for customers relying on the distributed nature of the Internet. They do not fit neatly into just one perspective.

Apple

Just as Tesla is preventing third party repairs, Apple is also making a hard turn on third party repairs, as can be illustrated by the (at least in tech circles) famous Apple third party repair provider Louis Rossman; “Apple is trying to turn refurbished into counterfeit.” (Rossman, 2018)

Technically, they are doing this by adding a “control chip” (for a lack of better non-technical term) which has to validate all components connected to the motherboard, such as display, touchpad, keyboard, etc, prior to boot. It will no longer be possible to combine two broken Apple devices into one working device.

This debate is set in the ongoing US issue of “right to repair”, the debate about if there should be a law enabling those with necessary skills to repair anything, which includes access to necessary tools and schematics. Apple is currently, de facto, preventing “right to repair” by putting schematics as intel-
lectual property (i.e. illegal for repair shops to use schematics without explicit permission by Apple) and are now going one step further by preventing repair at a technical level. Also interesting in this debate is that YouTube (subsidiary of Google, or rather Alphabet as the parent company is officially called) is now joining the side of Apple in the general issue by changing their policy so that Apple (and similar companies) can request the take-down of videos which show how to modify (or repair) their devices (see YoutubeArchivist, 2019, for a rundown of the issue), which undoubtably would hamper “right to repair” activists such as iFixIt (a private firm with a non-profit “right to repair”-arm) or Rossman Group (Louis Rossman’s firm).

This places Apple firmly into the integrative perspective in their view of their products, while they in other aspects are in the distributed perspective, such as their cross-site-scripting and -cookie prevention mechanisms (see Wi-lander, 2017) which actively handle the fact that the Internet is best-effort and end-to-end. Much the same as Tesla, they strive to integrate their own value chain up to a certain point but use the Internet and its distributed nature for customer experience.

Google and repositories

As previously mentioned, in Section 4.11 and Section 4.12, Google uses a monolithic approach for their repositories, i.e. the maintenance of the code. Although their code (to the extent which Google code is publicly visible through open source projects such as Chromium), follow common software design principles (i.e. either those mentioned in Section 4.13 or similar ones). Thus Google’s complete development process is a mix of notions from the distributed perspective and the integrative perspective.

\LaTeX and Microsoft Word

A more close to home example is the process of writing a document. In my experience, there are two major ways of composing documents; \LaTeX and Word.

Doing a comparison with design principles, such as the one in Section 8.7, \LaTeX firmly follows design principles by separating the typesetting from the writing process (separation of concerns), allowing extensions and additions (Proposition 5), favoring composition (Proposition 3) and so forth, strictly in the distributed perspective by design. It is common to automate \LaTeX-build-chains with the help of Makefile and version \LaTeX-source-files in similar ways as normal programming project (i.e. git, SVN or Mercurial). Word on the other hand does not present the same interfaces to the user, integrates version-handling and history, does not allow easy plugin into other build-chains, and rather acts as a silver-bullet tightly integrated solution strictly in the integrative perspective.
However, the process of writing text in itself is quite similar, a user uses a keyboard and so forth. The differences lie in how the output can be composed, how it is possible to use the same text piece multiple times (and still only edit in one place), whether word-processing is bundled, and so forth. This same comparison has been done before, for example in Healy (2019), but is a relevant example of two distinct approached to (in this case) managing text.

A digitization side note, Word explicitly formats text for paper (i.e. the same format as physical paper such as A4 or letter), whilst LATEX does not at all limit typesetting to paper and can as well typeset for interactive solutions, presentations, etc. Word is tightly coupled to the physical world paper (through printing or pdfs, even though there are plugins to render a static html page from a word-file and similar) whilst the loosely coupled LATEX-ecology can as well produce something different, such as a Word document, a new LATEX-file or something else entirely.

Linux “do not trust”-flag

An interesting quite recent addition to the Linux-kernel (i.e. the core of Linux operating systems) is the “do-not-trust-flag”, which specifies whether the operating system kernel should trust the hardware or not for encryption purposes. This can be seen as a reaction to recent years’ global hardware security issues, for example Spectre (see Kocher et al., 2018), Meltdown (see Lipp et al., 2018), Fallout (see Minkin et al., 2019), RIDL (see Schaik et al., 2019), the Supermicro issue (see Robertson & Riley, 2018) and Intel-SA-00086 (see Intel, 2017) to name a few. All of these concern security breaches at a computer hardware level, as opposed to most known security vulnerabilities being at a software level.

As said on the Linux-kernel developers mailing list:

This gives the user building their own kernel (or a Linux distribution) the option of deciding whether or not to trust the CPU’s hardware random number generator (e.g., RDRAND for x86 CPUs) as being correctly implemented and not having a back door introduced (perhaps courtesy of a Nation State’s law enforcement or intelligence agencies). (Ts’o, 2018)

7Interestingly this is one of the more used LATEXmodules, useful since some outlets require Word-documents. I have used it as well to hand in course assignments.
8As a simplification, the correct usage is that GNU Linux distributions are based on the Linux-kernel. See for example https://en.wikipedia.org/wiki/GNU/Linux_naming_controversy for a deeper dive into the issue.
9In this case specifically the hardware random number generator.
10Theodore Ts’o is a well known contributor to the Linux kernel. See https://github.com/tytso for overview of contributions.
The random number generator is key for all encryption algorithms with
generated keys (unless the key was physically delivered almost all applications
use generated keys). The argument continues:

I’m not sure Linux distro’s will thank us for this. The problem
is trusting the CPU manufacturer can be an emotional / political
issue [and not a technical one].

For example, assume that China has decided that as a result of the
“death sentence” that the US government threatened to impose on
ZTE after they were caught introducing privacy violating malware
on US consumers, that they needed to be self-sufficient in their
technology sector, and so they decided [they] needed to produce
their own CPU.

Even if I were convinced that Intel hadn’t backdoored RDRAND
(or an NSA agent backdoored RDRAND for them) such that the
NSA had a NOBUS (nobody but us) capability to crack RDRAND
generated numbers, if we made a change to unconditionally trust
RDRAND, then I didn’t want the upstream kernel developers to
have to answer the question, “why are you willing to trust Intel,
but you aren’t willing to trust a company owned and controlled
by a PLA general?” (Or a company owned and controlled by one
of Putin’s Oligarchs, if that makes you feel better.)

With this patch, we don’t put ourselves in this position — but we
do put the Linux distro’s in this position instead. The upside is it
gives the choice to each person building their own Linux kernel to
decide whether trusting RDRAND is worth it to avoid hangs due
to userspace trying to get cryptographic-grade entropy early in
the boot process. (Note: I trust RDRAND more than I do Jitter
Entropy.) (Ts’o, 2018)

Two important notes here; the Linux-kernel developers’ group (or organi-
zation?) took a decision not to always never trust hardware (the wording here
is peculiar but important), but rather left that decision to Linux distribution
maintainers (such as Ubuntu Linux or Linux Mint) to avoid political repercus-
sions, and that it is (implicitly) understood in computer hardware circles
that computer hardware in general should not always be trusted.

In most cases, Linux takes a distributed perspective approach, but this
example is exceptional in that direction since Linux adds support for the
case when you cannot trust the computer hardware itself, in essence the pen-
ultimate example of a best-effort solution in the software design case. That is,
best-effort in the sense that since the hardware cannot (explicitly) be trusted,
software level module have to do their best effort to pretend generation of
random numbers (software is per definition deterministic on its own, and
needs some random input, usually from the hardware, to generate random numbers).

**Mainline Linux kernel support in Android**

Another recent and relevant Linux discussion is the case of Android and the mainline Linux kernel. Android can in some sense be thought of as a Linux distribution, although with a lot of hardware and device specific additions and modifications. The rest of this section simplifies technology in terms of the Linux kernel, but is accurate at an aggregate level.

Currently, Android is not module-based but rather depends on three (or more) different repositories, or incarnations, of the Linux kernel with different modifications and additions (some being closed source and device specific, see the overview in Amadeo, 2019). This makes Android and device specific versions of Android dependent on certain Linux kernel versions, i.e. specifically breaking Proposition 2, “Program to an ‘interface’, not an ‘implementation’”, and infringing on other principles, see illustration in Figure 9.5.

Figure 9.5 shows three versions of the Linux kernel (labeled A, B and C) and three SoC specific Android kernels (labeled X, Y and Z) without an Application Binary Interface (ABI) (i.e. binary Application Programming Interface (API), also known as “binary kernel interface” or “stable kernel interface”) or other interface decoupling the Linux kernel implementation from the device specific Android implementation. All device specific Android kernels depend on a specific version of the Linux kernel, as such if the Linux kernel is patched to fix a security issue between version A and B, that fix does not appear in Android until manual work is done. Which, for business reasons, might not happen until Linux version C when device specific kernel Z is created.
There are proponents (and also those against, see, for example, Corbet, 2018; Kroah-Hartman, 2019, and follow the discussion) for modularizing Android by given closed source modules a static kernel interface (an ABI). This proposed ABI would allow manufacturers do adapt Android decoupled from Android version and kernel version (see Figure 9.6, currently they are not decoupled and live in interdependent repositories, and is the explanation why Android updates are so horrendously slow and use year old Linux kernels. For example the current Pixel 4 flagship is using a kernel which was more than two years old at launch, and probably no one will put in the work to upgrade the kernel).

Figure 9.6 shows Linux modularized through an ABI which allows out-of-repository modifications of the Linux kernel. In this solution device specific kernels (SoC X, Y, Z, and W) all depend on the Linux kernel ABI, rather than the Linux kernel version.

The reason Linux is not modularized at a kernel interface level is, as I understand it, an ideological reason. Simply put, by not having a static kernel level interface (an ABI) the easiest way for device manufactures to create drivers is to open source them (and integrate them into the public Linux kernel module repositories, i.e. “in the main kernel tree”), allowing a static kernel level interface would allow manufactures to close source their drivers without a development penalty and still retain the decoupling from Linux mainline kernel version (i.e. the same driver version can work with...
many different kernel versions, an impossibility for closed source modules / drivers today due to the development design of Linux and coordination of the Android project). Illustrative quote:\footnote{Greg Kroah-Hartman is a well known contributor to the Linux kernel. See \url{https://github.com/gregkh} for overview of contributions.}

You think you want a stable kernel interface [i.e. an ABI], but you really do not, and you don’t even know it. What you want is a stable running driver, and you get that only if your driver is in the main kernel tree. (Kroah-Hartman, 2019)

In effect, Linux was designed in a non-distributed perspective fashion for proprietary drivers, and I can only assume intentionally, which today is challenged due to all the issues with maintaining Android devices (which is, among other, a security risk). As such, the current debate can be framed as whether designing the technical aspects of Android and Linux in a distributed perspective fashion outweighs the “bad” of not incentivizing device manufacturers to open source their modules and drivers. For avoidance of doubt, open sourcing all drivers in the main Linux repositories is the technology-wise best solution (as strongly argued in Kroah-Hartman, 2019), see for example the following illustrative quote:

Simple, get your kernel driver into the main kernel tree (remember we are talking about drivers released under a GPL-compatible license here, if your code doesn’t fall under this category, good luck, you are on your own here, you leech). If your driver is in the tree, and a kernel interface changes, it will be fixed up by the person who did the kernel change in the first place. This ensures that your driver is always buildable, and works over time, with very little effort on your part. (Kroah-Hartman, 2019)

As such this example can be seen as a collision of open source values (M in the MARC-model), rationality in a market sense (R) and adherence to design principles regardless of context (M and R, since design principles are canonical ideals and rational consequences of software design history).

Also of note is that the above paragraphs describe a real problem for Android, an operating system running on more than 2.5 billion devices (according the Android group), operating on the trillion dollar mobile device market. In some sense, an ideology of open software is standing up to a trillion dollar market, which can save billions in development costs if it was easier to (or even automated) integrate closed source drivers, modules and other integrations into Linux and the Android kernel.
9.6. Examples other than the Internet

**Home automation**

An impressive example of distributed perspective, Home Assistant\(^{12}\) is an open source home automation system which can run on virtually any hardware (including virtual hardware) which is built using components contributed freely by its users. As an example, it is possible with a few lines of code (and technical know-how) to set up a camera and a neural network to start learning to recognize people with a few commands using Google’s open-sources libraries for machine learning\(^{13}\). Home Assistant also communicates well with proprietary home automation systems, such as the commercial Alexa by Amazon and Google Assistant by Google, and allows anyone to further extend the functionality of Home Assistant.

As software, Home Assistant embodies many of the principles built into the Internet coordination mechanisms, such as separation of concerns and running code and consensus instead of long range planning.

On the other end of home automation is smart home services such as Amazon Alexa and Google Home, which ironically rather are “smart cloud stupid home” in that they move control, and in effect agency, to the cloud rather than to keep it in the home. As an example, Amazon Alexa does not work without Internet access, which might prevent you from turning lights on and off, which is not in line with separation of concerns in that the home is no longer an independent entity.

However, smart home cloud services provide separation of concerns in other dimensions, but they do specifically not treat the Internet as a potential concern, which from the perspective of this thesis is a major concern. I.e. the design of Alexa and Google Assistant in general follow separation of concerns principles in that users can use plugins and modules freely.

In-home automation is resilient to BGP-hijacking and similar attacks in a way cloud-based home automation is not, even though the “do you trust your hardware?” question remains.

**Network security**

Both DeNardis and Raymond (2013) and Liu (1999) include security components in their respective discussion of Internet Coordination, whilst the definition I suggest does not include network level security issues.

My definition, and the distributed perspective, does not suggest that network security is not important, but rather that network security outside the processes of settings standards and coordinating unique identifiers is not an

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\(^{12}\)See [https://home-assistant.io](https://home-assistant.io) for deeper foray.

\(^{13}\)See [https://www.home-assistant.io/components/image_processing.tensorflow/](https://www.home-assistant.io/components/image_processing.tensorflow/) for Home Assistant example using TensorFlow (python library for machine learning) for identifying objects in live camera feeds (such as home mounted security cameras). All open source and freely available.
9. Discussion

Internet issue. Thus, the network security discussion belongs outside the Internet Coordination arenas and discussions.

This ties back into Section 8.8, that smart cities and other Internet-of-Things (IoT) implementations should not depend on the Internet as a service layer construct, but rather a best-effort means of communication. As such, service level requirements should be on top of the Internet, rather than in the Internet (concept). In a sense virtually adding properties on top of the Internet.

There are certainly cases where secure end-to-end service level digital communications services through the entire stack are required, and those cases should not use the Internet (in the distributed perspective, in other epistemic communities it might be more prudent to change the Internet into a service construct, or telecommunications, as for example some Public Protection and Disaster Relief (PPDR) implementations suggest). However, most digital applications are fine with separating infrastructure and security layers without issues.

Note though that any additional functionality added to the Internet breaks the concept of Least Common Internet in that more standards and unique identifiers have to be coordinated, more than what is required at minimum to coordinate separate networks (remember that the Internet at a technical level is rather a network of networks, an inter-network, than a single network in itself).

Also note that in the distributed perspective, the IoT concept just shift of focus, nothing inherently different or new. While the integrative perspective might argue that IoT requires different solutions and services than the Internet. As an integrative perspective example, see Weber (2009) which argues for a different governance structure for IoT than the one for the Internet (and also assumes that ICANN govern more than they do).

The last paragraph can be rephrased, IoT as a construct is not meaningful in the distributed perspective, just as I later on argue that the IT-artifact is meaningless when taking technology into account, since it is conceptually the same as the Internet. In an integrative perspective, looking at services instead of best-effort digital communication, it might be prudent to differentiate the Internet for humans from IoT, even though it is the same network in a technical sense.

Open Science

In terms of organization of science a recent initiative and movement called Open Science argues for separation of the components of science. Open Science separates science into six areas or concerns\textsuperscript{14}: Open Data, Open Source, Open Journal Systems, Open Access, Open Collaboration, Open Code.

\textsuperscript{14}Here I show the separation of concerns, since the separation itself is the object of interest, rather than the actual practical division / separation. I recommend interested readers to look up Open Science and the components of each of the concerns.
9.6. Examples other than the Internet

Open Methodology, Open Peer Review, Open Access and Open Education Resources (see Figure 9.7).

Open Science intends to unbundle science to create a larger sharing surface and access to information behind publication, rather than publications themselves. As such Open Science as an distributed perspective take on science by separating the construct of science into multiple meaningful components by separation of concerns.

The opposite of distributed perspective Open Science would be science where those external to a publication only has access to the publication itself (i.e. representation of the science), and cannot see or modify anything underlying said publication.

Taken to its extremes using the publication as the object of science in the integrative perspective and the Open Science components as a meaningful separation of concerns in the distributed perspective; an integrative perspective view of science would entail that only publications contribute to science, while an distributed perspective would entail that contributions to any the components of Open Science is meaningful for the construct of science.

Revisiting perspectives

In this chapter I suggest two connected but almost dichotomous perspectives, the distributed perspective and the integrative perspective, as a means of both technical and business model organization.

As my examples show, there are a multitude of offerings in both perspectives, but almost all services and offers concerning the Internet are in the distributed perspective. The exceptions include smart home services such as Alexa and Google Assistance, in that they do not take height for the Internet not being available. In essence, all offerings except those from infrastructure
and network operators (i.e. ISPs who own infrastructure as well) are based on the notion of the distributed perspective of the Internet. Even those offers by firms trying to integrate their value chain as much as possible admit in their business models that the Internet is rather distributed perspective than integrative perspective.

Illustrated in the perspectives, the Internet (as captured in this thesis) has gone from being dominated by technology in the distributed perspective to (a today) more nuanced construct where technology, markets and bureaucracies together form the Internet. See Figure 9.8 for an illustration of the Internet in the perspectives before the commercialization of the Internet. See Figure 9.9 for the more nuanced view of the Internet today.

Figure 9.8: Internet at inception in perspectives

Figure 9.8 illustrates an Internet influenced by technology, mostly designed with a distributed perspective notion of separation of concerns, without real pressure from regulation and commercial services to become something else.
9.6. Examples other than the Internet

Figure 9.9: Internet (currently vs at inception) in the perspectives

And those forces which came from markets mostly leverages concepts belonging in the distributed perspective, rather than full bundled services.

In comparison, Figure 9.9 show an Internet where market forces seems to outweigh technology as the dominant factor in changing the Internet, even though technology is intrinsically important. Compared to Figure 9.8 services are to a greater extent vertically integrated, for example Facebook and Google offer integrated sets of functions rather than just one layer or concern (i.e. only email, or only chat, only image storage, etc), where business concerns outweigh technological concerns.

In contrast to the Internet, telecommunications services are mostly dominated by values in the integrative perspective, even if the technology per se could be designed along the lines of common engineering principles (i.e. by the distributed perspective). Cellular services is shown in Figure 9.10 and a comparative example to the Internet. Telecommunications has been dominated by business or state interests, as such I illustrate regulation and markets by
the integrative perspective, even if the technology is not. Also shown in Figure 9.10 is technology as significantly less important in shaping the concept of cellular services.

In the case of IoT, it is probable that the market dominated cellular industry will clash with the more technology driven Internet (even if market logic and reasoning seem to matter more currently than in the earlier Internet).

All of Figures 9.8 to 9.10 should be seen as illustrative given the empirical data I have collected in a Western context, rather than absolute. The figures are illustrative examples rather than analytical.

9.7 Matching technology and coordination

As argued previously in Section 4.10 with texts such as Orlikowski (1992), Orlikowski and Iacono (2001) and indirectly supported by Chan and Reich (2007), Croteau and Bergeron (2001), Raymond et al. (1995) understanding
9.7. Matching technology and coordination

(in the sense of domain specific understanding) is a necessity to understand what is going on in the larger picture. This might not seem that far-fetched, but as argued in Section 4.10, literature, or rather its authors, do not always bother itself (themselves) with fully understanding what is going on outside its (their) thought collective.

The notion that matching technological architecture and organization would cause better alignment of information technology (IT) might not seem too far-fetched, and I would like without much further ado state that it is important that technology is aligned with the organization, since this is what my case suggests.

As an example of non-alignment I have encountered, at my university all computers are centrally administered, that is they get access to common services through a central credential system, updates are pushed out from central servers etc. But only for those computers on the local network, i.e. not for those laptops outside the university. The computers are also locked to only update time on the local network using the university’s internal servers. This has the interesting consequence that if you lose time (for example due to disconnecting laptop battery or completely discharging the laptop\(^\text{15}\)) your clock will not be reset to correct time as long as you are outside the university. This ultimately makes the computer unusable since a correct notion of time is required since most certificate validation mechanisms rely on time. For example, it is impossible to check your mail, log into the university intranet or start a VPN client since your laptop will not trust anyone. I.e. it is impossible to set your time right unless you physically enter one of the campuses again (or have the technical know-how required to elevate a user account and override the centrally managed time settings).

I think this is a perfect example of how IT can be misaligned with an organization, since it can be assumed that university employees are supposed to sometimes use their laptops outside the campus area, and that the laptops should function as normal and behave as normal when doing so. In terms of the perspectives, the notion that a certain geographic location is required for work is in the integrative perspective’s ballpark. The distributed perspective (and separation of concerns) solution would be an IT-infrastructure which is independent on the location of work, since IT and work by design should be independent in such a perspective (to build directly on Proposition 4, “the Single Responsibility Principle”; IT processes and IT-infrastructure (including synchronizing time) should not change if the location of work changes).

On a more general note, the Internet’s technology side and its coordination side match, at least as long as viewed from a distributed perspective, which is one of the reasons the Internet was successful to begin with. The Internet

\(^{15}\)Older laptops, in my view, always had a separate small battery to keep time if the larger battery was disconnected or completely discharged. This no longer seems to be the case in my experience, and the clock problem happened to me.
builds on a distributed notion of coordination and a distributed notion of the technical network with no overreaching regulatory authority.

It has been suggested that blockchains should replace the organizations in charge of handling the unique identifiers of the Internet today. Even though technically feasible (possible to keep track of who “owns” a particular resource, such as a domain-name or Internet Protocol (IP)-address block or prefix) there are fundamental issues in the way information is stored in blockchains.

Contrary to, for example, most databases, information in blockchains is permanent in the sense that it cannot be altered. This is problematic in many senses, but particularly in a General Data Protection Regulation (GDPR) sense, since the original data would stay on the chain even if a domain or IP-address block changed owner, which is in direct conflict with the “right to be forgotten” part of GDPR.

For example, Hogewoning (2018) does a similar argument, but also adds technical issues with using blockchains as a definitive ledger of unique identifier information. One such, quite technical, example is that normally, staging is required to set up an IP-prefix before actual use, which would be impossible if only the owner (in the perspective of the chain) is allowed to make changes to the prefix (see Hogewoning, 2018). In a practical sense, this means that parts of the Internet (i.e. the transferred prefixes) could be “blacked out” in connection to IP-prefix transfers. Another major issue with blockchains is that they distribute power and coordination, not storage. A blockchain requires all nodes who want to participate to hold a complete set of the data, which is utterly infeasible in the DNS-case (too many domain-names, too much data) and a bit less infeasible in the BGP-case (BGP, as the name suggest (border gateway protocol) the protocol concerns the borders between Autonomous Systems (AS), not the entire network. But a blockchain solution would rather require ASs to know of the entire network rather than just their neighbors).

The right to be forgotten is a general issue with blockchains, it is not limited to Internet-implementations, which makes me wonder why there is so much hype concerning blockchains in general and together with Internet Coordination specifically.

And yet organizations today look for blockchain solutions even though their business model is not aligned with distributed trust based on dedicated computer resources, in essence a consensus system based on computing power.

In the more general IT in organizations case, as argued in Orlikowski and Iacono (2001) the IT-artifact is usually an issue. The Internet Coordination ecology does not have an issue with IT-artifacts, mostly since the concept of an artifact which is separate from the organizing itself is not meaningful in
9.8 Organizing by the perspectives

Here I present a constructed example concerning middle ground of the perspectives based on a few assumptions regarding how hospitals work. Based on Mintzberg (1993) I assume that mainly physicians and nurses do work (the operating core) in hospitals and that they mostly are coordinated by means of training (standardization of skills (SS)).

The perspectives suggest there are two ways to organize with IT in such an organization; the distributed perspective in which the operating core itself is responsible for organizing IT and developing necessary IT-systems, including those formed of medical records. This would require that physicians and nurses either learned to program or that programmers started to work in the operating cores of hospitals. Presumably a quite expensive option in terms of capital and time, but resilient to predicted change, assuming that those in the operating core are experts on their topics (i.e. MA). The notion in the distributed perspective is that as long as those with interest in the outcomes (such as the epistemic community for that area) are in charge of decisions the outcomes will align, such as the organization with IT in this constructed example. Even if the requirements change, as they must for efficiency since this perspective optimize on minimizing effects of change.

The other way of designing IT in such as organization (from the integrative perspective) would be to push IT as a standardizer of work from the technostructure. Such a system would be easier to design, partly because at a

that context. My case suggests that IT in organizations should organize so that epistemic communities interested in changing the IT environment should be able to do so, i.e. do not separate those with an interest in IT from the power of changing IT and do not submit people to IT when they cannot affect IT. In the lens in Mintzberg (1980, 1993) this implies that IT should not be used for standardization purposes (generalized from this case, not a universal truth). Taken on step further, IT should stem from the experts in the operating core or the strategic apex to avoid behaving as a standardizing pressure (which technostructure and middle-line coordination behaves as in many cases in Mintzberg, 1993).

Using the Internet case and the perspectives even further: the perspectives suggest that there are two philosophical ways to organize IT, although there is middle ground. First way, distribute and decentralize to make entities independent on each other to avoid issues with both internal and external change (optimize for change, adhocracy and mutual adjustment (MA) in Mintzberg, 1993, terms). Second way, integrate systems and processes, such that work is coupled to IT-implementation (optimize for efficiency in a static environment, machine bureaucracy and standardization of work process (SWP) in Mintzberg, 1993, terms).
9. Discussion

technostructure level it is possible to design a system without full consideration of how work is actually done (for example ignoring multimorbidity\textsuperscript{16} and instead design processes per morbidity). An obvious flaw in such a system, is that if the coordination given by the system (i.e. SWP) does not agree with training (i.e. SS) there will be coordination problems, as it is not obvious which coordination mechanism to adhere to (and also since the highly skilled workers, i.e. physicians and nurses, are told to follow “instructions” rather than their own perceptions and training). The notion in the integrative perspective is that a central entity (through whatever coordinates the central entity) is more efficient (in some dimension) in setting all the rules of engagement, and in this constructed example decides what it is that the operating core should do (and how it should be done).

As such I suggest that neither of the perspectives are good lodestars on their own, but rather as an indication of two extremes of using IT in an organization. Also, note that this example avoids the art of building IT systems, and rather treat them as something which can be built if they can be imagined (which ostensibly is true to quite an extent).

Although, unavoidably, implementation matter more than adherence to a certain philosophy in IT. As an example the accuracy and usefulness of the system matter more than if it is centrally designed or designed by users (in my experience). As such the organizing and composition of the development team outweighs the principles they follow in the short term, for example a fast prototyping, build server, continuous integration and test driven development using team will outperform a team which does not fast prototype, use build servers, continuous integration or test driven development. This, in my experience, since answers to questions such as “how do we know we are building the right thing the right way for the right people?”, “how do we make sure all the code written by all these people work together?” or “are we building that which we think we are building?” are hard to answer in a planning stage.

Another way of portraying organizing and IT by the perspectives is the use of the IT-artifact: in the distributed perspective the notion of an IT-artifact, that is one existing entity which can be imbued with the properties of a system in use, is an impossible manifestation, while in the integrative perspective, the notion of an IT-artifact rather gives credibility to the notion of an integrative perspective, since there is an artifact to use business logic on (such as writing contracts, selling or procuring, in a sense business logic can be seen as an isomorphic pressure).

As such in the integrative perspective such a system can be meaningfully bought or contracted, while in a distributed perspective the components

\textsuperscript{16}That is patients with multiple, often chronic, illnesses. According to the results in Bähler, Huber, Brüngger, and Reich (2015), van der Zee-Neuen et al. (2016) and Slattery et al. (2017) multimorbidity is present in 50% to 80% of recurring hospital visits (majority of them are elderly) and on average account for 2 to 5 times higher costs per treatment than non-multimorbid patients.
(which individually are technically meaningful) of such a system could be bought or contracted. The argument being that one such system is not a meaningful entity in a technical sense since the components in such a system will have to change over time. Rephrased differently, it is possible to differentiate the perspectives by that the integrative perspective makes business sense on the larger scale, and the distributed perspective makes technical sense in a changing environment. And perhaps the perfect system, in terms of organization and IT, is rather a combination or a balancing act of both.

A more meaningful use of the perspectives in an IT context is design and use of IT-systems. Let us take a large organization, lets say an international conglomerate with a big IT-department and multiple subsidiaries in multiple jurisdictions. In a distributed perspective the IT-department would offer services on different layers, such as offering a cloud service, a machine service, an operating system service etc, while an integrative perspective approach would offer complete services, such as an ERP-service, an complete-computer-for-each-worker service, and so on. Essentially the notion of whether vertical or horizontal integration of concerns is the most problematic.

Or, if changing the previous example slightly, in a distributed perspective it is meaningful to organize government agency IT-infrastructure (such as a cloud-provider agency) in one agency and use public procurement to provide services on top of that IT-infrastructure, rather than the public procurement of all services in the integrative perspective.

9.9 Society by the perspectives

At a first glance it might seem prudent to compare the Internet to other important societal infrastructure services, such as the postal service, canal projects, railway systems and road networks. The purpose of these paragraphs is to point out and ground the notion that a fuller comparison would be interesting, both to practitioners and academics in fields touched by the Internet. Here follows a comparison of the Internet, postal services, railroad systems and financial services.

As this thesis argues, the Internet can meaningfully be approximated by the triad of Internet Standards (the formulation of the standards themselves and their free-to-use-but-not-enforced model), the IANA-function (and its coordination) and the infrastructure and network operators (in essence the network infrastructure ownership and implementation of Internet Standards). See Figure 9.11. As such standards are loosely agreed on, and set by those with a stake in the process, and there is no enforcement of standards. Standards are (mostly) technical and do not adhere to legislative issues such as

Undoubtedly, a fuller comparison is interesting both in a practical and scientific sense, but due to time and space constraints they do not fit in this thesis, and are in a sense left as an exercise to the reader.
9. Discussion

jurisdictions. Internet Standards does not regulate, control or suggest market rates (directly).

Figure 9.11: Central concepts in the Internet Coordination ecology

The postal services are, in essence, run by a mix of national postal services or agencies and privately owned firms delivering mail. Standards are in essence set by the Universal Postal Union (UPU) (an arm of the United Nations (UN) since 1948, comparable to the ITU\textsuperscript{18}) and are (in my understanding) derived from the interests of states. UPU regulates rates (even though some bilateral agreements skirts them, as an example the US has several bilateral agreements with European states which set rates different from those agreed on by the UPU). Here it should be noted that the US, one of the biggest players in the “postal ecology”, is withdrawing from the UPU (signed October 2018, effective October 2019, see Union, 2019, for the UPU press release on how the issue is handled, options include an “Extraordinary Congress” by the UPU), which is causing issues at an international level. This can be seen as a move from an integrative perspective to halfway to a distributed perspective view on postal services.

Not to be forgotten are package delivery services which are not part of the UPU, examples include private firms (UPS, FedEx, DHL (part of Deutsche

\textsuperscript{18}One of many post-war collaboration attempts: put UPU och ITU as arms of the UN, agree on international fiscal policy and tender (Bretton Woods), and other actions in the name of global governance.
9.9. Society by the perspectives

Post, which is privatized) etc) which do international deliveries in some parts of the world. They set their own fees (barring tariffs and similar) rather than adhering to UPU specified fees. As such, UPS and FedEx stand to gain from the US withdrawing from the UPU, as without the UPU agreement they can compete with the US Postal Service who was legally bound to offer certain prices to sovereign postal services (as an example, neither UPS nor FedEx can compete (rationally) with the US Postal Service on pricing of delivery of parcels from China).

Railroad systems are an interesting contrast to both the Internet and postal service since there are no international standards, only regional or national ones. A couple of examples: the US, Europe, Australia and China use standard gauge (the name for 1435 mm wide rail), while South America in a mix (Argentina, as an example, has a blend of narrow (1000 mm) and broad (1676 mm) gauge), Africa mostly narrow gauge (1067 mm, i.e. not the same narrow gauge as some parts of South America), former Soviet states use broad gauge (1520 mm, “Russian gauge”) and so forth. I.e. railway cars made for one region often cannot be used outside that region. The British legislation “An Act for regulating the Gauge of Railways (1846)” set the standard gauge (i.e. 1435 mm) as the commonwealth standard, therefore the name “standard gauge”.

Also, ownership for rails is a mixed story, most rail systems and transport lines used to be state owned (just as telecommunications used to be state owned, see argument and some history in Cowhey, 1990) but have over time turned into private corporations (sometimes owned by the state, such as in Germany, Sweden, the US, to a lesser extent Japan, and so forth). As a rule of thumb, railway transport is privatized to a larger extent than railway infrastructure.

As such, the Internet and postal systems have standards, set by different sets of actors through different coordination mechanisms. Railways use similar mechanisms as the postal services (i.e. nation states as actors through, for example, legislation) but there are no widely accepted international standards. Postal services and rail services both trend towards privatization, both as commercialization of previous state agencies and as new private international actors.

Table 9.4 summarizes the differences for communications, and adds in telegraphs and telecommunications as a precursor or different regime than the Internet. As such it portrays three regimes of remote communication, of which two are digital (and in essence the distributed perspective and the integrative perspective) and one pre-digital, and in extension a similar exercise is done for postal services and railways in Table 9.5. I.e. UPU coordinated (regulated?) postal services follows similar principles as the integrative perspective for digital communications, and private parcel services follow the distributed perspective closer (although still distinctly middle ground). Railways are similar in design, original railways were both at an infrastructure and
service level controlled directly by state agencies, and today there is (at least to some extent) competition at the service level in many Western countries.

Note that Table 9.4 shows monolithic (telegraph), hierarchical integration of concerns (telecommunications) and separation of concerns (or distributed perspective, the Internet) (in that order). While Table 9.5 shows monolithic (state monopoly and UPU) and hierarchical integration of concerns (private parcel services and competing transportation services) and Table 9.6 show hierarchical integration of concerns (traditional banking), hierarchical separation of concerns induced integration of concerns (“appified” banking) and hypothetical separation of concerns (distributed banking / payments).

These examples have in common that it is possible to separate them into two distinct components: an infrastructure layer, and a service layer. Where infrastructure can be optic fiber cables, rail infrastructure or roads. And service concern packet delivery, parcel delivery and experience in trains.

Also interesting are the trends. Communications has gone from nation state interests (such as early radios and telegraphs) to interests of large verifiable monopolies (such as the formerly state owned telecommunications giants) to smaller firms providing parts of the service. Similar trends can be seen both for postal services and railways, except the empirical data to support profitability does not exist yet, which is natural since running a parcel delivery service or a rail transport company naturally has higher capital costs than, for example, running a virtual ISP. Noteworthy is that communications, postal services and railways were state affairs and started to turn commercial (in a western context) in the early 1990s.

In the two first financial services regimes, money systems are by coordination and technology hierarchical. Often (state backed) central banks control the availability of money through repurchasing agreements based on a monopoly of currency, and commercial banks in turn provides money markets to end-customers (such as firms, public institutions and citizens in need of financing, i.e. money at a specific time).

Currently, this regime often offers services in an integrative perspective to the end-customer, although there is regulation in place to enable vertical separation of concerns such as the Payment Service Directive (PSD) (especially the second iteration) for payment services (i.e. a large part of consumer banking). See Li (2001) for a similar argument. Coordination through regulation and lobbying epistemic communities which set the agenda (rather than the epistemic community setting the agenda itself, as is the case with the Internet). Examples in finance include but is not limited to European Market Infrastructure Regulation (EMIR) (regulation of derivatives trading and reporting) and BASEL (regulation of commercial banking).

The distributed perspective of financial services are distributed concepts, such as many blockchain projects. Although it should be noted that some of the more successful blockchain projects, such as Ripple, are rather hierarchical than distributed by the nature of their implementation, even though
Table 9.4: Synthesis of societal services, this table contains telegraphs, telecommunications and the Internet.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Remote communication</th>
<th>the Internet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(electrical) Telegraph</td>
<td>(digital) Telecommunications</td>
</tr>
<tr>
<td>Coordination</td>
<td>State level multilateral agreements (in practice the ITU). These dictate prices and use.</td>
<td>State level interests, to national states through ownership, international standards agreed on in the ITU. Pricing from agreements to markets.</td>
</tr>
<tr>
<td>Technology</td>
<td>Analog electric circuits with manual interpretation (Morse code as the first meaningful ITU standard).</td>
<td>Standards set through multilateral agreements (ITU and subdivisions), concerns frequency spectrum allocations, unique identifiers (such as phone prefixes) and protocols (such as X.25, an earlier TCP/IP competitor in the integrative perspective).</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Public as in states owned and operated telegraph infrastructure.</td>
<td>Mostly private as in cable-TV networks and cell-phone infrastructure is mostly privately held.</td>
</tr>
<tr>
<td>Theme</td>
<td>Postal Service</td>
<td>Railways</td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td>----------</td>
</tr>
<tr>
<td>Public and non-UPU bound</td>
<td>Public and non-UPU bound</td>
<td>Public and non-UPU bound</td>
</tr>
<tr>
<td>Private and UPU bound</td>
<td>Private and UPU bound</td>
<td>Private and UPU bound</td>
</tr>
<tr>
<td>Infrastructure (rail)</td>
<td>Infrastructure (rail)</td>
<td>Infrastructure (rail)</td>
</tr>
<tr>
<td>Public service and regulation</td>
<td>Public service and regulation</td>
<td>Public service and regulation</td>
</tr>
<tr>
<td>Technology</td>
<td>Technology</td>
<td>Technology</td>
</tr>
<tr>
<td>Information or content put in cellulose based containers often with end-user delivery.</td>
<td>Information or content put in cellulose based containers often with end-user delivery.</td>
<td>Information or content put in cellulose based containers often with end-user delivery.</td>
</tr>
<tr>
<td>Cooperation (such as CP) through the regional coordination platform between competitors.</td>
<td>Cooperation (such as CP) through the regional coordination platform between competitors.</td>
<td>Cooperation (such as CP) through the regional coordination platform between competitors.</td>
</tr>
<tr>
<td>Often legislation, regional coordination for interoperability, such as gauge. Pricing set by legislation / regulatory agency.</td>
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<td>Often legislation, regional coordination for interoperability, such as gauge. Pricing set by legislation / regulatory agency.</td>
</tr>
<tr>
<td>In practice former legislation and existing rail with pricing and incentives set through (sometimes virtual) market forces.</td>
<td>In practice former legislation and existing rail with pricing and incentives set through (sometimes virtual) market forces.</td>
<td>In practice former legislation and existing rail with pricing and incentives set through (sometimes virtual) market forces.</td>
</tr>
<tr>
<td>Table 9.5: Synthesis of societal services This table combines different regimes for postal services and rail way systems.</td>
<td>Table 9.5: Synthesis of societal services This table combines different regimes for postal services and rail way systems.</td>
<td>Table 9.5: Synthesis of societal services This table combines different regimes for postal services and rail way systems.</td>
</tr>
</tbody>
</table>

International coordination (such as CP) through the regional coordination platform between competitors.
they might argue and use the narrative of a distributed solution due to, for example, marketing concerns (i.e. practical Byzantine fault tolerance (pBFT) rather than Proof of Work (PoW) in their design). A middle ground between distributed financial services and traditional vertically integrated financial services are such services as those made possible by PSD and similar regulation which allows for vertical separation of concerns, examples include Klarna payment services, Paypal, Google Pay, Samsung Pay and similar initiatives (i.e. in practice, payment services often compete with traditional commercial banks).

Also noteworthy for financial services is the switch, in general terms, from proprietary networks to the Internet. Examples include the Reuters 3000 which commonly ran on private T1s19 which got replaced by (Thomson) Reuters Eikon which normally uses the Internet, the Bloomberg terminal from using proprietary networks to using the Internet, bank transfers using dedicated SWIFT lines to using the Internet and new trading terminals such as FXall20 using the Internet.

The important point in this section is that remote communication can be divided into three different regimes or views of communications (as shown in Table 9.4), where the first two can be mapped to the two regimes of rail transport and postal and parcel systems (see Table 9.5). But the third regime, the Internet regime or distributed perspective designed systems, is not present to the same extent in those areas (postal services and rail transport and systems).

In the case of financial services the distributed perspective is present, but is not commonly used nor accepted. And is to some extent the explicit target of regulation (such as the ban of bitcoin in China and ban of Libra in France). As such the Internet is the only commonly used example (I can find) which uses a distributed perspective or distributed notion of coordination and technology in its design.

Logic is also different, for example in Table 9.4 telecommunications usually go by business logic (i.e. any change should be motivated by business interests from an actor’s view in some ecology), compared to the Internet where change as well can happen due to interest and willingness to design technical systems (i.e. the left hand side of the MARC-model). Similar for financial services in Table 9.6, where traditional banking and appified banking follow business logic, and the more distributed solution can not be said to do the same. Even though there are examples of for-profit business ventures, such as Ripple, doing financial services (partly) in the distributed perspective. As a counter example, bitcoin needs exorbitant amounts of energy, and the question whether bitcoin creates or adds value, overall, is quite subjective.

19 I.e. a dedicated line for this application.
20 FXall has been listed, owned by Thomson Reuters and is now owned by a subsidiary of Thomson Reuters and Blackstone (not the more well known Blackrock).
Table 9.6: Synthesis of societal services, this table contains financial services.

Coordination

Hierarchical technical systems,
such as RIX, SWIFT and
Bloomberg.

Hierarchical, commercial
banks acting on right to exist
by central banks. Regulation
often set through lobbying
epistemic communities.

Traditional banking

More and more solutions use
the Internet rather than
proprietary communications
networks.

Mostly hierarchical technical
systems but addition of
systems such as Paypal, Swish,
etc.

Similar hierarchical structure
for raison d’être but a wider
offering of services to end-user
(i.e. payment solutions,
trading platforms, etc)

“Appified” banking

In general using the Internet
as infrastructure.

Distributed notion of
who-owns-what, such as
blockchain solutions.

Distributed notion of value
and tender, such as blockchain
solutions for ownership.

Distributed ecology

Financial services

Technology

Owned and operated by firms,
many as smaller separate
“Internets”

Theme

(Communications)
Infrastructure

292

Discussion
9.


As such, constellations like those found in Internet Coordination (in particular the distributed coordination nature of the IETF and technical implementation of routing) does not exist in neither postal services nor rail transport, who are rather hierarchical in both their coordination and technology dimensions. The question, then, is not what can society learn from the coordination of postal services and rail systems to better coordinate (govern?) the Internet, but rather what society can learn from the coordination of the Internet which can be applied to postal services, rail systems or other societal infrastructures and services.

The probable explanation that the Internet works in a distributed perspective are the, relatively, low investment costs to enter the ecology (i.e. less of a barrier of entry), distributed coordination and shorter “cycle times” (i.e. Internet and financial services (PSD and blockchain-finance) usually measure in seconds (per actor), while long railway transport, parcel delivery and traditional finance rather count days, or at least several hours and investments such as railway cars or trucks measure in tens of years). It has the consequence that many players show up, and as such the actors in the ecology needs rules of engagement to handle many competing systems and ideas. Such coordination is inherently expensive (if done well, and not, say, on the whim of a dictator) outside an adhocracy setting or a distributed setting and therefore not feasible in rapidly changing environment.

It might also be prudent to reason if the Internet plays a similar role to technology advancement as money can be argued to have played for the development of markets (as argued in Mitchell-Innes, 1914). That is, more of a facilitator of a common good needed for systems development, liquidity in the case of money (or coinage) which allowed for rapid economic development and faster sales and procurement based on a common understanding of debt, and a standardized technical inter-connectivity in the case of the Internet which allows real world applications of digital technology to keep up with its rapid development (10x every seven years, or so, as argued in Section 3.11). Interesting in this context is that Internet use / access and digital payments go almost hand in hand (compare the World Bank and ITU reports Demirguc-Kunt, Klapper, Singer, Ansar, & Hess, 2018; Sanou, 2017, the small percentage point differences. And also note that in developing and the Least Developed Countries (LDCs) digital payments has a higher adoption rate than all kinds of (physical) payment cards.). As such, a different toolbox than the one presented in this thesis is needed to properly understand what is going on from the perspective of society.

It should also be noted that I lack proper empirical understanding and evidence of the entirety of parcel services, railway systems and financial services as a whole to properly argue that the entirety of these arenas are as presented here, rather I have presented what I know that can easily be verified (such as gauge standards in Argentina and Bloomberg terminal Internet use). It is rather a suggestion of how to make sense of current societal and technological
trends. And nuggets of thought and information for someone else to pick up and continue to explore.

9.10 Society and policy

Returning to Chapter 7 and policy again, although written and presented in a policy context, it has the interesting policy consideration that policy is the wrong route to go (similarly to Glass & Tardiff, 2019). This, unsurprisingly, was an interesting viewpoint at a policy conference. Chapter 7 concerns the issue of net neutrality and how policy can be framed regarding net neutrality. If we broaden policy from just net neutrality and look at the Internet as a whole, which role should policy play?

Or, the more interesting question, which role can policy play? If we assume that policy and regulation should match the coordination and technology structures, it is problematic if not impossible for policy to regulate in detail. This is along the lines of the arguments in Mansell (2017) where it is argued that it might not be in everyone’s interest to keep current telecommunications regulatory models for parts of the Internet. Partly, as my interviews indicate as well, that the telecommunications epistemic community lobby more towards those in power than the Internet epistemic community does, and Mansell (2017) also makes the argument that as long as the debate is a debate on regulation, mostly state and corporate interests stand to gain (as opposed to citizens, “citizen interests in the digitally mediated environment are subordinated to corporate and state interests, making it difficult to assess whether the current period [... is favorable to corporate and state interests ... or] a ‘forking of the road’ - which could be more favourable to citizens” (Mansell, 2017, p. 2)).

In essence, the story of this thesis, including Chapter 5, Chapter 6 and Chapter 7, is that there are no shortcuts in understanding the Internet from both a coordination and a technology perspective; it takes time and is hard. And it is probable that parsimonious models are similarly hard or impossible to create for any field where the assumptions and realities of the field are changing rapidly, just as Mintzberg (1993) (and Coase (1937) and Taylor (1914) in different words) argues that standards and structures are good for efficiency for repetitive tasks, they can be problematic for rapidly changing tasks when standards and structure overhead becomes prohibitively expensive (or inaccurate). This is a similar argument the Duhem-Quine thesis in philosophy of science in that there are always auxiliary theories which shape the understanding and interpretation of the setting, and those need to be retried and not assumed.
9.11 Revisiting interviews and method

A reflection on the process itself might be prudent here close to the end of this text. And a possibility for me as researcher to come clean on how I ended up with this discussion. As mentioned in Chapter 2 most interviews were conducted with people in the Internet epistemic community, which might sound natural since the Internet was the object of study. This had the quirk that I initially missed that which ended up as the integrative perspective, that is another view of the Internet than that synthesized in the distributed perspective. It was first at the second telecommunications conference I attended that I fully grasped that there was a different, sometimes very similar, view of the Internet out there. As long as I talked to Internet people, read Internet Standards and Internet organization bylaws and statues, the integrative perspective only showed up as those “who do not understand the Internet”, rather than a different way of organizing digital communication networks.

These perspectives are not the result of single individuals, but rather the ends of a spectrum when I plotted the narratives and views of the Internet I encountered in interviews and texts.

Since I started in the Internet as a bottom-up phenomenon corner, the earlier chapters are dedicated to describing that Internet. I find it plausible that the thesis would have been organized differently had I started interviewing at telecommunications companies instead (i.e. had they been more willing to talk to me, which they might have been if I had framed my research differently, since my approach was to talk about the Internet and its governance, rather than the business models of telecommunications companies). But the later half of the thesis would have ended up similarly had I encountered the Internet coordination organizations later in the process.

In Table 9.7, I show how my different data sources added to or could be said to plot in the two perspectives. In general, the distributed perspective was driven by synthesis of interviews and the integrative perspective driven by policy literature on telecommunications and informal discussion (which did not pan out as interviews). Had I only read the literature I read, I would have concluded that the integrative perspective is the only prevalent way to view the Internet, and had I only done the interviews I did, I would have concluded that the distributed perspective is the only prevalent way of viewing the Internet.

Another way of framing it is that I have encountered the distributed perspective through interacting with the Internet itself (i.e. Chapter 7) and talking to people in the Internet epistemic community about the Internet. And I have encountered the integrative perspective mostly in literature and areas where digital communication networks and their policy and economics is discussed as an academic exercise. Also, the distributed perspective shows up lately in Netnod (2019) and IVA (2019), although implicitly, in how Internet access can be defined and society be organized around digitization.
9. **Discussion**

Table 9.7: Revisit of method and influences, approximation of how much influence different sources had on the perspectives.

<table>
<thead>
<tr>
<th>Source</th>
<th>Distributed perspective</th>
<th>Integrative perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>interviews</td>
<td>considerable, formed the core of the perspective</td>
<td>small, give indications that there were different way of looking at the Internet, but</td>
</tr>
<tr>
<td></td>
<td></td>
<td>not as accepted ways</td>
</tr>
<tr>
<td>discussions</td>
<td>considerable, as above</td>
<td>large, outside of interviews more people were willing to open up on what they consider to be the Internet and what it should be</td>
</tr>
<tr>
<td>literature</td>
<td>small, as in almost no academic literature on the organization and coordination of the Internet is written in the distributed perspective</td>
<td>considerable, since most telecommunications literature approach the Internet as a regulatory or policy target</td>
</tr>
<tr>
<td>conferences</td>
<td>small, I visited academic areas where this perspective was discussed, but no conferences where the distributed perspective was the one and only prevalent view</td>
<td>large, I visited two telecommunications conferences where the integrative perspective was the dominant view of the Internet</td>
</tr>
<tr>
<td>Internet Standards</td>
<td>considerable, as the Internet Standards describe the Internet as explicitly not integrated or top-down</td>
<td>none, they do not mention that the Internet could be something different</td>
</tr>
<tr>
<td>bylaws and statutes</td>
<td>large, as above</td>
<td>small, some bylaws contain references to systems which work differently, as such indicating that there are other regimes or systems in place</td>
</tr>
<tr>
<td>the Internet itself</td>
<td>large, since the Internet works in a distributed fashion and I live in a net-neutral-regime</td>
<td>small, since I have experienced other regimes than the net-neutral-regime on travels</td>
</tr>
</tbody>
</table>
As I intend to paint opposites, the perspectives are developed to describe the extremes of the actual thoughts behind the perspectives rather than the averages (and as such are in some aspects incommensurable). If I had only encountered one perspective, rather than the two I encountered (there could be more), that perspective would have been described as more nuanced (i.e. Chapter 5 is more nuanced than the distributed perspective).

9.12 Revisiting the Internet

It is also prudent to revisit the Internet and its definition again, several chapters after its conception to see if it holds up to scrutiny in the new light of the perspectives presented in Section 9.1.

The Internet is in this thesis, in particular in Chapter 5, defined as “a set of protocols for digital end-to-end communication affected by its users”. As argued previously, this has the implication that the Internet concerns digital communication (technical dimension), end-to-end communication (technical dimension), which is affected by its users (coordination dimension). This places the Internet in the distributed perspective since end-to-end communication implies separation of propagation and information (i.e. separation of concerns) and user in charge or affecting the development implies that those using the (inter-)network should dictate its future (i.e. separation of concerns in technical terms or an epistemic community itself setting the agenda rather than acting through another body).

Is it possible to create digital networks which are not the Internet, and does that distinction add useful meaning?

One example of a different digital communications network is cable-TV. Cable-TV is sold as a bundled service where the user is only in peripheral charge, and the user is usually limited to receiving information, as is the case with watching TV over cable-TV. Also, a cable-TV user is commonly limited to equipment provided by the provider, which further limits possible use of the digital network. For example, it is not possible to create a financial system on top of cable-TV as a user, which was done with (mixed results) bitcoin and the Internet.

Another kind of different digital communications network are the provider internal networks of telecommunications companies for cell-phone networks, these typically do not run IP internally and allow for little or not change from users (though it should be noted that several interviewees implied that larger telecommunications companies are switching to IP based networks internally). Even the standards themselves are large and hard to get at, i.e. standards managed in an integrative perspective.

As such the definition holds and is meaningful in distinguishing Internet-like digital networks from other networks. And it is also possible to imagine
other networks which are not known as the Internet to adhere to the distributed perspective and therefore be an Internet.
10 Conclusions

Do not confuse the Internet with telecommunications
[paraphrased]
— Interviewee

This chapter contains shorter answers, or rather explanations, to my research questions as well as reasoning on the theoretical and practical implications of those answers. The next chapter, Chapter 11, goes beyond the questions themselves and suggest further avenues for research.

10.1 Answering the research questions

RQ 1 How can the Internet meaningfully be described and conceptualized using coordination and technology dimensions?

In essence, the Internet is a phenomenon of intertwined technology and coordination, in that the Internet is not only technology nor is it only of coordination (see Table 10.1). The Internet is rather ideas of and practical coordination and technology evolving dynamically together.

The Internet has a long history of distributed voluntary bottom-up governance where empirical evidence and function has lead the standard-setting process ahead of other ideals such as planning or conforming to previous architectures. The practical organization and coordination of the Internet is
10. Conclusions

Table 10.1: Dimensions of the Internet

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>coordination</td>
<td>Explicitly loose bottom up with focus on empirically motivated decisions.</td>
</tr>
<tr>
<td>technology</td>
<td>End-to-end best effort digital communication.</td>
</tr>
</tbody>
</table>

intentional, and explicitly uses different structures than those for nation-state based multilateral agreements, as is common in the international telecommunications regime (cf. arguments in Cowhey, 1990, and organizations such as the International Telecommunications Union (ITU)).

The central concepts of the Internet are included in the Least Common Internet, that is the minimum coordination needed to run the Internet, such as coordination of some standards (such as the Internet Standards today) and some unique identifiers (such as those coordinated for the Internet Assigned Numbers Authority (IANA)-function today).

Figure 10.1: Central concepts in the Internet Coordination ecology, referred to as the Least Common Internet, i.e. that which ultimately is coordinated in Internet Coordination arenas and that which constitutes the practical and technical Internet.
The Internet as a whole (both coordination and technology characteristics) follow software design principles, such as low coupling and high cohesion, composition over inheritance and the SOLID-principles. As such the principles of coordination and technology are aligned, as well as the implementations of the principles. Although the technical Internet dimension (see Figure 10.2) differs from the coordination Internet dimension (see Figure 10.1) in what you can see in either dimension alone.

Figure 10.2: An infrastructure view of the Internet.

It is also important to understand that the infrastructure part of the Internet is a platform on which other services can be offered or run, one of these services is the web. The web runs on top of the Internet, and has different coordination mechanisms in place. Technically, the web runs on another layer, and all layers should (in the distributed perspective) be separated in both a coordination and a technology sense. The common computer science term
is known as separation of concerns and violation of this principle is usually known as layer violation.

Comparing the Internet to other digital networks, such as SWIFT, cable-TV, Telex, etc, they are all at the forefront of technology (in respective ages), but conceptually different from the Internet in terms of managing the internet aspects, such as unique identifiers. I.e. conceptually different in a coordination sense, but quite similar, for their ages, in technology design.

The smallest possible definition of the Internet is “a set of protocols for digital end-to-end communication affected by its users”, which has a number of implications. First, the Internet is not a function of any single or a set of protocols (the Internet as a set of protocols is one prevalent view of the Internet), but rather the other way around. Internet Protocol (IP), Domain Name System (DNS), Border Gateway Protocol (BGP), etc are all dependent on the idea that is the Internet. There could still be an Internet, even if IP, Internet Corporation for Assigned Names and Number (ICANN) or the Internet Engineering Task Force (IETF) is replaced by something else. What rather could change the Internet is if the original values, such as end-to-end and best-effort through bottom-up processes, were changed or removed.

**RQ 2 How is the Internet, as conceptualized, here, coordinated?**

The Internet is coordinated through, in essence, three distinct but separate collections of processes. Internet Standards through informal multi-stakeholderism through the IETF based on voluntary work where contributions to standards are (supposed to be) valued on their intrinsic values (in a technical design perspective to prepare for change) rather than the power of the proposer. The standards process is characterized by openness, hard to reach consensus and an epistemic community setting its own agenda.

The design of the process shows signs of engineering and separation of concerns values, that is the processes for Internet Standard themselves are designed similarly as a system expecting change should be designed. The notion is that interdependence is “bad”, since interdependence gives a raison d’être to modules or organizations which not necessarily stem from the processes or work done in said module or organization. As such, both groups in the standardization process and standards themselves are (to an extent) replaceable by other groupings or standards. For example, IPv6 can replace IPv4 without major modifications to other protocols, and one working group be replaced by another.

Unique identifiers, i.e. IP addresses, Autonomous System Numbers (ASN), prefixes, and domain names, are coordinated by policy through a, compared to the IETF, formal multi-stakeholder process at ICANN. The processes for unique identifiers contain fewer technical considerations than the processes
for Internet Standards, and have over time come to show signs of isomorphic pressure from state policy and regulation thought styles (which I have not identified in the Internet Standards process).

Also central to the coordination of the Internet, is the infrastructure the Internet practically runs on, the infrastructure and network operators (i.e. everyone involved in running a network or some part of a network at some level, however, mainly Internet Service Providers (ISP) and Internet Exchange Points (IXP)). Most infrastructure and network operators are organized in for-profit constellations, as such use of Internet Standards represents a market decision. For example, BGP-policies and peering by large ISPs are based on perceived value capture.

Also important is that two of the arenas for these central processes of the Internet, ICANN and IETF, are replaceable.

ICANN is replaceable since ICANN is a facilitator for coordination, rather than a coordinator, and the most important Internet maintenance function, the IANA-function, could be housed elsewhere under different conditions. Do note that with the above conceptualization of the Internet; the protocols could change and there would still be an Internet.

The IETF coordinates, through its members, suggestions for standards. The most prominent of these standards are labeled Internet Standards. These standards are not enforced or policed, only published. Other fora could take this role.

Contrary to common belief the Internet is de facto not under regulation the same way telephony, broadcasting, radio and other traditional services are. However, the landscape is changing; there is significant pressure from the ITU to put an IANA-like function under the ITU. This could leave the technology dimension of the Internet intact, but change the coordination dimension into a, for example, top-down non-Internet structure. Such a change of coordination would unavoidably change the technology aspects, as coordination and technology is intertwined, and could provide a different kind of network (or collaboration of networks). This would be a layer violation in the sense of the distributed perspective in the coordination dimension, since there should be a separation of concerns principle in place on the coordination side (as well as the technology side) according to core Internet design principles in the distributed perspective.

The external policy and regulation pressures have changed the way ICANN is organized to a more formalized structure with the Empowered Community (EC) and subgroups. ICANN has also taken a step back in its description of its mandate and is now focusing on what can best be described as “one Internet”, that is; one naming-root (i.e. IANA) and one numbering coordination function (also IANA).

The coordination mechanisms are well aligned with the standards and infrastructure, and there is a clear separation of concerns notion involved in
10. Conclusions

almost all aspects of Internet coordination. The technology of the Internet matches the coordination structure of the Internet.

This has the consequence that the Internet is resilient internally to mission disruption and social change, but complicates matters which lie outside the core Least Common Internet. As an example, trust in the Internet might be lowered due to misuse of the Internet by nefarious actors, and that would not necessarily be considered an Internet-issue by Internet actors since nefarious actors are normally handled by jurisdictions and law enforcement agencies. Rather the opposite, that the Internet (as seen in this thesis) is threatened by those epistemic communities who push for the Internet as a telecommunications network with multilateral state oversight. Since in such a regime the Internet would be defined by states in multilateral agreements rather than the bottom-up multi-stakeholder model in place today (which I consider a core part of the Internet’s coordination dimension) and ultimately change what the implementation of the Internet is and can be used for.

RQ 3 Which are the prevalent perspectives of how to coordinate, design and run digital communications networks?

I identify two prevalent and sometimes dichotomous views on digital communication networks; the distributed perspective which includes networks and interconnected networks such as the Internet, and the integrative perspective which includes networks such as cable-TV, cellphones (and other regulated spectrum communications), and the telegraph.

The integrative perspective is dominated by legal and business logic; contracts are enforceable and jurisdictions matter, service offerings are bundled with transportation and propagation layers, and actors can capture value as is technically possible. For example, in the integrative perspective it is logical than an ISP owns infrastructure, sells Internet access (or other access), offers telephony and cable-TV-like services, all at the same time. This since vertical integration improves market position, for example, by owning infrastructure you can prevent others from selling services on your infrastructure. As such, practical net neutrality is a disservice in the integrative perspective.

The other framing, the distributed perspective, primarily (and only follows in its extremes) follows software and other technical design principles. These principles, in general, are centered around the notion of managing significant change\(^1\) efficiently through separation of concerns, that is low coupling (or high independence), high cohesion (strong functional grouping of independent functionality) and allowing any logic (such as markets and value capture) to reign fully within those technically motivated constraints. As such, practical net neutrality is a design consequence in a network or collection of networks

\(^1\)Change in the interval 40%/yr to 50%/yr, that is the magnitude of change to be expected with digital technology. See Section 3.11 for argument for full argument.
designed according to the distributed perspective. The reason for this is that to manage change efficiently\(^2\) the packet propagation mechanisms and standards of the network need to be independent of transmission control, session state protocols and all use of the network.

With regard to telecommunication standards and processes, i.e. ITU and similar standards and processes, are governed and coordinated in a fundamentally different way than Internet standards. The Internet is inherently bottom-up whilst many telecommunication standards are from a process of multi-lateral agreements turned into standards. Note that the Internet as it is used is often dependent on telecommunications standards, such as cellular standards for mobile data, of which the data could be Internet data. As such Internet Standards are designed to be decoupled from telecommunications standards (and other Internet Standards) implementation wise, but can (and perhaps should) use them. See for example the reasoning in Section 9.1. As such it is impossible to distinguish these kinds of networks from an external perspective without taking both technology and coordination into consideration.

I argue that “governance” is a contentious term which is best avoided when discussing Internet coordination, due to the lack of consensus of the meaning of governance. I suggest the term Internet Coordination instead. The notion that many with a distributed perspective of the Internet do not consider the Internet as governed, rather coordinated, sometimes makes for weird interactions between Internet-people (i.e. members of Internet thought collectives and epistemic communities) and state level legislators and policymakers.

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\(^2\)The design principle is that you should design in such a way that any future change should only implicate change in one part or module of the whole, i.e. separation of concerns through that which might change, see Proposition 4.
11 Contributions and implications

Do not assume that the Internet as we know it will be around five years from now
— Interviewee

The purpose of this chapter is to go beyond the empirical setting of this thesis and suggest further avenues for research, and practice, and in some cases provide additional comments on how to conduct those practices. This chapter is presented around the themes in Table 1.2 and further divided into contributions and implications, where possible.

In general terms, this thesis lies closer in conceptualizations of the Internet to standards, reports and opinions from mostly engineers and technically knowledgeable (such as Bradner, 1996; Glass & Tardiff, 2019; Hovey & Bradner, 1996; IVA, 2019; Markus, 2006; Netnod, 2019, etc, some implicit and some explicit on the nature of the Internet) than contemporary economics and policy literature (such as Bourreau, Kourandi, & Valletti, 2015; Cheng et al., 2011; Economides & Täg, 2009; Hahn & Wallsten, 2006; Hylton, 2017; Wallsten & Hausladen, 2009, etc, some explicit and some implicit on the nature of the Internet).

This thesis suggests that, in theoretical terms, it is more fruitful to conceptualize the Internet in similar terms as money from the perspective of society. As such, the notion that anthropological studies by researchers wielding a significant understanding of both technology and coordination are what ultimately will explain the Internet in societal terms is not a strange notion.
Implications for Internet practice. This thesis considers the Internet different from telecommunications networks, primarily in a coordination sense rather than a technology sense, since the networks could use the same standards and technologies. This thesis considers the Internet to be built around principles of the distributed perspective, which implies design characteristics such as separation of concerns. While, on the other hand, telecommunications networks adhere to an integrative perspective view of its coordination. It is also possible to imagine an integrative perspective view of technology, but currently such networks are rare (i.e. legacy phone and telegraph networks), and telecommunications networks can rather be said to be a distributed perspective technical implementation under an integrative perspective view of coordination.

The Internet as an idea and phenomenon requires a different treatment than telecommunications, as the Internet is not based on notions of jurisdiction and contractual sense, and such most, if not all, regulation of the Least Common Internet itself unavoidably changes and puts pressure on the Internet.

I note the different coordination values and practices in Internet Corporation for Assigned Names and Number (ICANN) and Internet Engineering Task Force (IETF), both on paper and in practice. These differences imply that ICANN is perceived to govern and control the Internet to a larger extent than they do. ICANN essentially have three options: (1) govern and control explicitly to meet expectations but push the coordination of the unique identifiers of the Internet out of the principles of the distributed perspective, (2) clearly state their mandate and mission to avoid misconceptions of their purpose, by this risking that other constellations vie for the governance previously thought orchestrated at ICANN, or (3) do nothing, and therefore keep the status quo of ICANN as a squatter (see ecology roles in Chapter 5) of matters concerning Internet Coordination (or, rather Internet Governance as perceived by external actors interested in the role).

I do not through this study perceive a similar wicked problem for the IETF; as the IETF maintain a structure seeped with notion from the distributed perspective. However, there are indications that the members of the IETF are vying to turn the IETF further away from nation states.

Simplified, this study indicates that at inception the Internet Standards process and the unique identifiers process followed similar values and design principles, but that the unique identifiers process (i.e. ICANN today) is nearing jurisdictional and contractual meaningfulness over technical coordination, while the Internet Standard process (i.e. IETF) is turning away from the same. As such, the Internet Standards process and the unique identifiers process are diverging towards different values and principles. However, I lack the data to say so with certainty, but it is indicated by my interviews and discussions that there is a (potentially) growing schism.
Implications for technology  This thesis focuses on the intertwined nature of technology and coordination, and as such suggests that alignment of coordination or organizing and technology is a fruitful and worthy endeavor.

Internet Standards have, and should continue to, follow principles such as separation of concerns, as long as the coordination of the Internet does, since the Internet today is dependent on the independence of the technologies and standards used.

A practical example, technologies such as Domain Name System (DNS) or Domain Name System Security Extensions (DNSSEC) over Hypertext Transfer Protocol Secure (HTTPS) or Transport Layer Security (TLS)\(^1\) in a design sense are layer violations in that they can bypass the DNS implementation of the operating system (the norm) as suggested by Mozilla and Google, but also prevent users from possible layer violations by, for example, Internet Service Providers (ISP) trying to block or modify DNS traffic. As such design of practical Internet Standards are inherently an act of balance of practical need and adherence to principles.

Contributions for management theory  This thesis suggests that further research into Internet Coordination in particular and digitization in general needs to be multi- or interdisciplinary (with current thought collectives, fields or disciplines) to capture the dynamics of an ecology. In technical terms, digitization requires basis vectors in both coordination and technology to meaningfully (in the perspective of this thesis) span the vector space that is digitization. This thesis is not suggesting that two axes are enough, it is suggesting that these two axis together provide more insight into the Internet and digitization. Even more basis vectors, or thought collectives, might be required for a more nuanced understanding of the currently quite technical reality we live in. Also note that this thesis tries to describe technology in a digitized context, it does not try to abstract it into a slimmer construct (such as a black-box).

And as argued in Section 3.11, technology, and especially digital technology, is rapidly changing and evolving. And paradigm shifts seem to occur every seven years or so (cf. scientific paradigms in Kuhn, 1962, although I here refer to technological paradigms). As such, research approaches which do not explicitly care for the nature of digitization and the nature of technology will risk missing paradigm shifts, and as such draw incorrect conclusions based on incorrect modeling or abstraction of the empirical setting. This is a similar argument as the one made in Section 4.6.

The notion is that to generalize from a digitized setting the entirety of the setting needs attention rather than assumption.

As such, this thesis suggests that the IT-artifact is not a meaningful conceptualization in contexts where technology and coordination interact (cf. 

\(^1\) Usually know by their acronyms, DoH and DoT.
11. Contributions and implications

Orlikowski & Iacono, 2001; Weber, 2003, where the distinction is meaningful, and theories for (or at least theorizing of) interactions where agency does not solely lie outside of technology are needed. It is possible that a model or conceptualization accurate enough of such a setting is as complicated or more complicated than the setting itself; or in information systems terminology, the representation outweights the represented system and as such serves no analytical value.

Rather, fit and alignment of technology (information systems, smartphones, key-cards, vehicle engine systems, etc) and coordination (organizing, training, policy, strategy, etc) needs to be considered (cf. problematization of fit / alignment in literature such as Askenäs & Westelius, 2003; Chan & Reich, 2007; Croteau & Bergeron, 2001; Leonardi & Barley, 2010; Raymond et al., 1995; Zuboff, 1988). Just as organization can be organized in a multitude of ways, technology and management of technology can be aligned and organized (designed?) in a multitude of ways (cf. the technically oriented (and not academic) arguments in Vassallo et al., 2017; Zaar, 2017).

Managerial implications For organizations (some of all Internet users), it is important to align business models to Internet function if their strategy is reliant on the Internet for execution. Such as Tesla requiring a distributed perspective function of the Internet to properly function. It is also important to consider plans of action if the Internet as such were to change (for example if the Internet were to be coordinated under an integrative perspective regime), since both the naming coordination in place is challenged at international level and policy-makers are getting tougher with policy with regard to the Internet.

The Internet is both a technology and a coordination phenomenon; both need to be understood to make sense of the Internet in a way meaningful to its coordination. Also, coordination of technology (in the setting of this thesis) matters more than contemporary literature suggests, for example the prime differentiation between classical telecommunications and the Internet is coordination, not the technology itself.

Practically, firms and other organizations should (in light of this thesis) model the Internet in their internal risk processes (i.e. “what happens if the Internet disappears?”). The ITU Plenipotentiary (ITU PP) meeting and handle-system discussions, the net neutrality debate and policy in the U.S. and Article 15 and 17 of the EU copyright directive are just examples of recent or upcoming events which shape parts of what the Internet is and can be seen as, even though they do not directly relate to the Least Common Internet, i.e. naming, numbering or standard-setting (in the sense of Internet Standards).

In other words, Internet function and functionality cannot be assumed, and as such this thesis recommends organizations interested in how the Internet is coordinated to participate in the coordination process. Most tech-firms are,
indirectly, invested in current Internet function. Literature on the subject is often quite old, and in that sense outdated on what the Internet is (see, for example Afuah, 2002; Mehrten, Cragg, & Mills, 2001; Shapiro & Varian, 1998, for prior, but today outdated (just as this thesis will be)) and therefore on how it should be treated (since the Internet is black-boxed and important changes lost in abstractions the implications do not stand the test of time).

This since the Internet is designed to efficiently become what is needed rather than to stay static. The last sentence bears to be repeated. The Internet changes with (digital) technology (which changes rapidly) and use (which usually follows technological change or creates technological change) and it is designed to change, and the Internet’s coordination mechanisms are designed to handle these pressures, i.e. allowing mission evolution rather than mission disruption (to use the terms in Reiser, 2006).

Such mismatch is, as far as the reviewed literature goes, untouched. Cowhey (1990) discusses the broader coordination of telecommunications networks, but leaves technology out of the picture. Technical standards, in general, discuss the technical reality of the networks but do not discuss their coordination or the logic behind them (business logic? Common good logic? Fun playing with high-technology logic? (such as skunk-works)).

Contributions to policy research The notion that the Internet is something else than just protocols in a telecommunications world affect how it is possible to reason regarding policy enforcement at a sovereign-state level. Telecommunications policy would have to adapt so that state policy in practice does not seem to affect core Internet functions (such as naming and numbering) today, as has been noted previously but not explained in this level of detail (at the time of writing).

Chapter 7 suggests a matrix (Table 11.1, same as Table 8.6, updated version of Table 7.14) for identifying different regimes for digital communications networks, based on the norms of which the rules of engagement are coordinated (regulation vs market) and practical net neutrality (whether infrastructure and network operators de facto capture value by differentiating traffic). This matrix is a contribution to telecommunications to better nuance network regimes (as called for in Glass & Tardiff, 2019).

See for example the issues raised in Mueller and Chango (2008) and the notion that global governance (as previously conceptualized) is challenged by the way the Internet is coordinated (or governed, as the term Mueller & Chango, 2008, uses). This is also in line with theory and suggestions in Glass and Tardiff (2019), that the current understanding of Internet Coordination and Internet Governance is limited and that new ways of conceptualizing net neutrality is needed (as suggested in Chapter 7 and shown in Table 11.1).

This thesis frames current net neutrality literature (cf. Cheng et al., 2011; Hahn & Wallsten, 2006; Lee & Wu, 2009; Litan & Singer, 2006; Musacchio
11. Contributions and implications

Table 11.1: Typology of digital communication networks

<table>
<thead>
<tr>
<th>Policy logic</th>
<th>De facto net neutrality</th>
<th>Net neutrality possible but not norm</th>
<th>No net neutrality in practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory policy</td>
<td>Regulated Internet</td>
<td>Regulated digital communications</td>
<td>Regulated telecom</td>
</tr>
<tr>
<td>Mixed policy</td>
<td>Mixed Internet</td>
<td>Neutral Internet</td>
<td>Mixed telecom</td>
</tr>
<tr>
<td>Market policy</td>
<td>Early Internet</td>
<td>Market Internet</td>
<td>Market telecom</td>
</tr>
</tbody>
</table>

et al., 2009; Pil et al., 2010; Wallsten & Hausladen, 2009, as examples) as the special (often as a cable-TV case with two or three involved actors) and not the general case of net neutrality in the perspective of digital communications (such as the Internet). And it is not assumed that the special case can be generalized from the special case. Similarly, the special and the general theories of relativity are quite separate (cf. Einstein, 1920) even if intrinsically connected. As such this thesis contributes to the notion that a general net neutrality theory need to take into consideration the complexity of the actual Internet and other possible constellations of networks, for example as shown in Figure 3.5 and Table 3.6, with millions of routable and interconnected entities (and ultimately billions of devices and users).

Implications for policy and regulation National regulatory policy is problematic on all accounts with regard to the Internet since such policy is made on a different premise than the Internet is governed (or rather coordinated) on.

Also problematic for nation-state policy is that such policy in general is only valid in one or a few jurisdiction(s), and the Internet is intentionally designed only to adhere to technical considerations and not legal ones (i.e. the original notion is that the coordination of the Internet should be limited by its technological constraints rather than perceptions of jurisdictions). If policy is necessary, it should only (in the distributed perspective) enforce that which is coordinated by the Internet’s own coordination mechanisms or concerns network behavior at a high level, from an Internet perspective if original design principles are followed (national regulatory authorities might of course argue that it is in their mandate, as it probably is in most jurisdictions, in a legal sense, although not legitimately according to Internet proponents). It
should be noted explicitly that the Internet in this sense is a platform, and the platform should not be exposed to policy (according to the distributed perspective). Policy should rather expose that which uses the platform (such as websites, Facebook, YouTube, Netflix, shodan.io, etc) in the distributed perspective and given how the Internet is designed. Regulation of the Internet by the integrative perspective will change Internet coordination mechanisms, probably by increasing importance of national regulatory authorities and nation-states in Internet Coordination processes.

Also, important is that there is a belief that Internet Coordination should not take politics or economics into account, as illustrated in Chapter 7, where a central grouping skirt the issue of net neutrality since it is not primarily a technical issue, but focus on the technical aspects of running the network, such as maintaining a working standards track (i.e. what IETF does) and maintaining a working naming and numbering system (i.e. what the Internet Assigned Numbers Authority (IANA)-function does). This belief in conjunction with that the coordination of the Internet is loose has the consequence that the Internet has no formal champions, and the Internet cannot be considered to be represented in settings such as the International Telecommunications Union (ITU), the United Nations (UN) or nation-state assemblies (there are certainly those epistemic communities who work or lobby for the Internet as they see it towards nation-state assemblies and similar, but not formally on behalf of the Internet). In effect, there is no official Internet policy for external matters except what the actors actually do.

One implication for policy from a distributed perspective in terms of net neutrality is that government policy or regulation should not directly concern itself with net neutrality, but rather creating the market conditions where net neutrality can exist as a reasonable Internet access option from infrastructure and network operators. For example, the usual reason for no-net-neutrality regimes is lack of competition at an Internet access service level. Thus, regulation which creates competition at an Internet-access service level is preferable to regulation which forces net neutrality hard in either direction. In an integrative perspective net neutrality would not necessarily be goal, and could rather be a regime to strive against.

Society in theory and practice  At a societal level this thesis suggests viewing the Internet as a platform for digital communication which in turn can be used by other actors (compare with “digital platform” in de Reuver et al., 2017). In such a perspective the Internet ecology (as an existing collection of entities) is the set of actors involved with coordination of the Least Common Internet; that is the least technical coordination needed for disparate networks to interconnect.

In extension, in this societal lens, the Internet is more meaningfully compared to monetary systems (such as central bank backed monies) as systems
which enable different rules of engagement by actors. As an example, money allows markets to settle debt instantly, given institutions for this purpose, and therefore allows endeavors (such as firms) to manage counterpart risk (that is instead of trading on a promise from counterpart, trading on directly transferable money).

This thesis also argues that it is problematic that the public discourse with regard to the Internet often confuses services on the Internet, such as the web, Facebook, Netflix etc, with the Internet itself (without actually blaming anyone, this is more of a “bildung is good and needed” argument, just as it is important to differentiate money from what the money is used for). As long as the public discourse sees no difference between the Internet and platforms and services built on top of the Internet, nor acknowledges the coordination mechanisms in place, regulation will probably be inefficient, inaccurate and written for an integrative perspective on digital communication. This is similar as not distinguishing between actors providing materials for roads, building roads, maintaining roads, cars driving on roads, cab services and public transportation. An Internet regulated as an integrated service would be a different Internet than we have today, even though technically the same, due to the current bottom-up structures composed of the Internet epistemic community itself (similar argument as before, the coordination of the Internet, or other digital network, is more important than the technology of the same network (within reasonable limits)).

The Internet coordination functions were designed in a way appropriate with the way a software architect would design a similar system. It is natural that any organizational designer would fall back to his / her own toolbox for solving organizational problems, and if that happens to be computer science or engineering, so be it. As such the Internet can be said to be exposed to the normative isomorphic forces described in DiMaggio and Powell (1983) but for engineers rather than managers. The same reasoning is in line with the argument in Mintzberg (1993) that you do what you are trained to do to solve problems, so if an engineer is encountered with an organizational problem, it is likely to be solved with engineering principles (see and compare to the empirical account in Kantor & Streitfeld, 2015, of the organization of Amazon). Also important in this sense is that the Internet epistemic community itself is in charge of Internet coordination, rather than the norm of the primary epistemic community for an area working as a lobby-organization towards those in power.

The Internet provides machine to machine communication, almost instantaneous transfer of artificially trained intelligence and scientific research, interplanetary communication (standards forthcoming), virtual organizations managing car fleets of millions, jurisdiction free transfer of intellectually interesting property and ad-ecologies where information become a millisecond market good. By this not suggesting that the Internet is “good” in all aspects, rather that the Internet has yet to be problematized in all aspects.
Just as money has yet to be fully problematized and understood, there are still things to be problematized and understood. On a speculated comparison with money note, the Internet is in the “use money to buy milk” stage, rather than in the “create financial institutions for large collateral endeavors” or “large collections of nominal value to cover liabilities in case of disaster” stage. And just as these types of institutions have popped up due to the existence of money over time, certainly new types of institutions will pop up over time due to the Internet which we now might only speculate on. Autonomous snow plowing fleets? Actual use of decentralized debt management systems (such as crypto currencies)? Distributed storage and validation of scientific research? Dissolution of nation states?

Only time will tell.

Contributions to scientizing. Here using the uncommon expression scientizing as the process of “creating” science, the same way theorizing is the process of creating theory.

This thesis is an example of bundling or composing a thought style (or potentially a thought collective, given enough readers) out of several thought collectives (or paradigms, by removing and reconstructing auxiliary assumptions and theses which ground thought collectives and paradigms). In particular, this thesis uses different thought collectives to describe the technical or engineering aspects of the Internet and combines it with an ecology view of the Internet’s coordination, to conceptualize the Internet meaningfully in a new (or perhaps my) thought style.

As argued in Section 2.4, bundling or using multiple thought collectives gives additional credibility to the accuracy of the theorizing or description (or power of the result in a quantitative frequentist manner), rather than going deep within one thought collective.

My view is that, to make sense of an interconnected world, in particular when agency is floating and present both in common actors such as people, and also other forms such as artificial intelligence (AI) implementations, automatic

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2 Even though there are literal shelf-meters on the subject, the Bretton Woods conference, the practical dissolution of the Bretton Woods system in 1971, the Euro and now the rise (?) of, even some central bank backed, crypto currencies can serve as indicators that the debate is far from over. Or, epistemically rephrased, central bank backed credit monies are to a certain extent explored, but other types of monies are not in a digitized society.

3 As the perspectives are designed the current scientific ecology fits in the integrative perspective rather than the distributed perspective. For science to be in the distributed perspective: methodology, data, peer review, access, etc would have to be decoupled; so that science (fact? knowledge? product of a philosophical view of science?) can live, be accessible and developed independent of publication method, research methodology, data and original researcher. See, for example, the Open Science initiative and the unbundling of science.

4 Not in a tinfoil-hat way, rather that the Internet gives rise to other ways of organizing society. Are nation states the pinnacle of organization of society in all possible futures given the Internet?
11. Contributions and implications

contracts on blockchains, etc, we need multiple thought collectives working together (aligning?) to make sense of the world. In essence, this is a call for interdisciplinary research, but rather than a call for papers of interdisciplinary design, a call for researchers living and making sense of the world in what is now the empty spaces between the monoliths of established thought collectives and their intrinsic abstractions and assumptions.

11.1 Into the scrying ball

The Internet as a coordination problem is still a generally untouched issue. This thesis scrapes the surface, presents research, views and suggestions. The conceptualization of the Internet as presented in this thesis is unique in academic circles. But also problematic in that it requires some policy, some management / coordination and some technical understanding to be useful. For example, the policymaker with no knowledge of naming or routing might believe that the Internet works like cable-TV, and statements such as

the design of the Internet is to separate concerns

are essentially meaningless in such a thought collective.

The conflict between the distributed perspective and the integrative perspective will undoubtedly be important in the future, at its most basic level; should the Internet be open, free, end-to-end and best-effort in that network owners are not allowed to differentiate value capture depending on traffic mix (i.e. less vertical integration and focus on horizontal competition) or if services today on the Internet should be bundled with Internet-access (i.e. offers include Internet-access, Netflix and YouTube)?

This conflict is in my local setting conceptualized as vertical vs horizontal integration and separation (of concerns) as “drainage pipes [vertical integration] vs lasagna [vertical separation and sometimes implying horizontal integration]”. See for example IVA (2019).

One example of looking forward is our conference contribution (see Brege & Lindeberg, 2018), where we explored how business models (in the sense of how businesses do business) are affected by a practical net neutrality versus no-net neutrality regime. Interesting is that we could not find any advanced digitized services which are not affected by the Internet and its coordination today, which solidifies the argument that the Internet can rather be seen as a society level catalyst (just as money) rather than a particular service level digital function. Even if, as told by an interviewee, firms and organizations (and surely the public) are unaware of it.

This thesis also suggests that the notion of aligning organization with technology is almost a necessity when looking forward, as technology is invested with increasing amounts of agency and the lines between organizing, coordination and technology gets blurred. This as a logical generalization given this
study. This is in line with business IT alignment studies such as Raymond et al. (1995), Chan and Reich (2007) and Croteau and Bergeron (2001) and more general suggestions such as those in Orlikowski (1992) and Orlikowski and Iacono (2001).

If we take one step back and apply the same lens on society as a whole, other similar issues show up, such as the “right to repair” issues (today a vocal debate in the US due to Apple, Tesla etc), and today far-fetched but potentially interesting areas such as the right to control and modify your own equipment (see D.C. Circuit, 1957, for the seminal Hush-A-Phone judging which gave users the right to slightly modify their telephones). For example, should owners of cars be allowed to modify the firm- and software as long as the modified software adhere to safety standards? Will there be a market for autonomous car software which could be used regardless of actual car make? (a distributed perspective example)

There are forces in play, currently, which would like the Internet to be less open than it is today (i.e. a shift from a distributed perspective Internet to another kind of integrative perspective digital communications network), as such the Internet and its openness should not be taken for granted\(^5\). Examples of recent events which go against Internet design principles (see Section 8.7) include the way net neutrality was handled in the U.S. (see Chapter 7 for a more nuanced argument), as well as the recent EU policy decisions where infrastructure and network operators have responsibility towards copyright legislation (i.e. a step from a distributed perspective Internet towards an integrative perspective digital communications network). However, in an almost surprising twist the ITU did not recommend a push towards state control at ITU PP 2018, which many had feared or hoped for. It bears to be repeated here, that the actual technical design of the Internet is designed by its coordination mechanism to change to adhere to external need, but the Internet coordination mechanisms themselves are not intended to fundamentally change (according to the perspectives captured in this thesis). A similar conundrum exists in almost all democratic organizations, can members vote to invalidate their own right to vote? (i.e. change its coordination mechanisms fundamentally)

A large part of our society today indirectly assumes that the Internet will continue to work as it does today (which certainly is not unique to the Internet). There is reason to suspect that the Internet will not, since large forces are in play against the notion of a distributed global digital communications network where a vast assortment of stakeholders, rather than just nation-states, have a role to play. Such forces include, but is not limited to, pushes towards Internet naming as a state level issue, general political pressure towards sovereignty over coordination at an international level, and more

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\(^5\)Open, here used implicitly as a consequence of a network with a separation of concerns design, rather than the political notion of “openness”.
specific pushes such as more extensive use of nation level firewalls (such as the “great firewall of China”).

And for industry or business-to-business context, will there be new horizontal digitized markets? For example, today industry production robots are bundled with software and control; in a distributed perspective the natural way forward is to separate the physical robot from software and control, such that the manufacturer of the robot expose an Application Programming Interface (API) to the robot itself but deliver a “stupid robot” to which other companies sell firm- and software depending on application. Although software development might have higher profit margins and scale better than robot-production, so perhaps robot manufacturers will sell their production and focus on robot control (once production robots get standardized enough at an interface or specification level, the public can start producing standardized robots and lets firms compete at “robot service” level. As firms naturally need an environment where jurisdictions and contracts have meaning (and can be enforced)).

In general, in the perspective of this thesis, these changes are due to technology becoming an integral part of society, and the specific case of digital technology, which often is designed according to software design principles and as such enforce separation of concerns, refute layer violations and promote vertical separation over horizontal separation (or rather the inverse, vertical integration is technology-wise a larger issue than horizontal integration in terms of mitigating impact of (unavoidable) change).

At this broader level, this thesis presents two views, the distributed perspective and the integrative perspective, to make sense of ongoing events. They touch on integration and separation of concerns, design principles, creation of value versus capture of value, and in its fullest extension, ideologies of organization of society. At this broad level they roughly correlate to David Goodhart’s much acclaimed and criticized concepts (value tribes) of people coming from either Somewhere or Anywhere (see Goodhart, 2017). Where Anywheres contain a multitude of similarities with Internet Coordination in a distributed perspective sense, such as the balance of value creation and value capture in an ecology, freedoms, lack of unnecessary regulation, and so forth.

Looking forward there are signals, visible in my empirical data as well as events such as Brexit, the Hungarian situation and Trumpism which all point towards a future where the Internet as it exists today is not a necessary want. The reason is that the values embedded in the coordination of the Internet fall clearly in the distributed perspective and Anywheres rather than more closed, controlled and sovereign integrative perspective and Somewheres.

Do not take the Internet of today for granted.
Endnotes

*Immature artists copy, great artists steal*
— William Faulkner

This section contains information on reused material. Figures in Table 12.1 and epigraphs in Table 12.2.

The epigraph of this chapter appears in many forms, and has been attributed to many famous authors and opinion makers. Among others, Steve Jobs, Pablo Picasso, T.S. Elliot, Lionel Trilling, Igor Stravinsky, William Faulkner and more. The wording used here is commonly attributed to William Faulkner.

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<tr>
<td>Figure 3.1</td>
<td>Used with explicit permission of the Regional ccTLD organisations of CENTR, LACTLD, APTLD, AfTLD (via Lydia Stoddart of CENTR).</td>
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<tr>
<td>Figures 3.2 to 3.4</td>
<td>Available under CC BY-SA 3.0. See <a href="https://commons.wikimedia.org/wiki/File:Regional_Internet_Registries_world_map_until_2002.svg">Regional_Internet_Registries_world_map_until_2002.svg</a>, <a href="https://commons.wikimedia.org/wiki/File:Regional_Internet_Registries_world_map_2002-2005.svg">Regional_Internet_Registries_world_map_2002-2005.svg</a> and <a href="https://commons.wikimedia.org/wiki/File:Regional_Internet_Registries_world_map.svg">Regional_Internet_Registries_world_map.svg</a> for more information about respective figure.</td>
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<tr>
<td>Figure 3.6</td>
<td>Used with the explicit permission of its creator, Patrik Fältström.</td>
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<td>Figure 9.7</td>
<td>Available under CC BY 3.0, See <a href="https://commons.wikimedia.org/wiki/File:Open_Science_-_Prinzipien.png">Open_Science_-_Prinzipien.png</a></td>
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<td>All other figures</td>
<td>Created for use in this thesis.</td>
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Table 12.2: Epigraphs used in thesis.

<table>
<thead>
<tr>
<th>Quote</th>
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<tr>
<td>“I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail”</td>
<td>Popular quote by Abraham Maslow. Appears in, among other, Maslow (1962).</td>
</tr>
<tr>
<td>“Any sufficiently advanced technology is indistinguishable from magic”</td>
<td>Known as “Clarke’s Third Law”, in a set of three laws concerning the future. See, among other, Clarke (1984).</td>
</tr>
<tr>
<td>“For you it is advantageous that there is no consensus on how the Internet is coordinated, that means you have a job”</td>
<td>Said by interviewee when asked about different ideas of Internet Coordination.</td>
</tr>
<tr>
<td>“The Internet is not governed, it is coordinated”</td>
<td>Said by interviewee after I used “governance” in a discussion.</td>
</tr>
<tr>
<td>“[messed up] the zone-file by removing the trailing dot. For a couple of hours the [...]-zone was unresolvable”</td>
<td>Said by interviewee describing a recent human error.</td>
</tr>
<tr>
<td>“The Internet lives where anyone can access it”</td>
<td>Common quote often attributed to Vint Cerf.</td>
</tr>
<tr>
<td>“The Internet works because a lot of people cooperate to do things together”</td>
<td>Common quote often attributed to Jon Postel.</td>
</tr>
<tr>
<td>“If you trust the Internet you are doing it wrong”</td>
<td>Said by interviewee to distinguish service agreements and best-effort solutions.</td>
</tr>
<tr>
<td>“Do not confuse the Internet with telecommunications [paraphrased]”</td>
<td>Said by interviewee when discussing the terms Internet and telecommunications.</td>
</tr>
<tr>
<td>“Do not assume that the Internet as we know it will be around five years from now”</td>
<td>Said by interviewee when asked about the future of the Internet.</td>
</tr>
</tbody>
</table>
Glossary

**adhocracy** An organizational configuration in Mintzberg (1993) characterized by mutual adjustment (MA). 5, 95, 128, 158–161, 283, 293, see MA

**Advisory Committee** At-Large Advisory Committee (ALAC), Governmental Advisory Committee (GAC), Root Server System Advisory Committee (RSSAC) and Security and Stability Advisory Committee (SSAC) are the Advisory Committees of ICANN. 139, 140, 156, 173, 174, see also ICANN

**Application Binary Interface (ABI)** A binary API, which implies low level dependencies meaningful at machine or operating system level, rather than API which can be service level. 272–274

**Application Programming Interface (API)** A software or firmware level specification for interfacing, or communicating, with a piece of software (which could be part of something larger or physical, such as a car or factory robot). 72, 107, 111, 272, 273, 318

**appointment of person (AP)** Concept I have added to the five coordination concepts in Mintzberg (1993), due to none of the original concepts fitting well with appointments as a coordination tool. 127, 154–156

**ARPANET** Precursor to the Internet created by DARPA in an effort to create a digital communications network based on packet switching rather than circuit switching (i.e. telephony). 58, see Internet & DARPA
**automation** A technical term for a process or procedure which is done without human assistance/interference. 21, 93, 104, 275

**Autonomous System (AS)** Routable network, part of the Internet. Technical name for what in practice usually is an Internet Service Provider (ISP), but could theoretically be anyone with a network routable from the Internet. 4, 43, 44, 61, 69, 76, 78, 143, 145, 146, 193, 203, 204, 206, 208–219, 236, 245, 282, see numbering, IANA & BGP

**Autonomous System Number (ASN)** A unique number given to each Autonomous System, is used for routing purposes. An Autonomous System can announce several prefixes, and a prefix can be announced from several ASs. 59, 65, 143, 145, 204, 211–213, 302, see routing, IANA & BGP

**BASEL** A framework for capital requirements for commercial banks. In comparison to banking regulation, the BASEL framework is not a multilateral treaty per se, but is rather incorporated into law in countries who want to follow the recommendation. In practice banks are required to follow BASEL to partake in international high finance. 288

**Best Current Practice (BCP)** Suggested best-practice documents from the IETF. The most debated BCP is BCP-38 which deals with best practices for stopping denial-of-service attacks (see Ferguson & Senie, 2000, for document). 8, 70, 136, 137, 154, 224, 236, 237, 253, see also IETF

**BGPsec** BGP with trust, similar to DNS and DNSSEC, see Request for Comments (RFC)-8205 (Lepinski & Sriram, 2017) for specification. In practice verifies announced AS-paths with cryptographic signatures to avoid announcing “made up” routes. 67, 79–81, see BGP & routing

**BIND** Originally an acronym for Berkeley Internet Name Domain, BIND has become the most spread DNS software in use, it is even standard on Unix-like (i.e. BSD, Linux etc) operating systems. Technically BIND can act both as an authoritative DNS-server (i.e. a name server for a specific domain only) and a recursive resolver (i.e. resolved all DNS-requests). The ISC develops the core functionality of BIND, although there are spin-off projects, such as Bundy. 146, 147, 179–181, 185, 186, see also ISC

**bitcoin** A blockchain-implementation for a digital asset with distributed trust, rather than trusted third parties such as banks. The implementation is described in greater detail in the original paper (see Nakamoto, 2008). 79, 80, 291, 297, see blockchain
blockchain The concept or technology of a distributed digital ledger/database. Should not be confused with implementations, such as bitcoin. 7, 13, 78–81, 101, 241, 282, 288, 292, 293, 316, see bitcoin

Border Gateway Protocol (BGP) In this thesis used as a collection of protocols for AS routing, see RFC-8212 (Mauch et al., 2017) for technical details of the main BGP protocol. In this thesis, unless otherwise noted, I use BGP broadly for both eBGP and iBGP protocols, as such I use BGP in the broadest of senses. This is an important distinction since in the technical sense BGP only refers to the implementation of one eBGP protocol, which just happens to be the only one in use and therefore is used quite sloppily as a term in industry. Responsible for giving network operators an idea of where to send packets, in effect responsible for making sure that the networks know how to try to get your packets to reach their destination, if possible. 4, 5, 27, 43, 51, 55, 56, 61–65, 67, 70, 77–81, 101, 143, 204, 239, 240, 263–265, 275, 282, 302, 303, see routing

brand top-level domain (bTLD) TLD used for branding purposes, includes examples such as dot-bmw, dot-google, dot-microsoft and dot-bloomberg. Different from sTLD in that bTLD can only be used by organizations belonging to a group (as an example only BMW companies can use the dot-bmw domain according to ICANN-policy). 65, see TLD

Content Delivery Network (CDN) Wholesaler of Internet content delivery services, in practice CDNs host most websites. 73, 151, 210–212, 244, see also ISP & IXP

coordination A management concept which has a slightly different flavor depending on thought collective and thought style, used in this thesis as that which decides what you actually do in a given situation (in essence in line with Mintzberg, 1993), as such historical events such as training and prior experience matter. This is a different conceptualization than texts such as Okhuysen and Bechky (2009) and Thompson (1967) which rather see coordination as (current) activities between interdependent tasks. 3, 4, 6–17, 21, 28, 30, 32, 34–36, 45, 46, 50–52, 58, 61, 68, 72, 73, 80, 83, 84, 92–96, 98, 99, 104, 107, 109, 112–114, 116–120, 123, 125, 127, 128, 130, 133–136, 139, 141, 147, 148, 150, 151, 153, 154, 156, 158–161, 186, 191, 195, 200, 221, 222, 225, 227, 231, 236, 237, 242, 245, 248, 252, 257–261, 264, 274, 275, 281, 282, 284, 288–295, 297, 299–305, 307–318, see also governance

country code top-level domain (ccTLD) Highest level domains in DNS, given to registries representing countries. In many cases non-profits but also national regulatory authorities have the role (ex Zimbabwe). 53,
dark net A mystical fairy place with unicorns and rainbows. Or not, it is the concept of a virtual network run on-top of the Internet, often connected to the TOR-network and the dot-onion TLD. In essence a different Internet, where you instead of an ISP need the right client to connect. Sometimes referred to as the “dark web”, but (obviously) the “dark web” is a service running on top of the dark net. There are many implementations of dark nets, and the most well known one is the TOR-network, 7, see also Internet.

Defence Advanced Research Projects Agency (DARPA) US federal agency tasked with advanced and to some extent speculative research, 58, see ARPANET.

direct supervision (DS) Concept in Mintzberg (1993) to describe a regime were a direct supervisor is in charge of deciding what gets done, 92, 127, 128, 154, 155, 158, 159.

distributed denial of service (DDoS) Several hosts on the Internet collaborating to deny one or several hosts. A common approach today is to spoof source IP-address of the target and send request to web-caches which in turn flood the intended target with IP packets, 70, 236, see also IP.

distributed perspective A perspective with the notion that power regarding the Internet should be separated or distributed. The notion of coordination is bottom-up, and explicitly not part of sovereign regulatory frameworks. Conforms with many of the notions of a bottom-up governed Internet. Both separation of concerns and layer violation follow from this perspective. Constructed from Internet perspective to work in a broader setting. Can in general be said to optimize for minimum impact of (unavoidable) change, 10, 13–16, 117, 235, 249, 257–260, 262–264, 266–269, 271, 274–279, 281, 283–288, 291, 293, 295–298, 301, 303–305, 308, 310, 312, 313, 315–318, see also integrative perspective.

Domain Name System (DNS) A set of protocols and standards for resolving domain names. In practice converting a human readable name to a routable number such as an IP-address, but can be used for storing meta-data as well. Technically similar to DOA but different in a coordination and governance perspective, 5–7, 26, 38, 42, 51, 55, 56, 60, 62–67, 69, 70, 78–80, 101, 110, 120, 139, 146, 147, 158, 165, 168, 179–181, 184, 185, 187, 191, 192, 204, 206–208, 210, 217, 222, 234, 237–241, 260–262, 264, 266, 282, 302, 309, see IANA.
Domain Name System Security Extensions (DNSSEC) A version of DNS which supports cryptographic verification of responses, in essence the ability to verify the truth of the answers. 38, 42, 63, 64, 67, 79, 166, 180, 309, see DNS & IANA

Dynamic Host Configuration Protocol (DHCP) A protocol for configuring stateful hosts, common on IPv4 networks, and is supported but not recommended on IPv6 networks. 71, 72, see IP

domain A semi-technical term to describe the edge of the Internet or more correctly the edge of an Autonomous System. A normal Internet user is at the edge of the Internet, in a general sense only routing equipment is not at the edge of an AS (this is not fully technically correct, but is a useful description). There are certain functions which are only meaningful at the edge, such as filtering on source IP-address. 4, 42, 45, 68, 89, 146, 154, 167, 209, 223, 226, 233, 236, 238, 253, 260, 262, 263, see Internet

Electronic Frontier Foundation (EFF) Defined by their mantra “Defending your rights in a digital world” and organized as a non-profit. Does political work, i.e. they are not neutral in issues of the Internet, such as net neutrality, and for avoidance of doubt the EFF is on the side of distributed perspective in my conceptualization of distributed perspective vs integrative perspective. 35, 57, 233

Empowered Community (EC) An ICANN-structure tasked with, among others, electing the ICANN-board. Consists of ASO, ccNSO, GNSO, ALAC and GAC. In effect all Supporting Organizations and Advisory Committees except RSSAC and SSAC. 35, 139–142, 148, 155, 157, 161, 167, 172–176, 184, 185, 245–247, 259, 260, 303, see ICANN

epistemic community A group or community, such as a thought collective, with the intention of influencing the current regime or order. This thesis is using the conceptualization in Adler and Haas (1992) and Haas (1992), 2, 6, 7, 52, 56, 57, 87, 125, 142, 153, 157, 232, 233, 237, 241, 243, 247, 255, 267, 276, 283, 288, 292, 294, 295, 297, 302, 304, 305, 313, 314, see also thought collective

European Market Infrastructure Regulation (EMIR) An EU-level directive to regulate OTC-derivatives. Includes but is not limited to trading with interest rates and foreign exchange instruments. 288

European Union (EU) A membership organization where most members are European nation-states. 122, 154, 248, 266, see UN
Glossary

Fully Qualified Domain Name (FQDN) A Fully Qualified Domain Name (FQDN) is a full domain name, often with the trailing dot, in comparison to non-full domain names, such as only a host name. For example, www.google.com is a FQDN, while www.google is not. Technically very important to distinguish FQDNs from other domain names when configuring Domain Name System (DNS). 181

General Data Protection Regulation (GDPR) An EU-level treaty with regards to handling of personal information. Which includes all information pertaining to an individual in any sense, including but not limited to email-addresses, and also stipulates issues such as the “right to be forgotten”. 206, 282

generic top-level domain (gTLD) Highest level domains in DNS used for, in essence, all purposes except those related to ccTLDs. 65, 69, 139, 141–143, 148, 157–159, 247, see TLD

governance The formal top-down component of coordination in this thesis, in other thought collectives could describe the entirety of somethings governance. 3, 9, 12, 16, 27, 34, 52, 53, 72, 80, 84, 153, 161, 168, 169, 185, 187, 192, 200, 224, 260, 305, 308, 331, see also coordination

Hypertext Transfer Protocol (HTTP) A simple protocol made for transferring (hyper-)text over the Internet. A large part of the web is based on HTTP. 43, 67, 70, 239, 240, see web

Hypertext Transfer Protocol Secure (HTTPS) An extension of HTTP adding an encrypted layer, today mostly TLS version 1.2 or later and previously often SSL (today insecure). 67, 70, 309, see HTTP

IETF Administrative Oversight Committee (IAOC) Oversight committee for the IETF. Defined in RFC-4071 (Austein & Wijnen, 2005). Mentioned in documents but never mentioned in interviews. 178, see IETF

incommensurable In Fleck (1935) used to describe the non-matching of different thought collective and therefore their inability to agree on what is scientific fact and what is not. 23, 35, 195, 223, 297, see also thought collective

information technology (IT) Used broadly in this thesis for technology related to handling of or coordination of information in different forms. Often implies software and organization. Should not be confused with the IT-artifact in sociomateriality, which is a quite narrow construct. 84, 101, 102, 281–285, see technology
infrastructure and network operator  Broad descriptive terms of all actors involved in actual Internet function at a network level. Includes but is not limited to both of Internet Exchange Points (IXP) and Internet Service Providers (ISP). 14, 76, 85, 89, 147, 148, 153, 168, 172, 179, 181, 182, 199, 200, 226, 235–238, 244–246, 249, 262, 266, 277, 285, 303, 311, 313, 317, see IXP & ISP

integration of concerns  A general notion that concerns should be integrated. Examples cable-TV, where one service provider is in charge of infrastructure, data delivery and content availability. 104, 105, 108, 112, 248, 285, 288, 318, see integrative perspective, see also separation of concerns

integrative perspective  A notion comparable to traditional telecommunication networks with almost absolute vertical integration as was the case with the telegraph. Based on business logic and contracts, and often focuses on profit or revenue optimization, in contrast to the distributed perspective which focuses on optimizing for (unavoidable) change. 10, 14–16, 117, 235, 253, 257, 258, 260–264, 266, 268, 269, 276–281, 283–289, 295–297, 304, 308, 310, 313–318, see also distributed perspective

International Telecommunications Union (ITU)  Currently an arm of the UN which focuses on technical telecommunications standardization across the globe. Membership organization where states are members. Has a slightly different membership than the UN due to political issues, but in essence has the same members as the UN (at the time of writing the Vatican is a member of the ITU while Taiwan is not). 2, 50, 51, 57, 61, 87, 132, 133, 136, 144, 145, 148, 151, 156, 157, 161, 165, 166, 183–187, 191, 192, 221, 222, 237, 239, 241–244, 247, 254, 258, 260, 262, 263, 286, 289, 293, 300, 303, 305, 313, 317, see ICANN & UN

Internet  The concept of a best-effort bottom-up coordinated digital network, formally defined in this thesis as a set of protocols for digital end-to-end communication affected by its users. As a best-effort network, protocols such as TLS are required to ensure secure communication, protocols such as TCP or UDP to manage delivery and so on. The core technical Internet (i.e. vanilla IP) does not guarantee delivery. In this thesis clearly set in the distributed perspective as that which is the least coordinated core of a digital communications network, often (in this thesis) in the umbrella of Least Common Internet. xvi, 1–17, 19–21, 24–26, 28–30, 32–47, 49–64, 66, 67, 69–78, 80, 83–85, 87–90, 94, 97, 99, 101, 104, 105, 113–116, 118–120, 122–128, 130–139, 141, 143–148, 150–154, 156–161, 163–169, 171, 172, 175–183, 185–187, 189, 191–208, 214, 215, 217, 220–229, 231–255, 257–269, 275–283, 285, 287–289, 291–305, 307–318, 321, 332, see edge, AS, IANA, Internet Standard, Internet Coordination & Least Common Internet
Glossary

Internet Architecture Board (IAB) Committee of the IETF who, in general, provides IESG oversight and IESG confirmation. 137, 142, 177–179, see IETF

Internet Assigned Numbers Authority (IANA) Administrative function tasked with maintaining core Internet-functions. In practice naming (i.e. DNS), numbering (i.e. IP-address delegation) and standards needed for naming and numbering. 14, 49, 59, 62, 65, 66, 68–70, 73, 133, 139–143, 145, 147, 148, 150, 153, 155, 157, 158, 165–168, 172, 175, 176, 183–185, 187, 191, 192, 195, 222, 235, 237, 238, 242, 245, 251, 263, 266, 285, 300, 303, 313, see ICANN

Internet Control Message Protocol (ICMP) The primary Internet control protocol, handles meta-tasks, such as notifying senders that their packets got lost, were dropped, fragmented etc. Together with IP and BGP forms the basis of routing, even though ICMP technically is built on-top of IP-functionality. 70, 223, 234, 239, 240

Internet Coordination The concept of coordinating the Internet. A preferable term to Internet Governance (as is argued in this thesis). 9, 12, 16, 20, 25, 30, 37, 41, 51, 53, 54, 56, 57, 67, 74, 90, 91, 118, 121, 123–126, 128, 136, 145, 147–149, 152, 153, 157, 160, 161, 163, 166, 168, 176, 193, 199, 221–226, 235, 236, 243, 244, 247, 248, 250, 251, 258, 267, 275, 276, 282, 286, 293, 300, 305, 308, 309, 311, 313, 318, 321, see Internet & Least Common Internet


Internet Engineering Steering Group (IESG) In practice the board of the IETF and editor of the RFC document stream. 70, 137, 172, 177–179, 236, 237, 239, 259, 260, see ISOC & IETF

**Internet Exchange Point (IXP)** Wholesaler of Internet peering services, practically where ISPs exchange traffic. 66, 67, 85, 123, 126, 146, 148, 151, 154–156, 161, 166, 168, 171, 172, 174, 181, 182, 204, 209, 235, 244, 245, 253, 303, 329, see also ISP

**Internet Governance** The notion of how the Internet is governed. Problematic in the sense that it can be understood to need a someone governing a something. Internet Coordination is the preferable term. 20, 34–36, 51–54, 122, 124–126, 128, 130, 131, 135, 136, 151, 153, 160, 161, 168, 200, 221, 223, 244, 308, 311, see Internet Coordination

**Internet Governance Forum (IGF)** Successor to WSIS from 2006, an annual UN supported forum for policy dialogue on Internet Governance. 52–54, 123, 145, 166, see UN

**Internet perspective** Opposite to telecom perspective, forms the grounding for the distributed perspective. 193, 206, 207, 214, 217, 220, see telecom perspective & distributed perspective

**Internet Protocol (IP)** The primary Internet protocol, in essence contains three things; sender-address, receiver-address and contents. Usually, but not always, contains a TCP or UDP packet with more information about session and order to ensure delivery. For avoidance of doubt, IP does not guarantee delivery in any way, and is best-effort. See RFC-791 (Postel, 1981a) and its amendments for technical details. 3, 4, 26, 42, 57, 62, 63, 66, 69–71, 73, 78, 104, 110, 130, 133, 137, 223, 224, 234, 236, 239, 240, 282, 289, 297, 302

**Internet Research Steering Group (IRSG)** The board of the IRTF, similar in constituents and functions as the IESG is to the IETF. 178, see ISOC & IETF

**Internet Research Task Force (IRTF)** Long term sister of IETF, while the IETF is supposed to focus on implementations and standards the IRTF is supposed to focus on long term research. 137, 177, 178, see IETF


**Internet Society (ISOC)** Prime member of the technical universe. Administrative seat of the IETF. 136–139, 148, 157, 172, 177–179, 185, 192, 242, 245, 246, see IETF & ICANN
Glossary

**Internet Standard** A standard of the Internet Engineering Task Force Request for Comments standards track, which is formally known as the “the Internet Standards track” which constitutes those Requests for Comments known as Internet Standards. 12, 17, 19, 70, 120, 136, 138, 147, 160, 227, 234, 236, 237, 239, 244, 245, 252, 258, 285, 286, 295, 296, 300, 302, 303, 305, 308–310

**Internet-of-Things (IoT)** The notion of automations using the Internet for communication. 54, 65, 165, 199, 220, 228, 253, 276, 280, see Internet & automation

**IPv4** Version number 4 of IP. Most used version today. 7, 69–72, 110, 160, 168, 177, 204, 220, 221, 234, 240, 302, see IP & IPv6

**IPv6** Version number 6 of IP. Less used than IPv4, but is an improved version in many aspects. Is less dependent on central network functions for address allocation and routing than IPv4. 69–72, 160, 168, 220, 221, 234, 240, 302, see IP & IPv4

**IT-artifact** A sociomateriality construct to represent technology, in this thesis not to be confused with IT. see 117, 276, 282, 284

**layer violation** The notion that one (abstraction) layer in a structure is affecting (abstraction) layers above or below it. 37, 50, 104, 243, 257, 267, 302, 303, 309, 318, see distributed perspective & separation of concerns

**Least Common Internet** The notion of the least common functionality of the Internet, i.e. the minimum of that which needs to be coordinated for the Internet to work. In this thesis used as the limit of that which is considered Internet Coordination, such as that not part of the Least Common Internet should not be coordinated by Internet Coordination processes, and should rather be coordinated elsewhere, such as standards for network security, intellectual property rights, and so forth. In this thesis the current Least Common Internet is naming and numbering, and protocols pertaining to those functions, such as IP, BGP and DNS, and the coordination required for those protocols and processes. 16, 70, 232, 235, 262, 264, 267, 276, 300, 304, 308, 310, 313, see Internet & Internet Coordination

**Least Developed Country (LDC)** An ITU and UN term for the least developed of the developing countries. Refers to those, in practice, with the worst infrastructure in terms of Internet, healthcare, road networks, public schools etc. 293
**make** A software process automation tool, i.e. a tool for following generation rules. In general is given a set of inputs and process descriptions, and from them generate outputs. Is typically used for compiling software projects in Linux / Unix environments. The Microsoft counterpart is known as *msbuild* and was recently made open source. This thesis is generated with the help of Makefiles and make. 10, 31, 93, 94, see Makefile

**Makefile** The file containing the descriptions for one or several make-processes. 10, 31, 94, 269, see make

**Management Control (MC)** The notion of controlling one or more entities through any means, such as culture, organization, incentives or similar. 51, 52, 97, 169, see MCS & MCP

**Management Control Package (MCP)** The sum of all MCSs in a given context. Includes intended and unintended control mechanisms. 51, see MC

**Management Control System (MCS)** A conscious set of MC-practices designed interdependently (Grabner & Moers, 2013). 51, 56, 87, 95, 96, 116, see MC

**Memorandum of Understanding (MoU)** Can be seen as a non-binding contract or a more formal alternative to something like a gentleman’s agreement. Commonly used by ICANN, IETF and others to avoid legally binding agreements. 55, 59, 143, 150

**mutual adjustment (MA)** Concept in Mintzberg (1993) to describe a regime what is done is decided by what can be said to be mutual agreements and consensus. 92, 103, 127, 128, 154–156, 158, 159, 161, 283

**naming** A overview term for handling the unique naming resources of the Internet, such as domain-names handles through DNS. Coordinated by the IANA-function. 13, 51, 52, 56, 59, 61, 62, 64–66, 68, 69, 78, 79, 119, 130, 139, 150, 153, 157, 160, 165, 167, 168, 181, 185, 186, 191, 192, 226, 234, 235, 237, 241, 246, 247, 252, 260, 264, 266, 303, 310, 311, 313, 316, 317, see DNS, see also numbering & IANA

**national regulatory authority** National authority for regulation of a specific area, for all intents and purposes national regulatory authorities will imply the telecommunications regulator. 2, 47, 129, 136, 160, 172, 184, 223, 226, 260, 312, 313

**National Security Agency (NSA)** An U.S. agency for national-level intelligence. Was secret when founded, and NSA was jokingly said to mean *No Such Agency*. Conducts information gathering via the Internet, among many other sources. 36, 46, 146, 264
National Telecommunications & Information Administration (NTIA) United states public entity formally residing within the Department of Commerce. ICANN previously operated under scrutiny of NTIA. 139, see ICANN

net neutrality Often the political side of the notion that network operators should not discriminate traffic. For the purpose of this thesis defined as traffic perceived as de facto treated according to agreed standard absent potential harm to networks or their users . xix, 4, 7, 10, 12, 16, 17, 28, 30–33, 35, 37, 38, 41, 46, 73, 76, 78, 89, 113, 119, 120, 146, 181, 182, 189, 191–194, 196–203, 206, 207, 214, 217, 220, 223–229, 235, 238, 248–252, 258, 259, 294, 304, 310–313, 316, 317, see Internet

Network Address Translation (NAT) A broad term for translating network addresses, common in routers to put multiple devices behind one public IP-address. Necessary for IPv4 to function due to address exhaustion, and IPv6 is designed not to need NAT (although you could use it, since you could NAT anything). 71, see routing

Nominating Committee (NomCom) A committee which suggests (and sometimes appoints) board members. Both ICANN and IETF have their own view of Nominating Committees. 173–175, 178, 179

Number Resource Organization (NRO) Coordinatory entity where the RIRs are constituents. 69, 141, 143, 167, 174, see ASO

numbering A term for the service provided by the IANA-function through RIRs in which IP-addresses and ASNs are distributed and coordinated, i.e. coordination of the unique numbers of the Internet. A requirement for routing. 13, 51, 61, 62, 65, 68, 69, 78, 139, 143, 153, 157, 165, 167, 168, 181, 226, 234, 235, 237, 246, 247, 252, 260, 266, 310, 311, 313, see routing, see also naming & IANA

Open Science An idea of separating science into six concerns which are individually accessible. Is using the following concerns: Open Data, Open Source, Open Methodology, Open Peer Review, Open Access and Open Education Resources see 276, 277

Payment Service Directive (PSD) An EU-level directive to regulate payment services in the EU-region. As quoted on the Wikipedia page on the topic:

The Directive’s purpose was to increase pan-European competition and participation in the payments industry also from non-banks, and to provide for a level playing field by harmonizing consumer protection and the rights and obligations for payment providers and users (Wikipedia Contributors, 2019b)
In effect a **distributed perspective** on the currently **integrative perspective** banking and payments sector. 288, 291, 293

**port** Used to further specify receiver of a packet, usually on the form IP:port, i.e. 123.45.67.89:443 where “443” is the port. Could be thought of as the IP-address being the apartment building address, and the port as being the apartment number. Ports are at an UDP and TCP-level, the IP-layer does not implement ports. 62, 69, 146, 153, 154, 222, see UDP, TCP & IP

**practical Byzantine fault tolerance (pBFT)** Consensus method which relies on consensus of miners without **Proof of Work (PoW)** or **Proof of Stake (PoS)**, and is by all means much faster than proof-based mechanism. 79, 80, 291, see blockchain

**Proof of Stake (PoS)** A **blockchain** consensus category, there are multiple actual implementations. Consensus is based on ownership of asset rather than dedicated computing power. 79, 80, see blockchain

**Proof of Work (PoW)** A **blockchain** resource intensive consensus category, there are multiple actual implementations. Is used by **bitcoin**. 79–81, 101, 291, see bitcoin & blockchain

**Public Interest Registry (PIR)** A registry for public interest domains, controls (among others) dot-org, dot-ngo and dot-ong. Finances ISOC. 138, 177, see ISOC

**Public Protection and Disaster Relief (PPDR)** An umbrella term for departments concerned with security, safety and defense. PPDR radio communications is a heavily debated topic, and there are legislative PPDR propositions which do not take height for the best effort nature of the Internet, i.e. regulations made on the ground that the Internet works differently than it actually does. 154, 182, 276

**Public Technical Identifiers (PTI)** Administrative and legal entity for the IANA-function. 65, 140, 222, see IANA & ICANN

**Regional Internet Registry (RIR)** An often non-profit entity coordinating IP-address and ASN allocation in a geographic region. xviii, 59, 60, 69, 141, 143, 145, 148, 155, 167, 173, 174, 178, see IANA & numbering

**Request for Comments (RFC)** The document stream managed by the IETF through the IESG. In an academic perspective **Requests for Comments** can be seen as manuscript suggestions which have to pass and be approved by an editorial board (the IESG). In essence **Requests for Comments** define all **Internet Standards** and processes related to the IETF. 8, 12, 19, 35, 55, 70, 71, 76, 110, 124, 130, 132, 133, 136–138,
root-zone  The technical name for the top zone managed by the IANA-function. In practice IANA prepares the root-zone-file which is distributed to root-zone name server operators who for all intents and purposes run the root-zones. 65, 78

routing  A technical term for sending traffic or packets the right way over the Internet. Is in practice dependent on the IANA-function for coordination of routing information (i.e. numbering) 5, 6, 13, 19, 34, 41, 43, 50, 56, 63, 64, 69, 70, 72, 76–78, 80, 119, 130, 143, 145, 168, 182, 193, 204, 207, 226, 234, 240, 260, 264, 266, 293, 316, see numbering, see also BGP, DNS, naming & IANA

Secure Sockets Layer (SSL)  A today outdated cryptographic protocol for communication security. Succeeded by TLS. 70, see TLS

separation of concerns  A general notion that concerns should be separated. Examples include technical in separating the business layer from the persistence layer (i.e. databases) in an application, or political in that the legislative power should be separated form the executive and the judicial power. 7, 13, 14, 37, 47, 103–106, 108, 111, 112, 234, 239, 247–249, 257, 258, 267, 269, 275, 277, 278, 281, 288, 297, 302–305, 308, 309, 317, 318, see distributed perspective & layer violation, see also integration of concerns

social construction  The notion of a “something” which is not very well definable objective reality, but is rather more meaningful to see as something constructed (in beliefs) through social means. Should not be confused with social construct, a higher level meta term (a social construction is very often an instance of a social construct). An organization might be considered a social construction in that the organization does not exist in the physical world as a physical thing, yet those in the organization agree that the organization exists. 22, 99, 100

sociomateriality  A concept coined in Orlikowski (1992) which aim to describe the duality technology in organizations. The social refers to social interactions and activities, whereas the material refers to more material aspects such as technology. The core argument of Orlikowski (1992) is that to understand technology in organizing a dialectical understanding is needed, i.e. one needs to understand the organization and the technology both from a perspective of objective reality and social construction. 55, 84, 94, 98, 99, 101, 222, see social construction
sponsored generic top-level domain (sTLD) TLD sponsored by an organization for a specific purpose, such as dot-coop, dot-xxx and dot-post. 65, see TLD

standardization of outputs (SO) Concept in Mintzberg (1993) to describe a regime where outputs are standardized. 92, 102, 103, 107, 111, 112, 127, 154, 156

standardization of skills (SS) Concept in Mintzberg (1993) to describe a regime were training and skills are standardized. 92, 111, 117, 127, 154, 158, 159, 283, 284

standardization of work process (SWP) Concept in Mintzberg (1993) to describe a regime work is standardized by its processes (rather than for example training or specifications of outputs. 92, 102, 111, 117, 127, 128, 154, 155, 159, 161, 283, 284

Supporting Organization Address Supporting Organization (ASO), Country Code Names Supporting Organization (ccNSO) and Generic Names Supporting Organization (GNSO) are the Supporting Organizations of ICANN. 139, 140, 148, 156, 173, 174, 337, see also ICANN

Swedish Internet Foundation (IIS) The current holder of the dot-se ccTLD, and is run as a private foundation working for the “positive development of the Internet”, although it is not specified what that entails. 148, 158

Technical Expert Group (TEG) Group consisting of ICANN-board, TLG and invited participants. Formal task: The TEG is focused on forward-looking technical and technological issues, particularly as those issues impact the use of the Internet’s system of unique identifiers that, in the view of TEG members, ICANN’s board and staff should take into consideration when considering ICANN’s strategies and operations. 142, see ICANN

Technical Liaison Group (TLG) Group of technical experts tasked with providing technical advice to the ICANN-board. 140, 142, see TEG & ICANN

technology In this thesis I use technology broadly to define the material aspects of the Internet. In essence I use technology and coordination in a similar fashion to how sociomateriality uses the social and the material. 3, 4, 7–10, 13–17, 21, 28, 46, 50, 52, 73, 76, 88, 93, 99, 102, 104, 113, 116–120, 157, 192, 220, 222, 235, 254, 257–260, 262, 272, 274, 276, 278–281, 288–294, 299–305, 307–311, 314, 316, see also coordination & sociomateriality
telecom perspective  Opposite to Internet perspective, forms the grounding for the integrative perspective. 194, 206, 207, 214, 217, 220, 223, see Internet perspective & integrative perspective

telecommunications company  A company which main business lies under the regulatory oversight of an national regulatory authority. Does not explicitly have anything to do with the Internet. In this thesis presented as existing within the integrative perspective, i.e. the opposite of the distributed perspective in terms of organizing digital communications. 41, 184, 202, 297, see national regulatory authority

thought collective  According to Fleck (1935), a collection of thought styles which together agree on issues such as how to create scientific fact. Fleck (1935) uses it to explain scientific communities and the incommensurable. 6–8, 10, 13, 21–24, 27–31, 34, 52, 53, 56, 57, 74, 83, 84, 87, 93, 94, 117, 118, 168, 191, 193–195, 224, 228, 242, 247, 255, 281, 305, 309, 315, 316, see also thought style

thought style  According to Fleck (1935), a person’s way of making sense of reality and everything in it. 20, 21, 26, 73, 194, 195, 200, 207, 303, 315, see also thought collective

top-level domain (TLD)  Highest level domains in DNS, and are broadly categorized into three types (available in the root-zone); ccTLDs (such as .se and .de), gTLDs (such as .com or .org) and infrastructure domains (i.e. .arpa). 63, 65, 69, 78, 157, 158, 167, 175, 181, 191, 237, see TLD, see also naming

Transmission Control Protocol (TCP)  High level protocol intended for use as a highly reliable host-to-host protocol between hosts in packet-switched computer communication networks, and in interconnected systems of such networks (Postel, 1981b).

Opposite to UDP, TCP provides mechanisms for ensuring packet delivery, as such it is common to use Transmission Control Protocol (TCP) over Internet Protocol (IP), written as TCP/IP, to add a layer with packet delivery mechanisms over the fire-and-forget IP. See RFC-793 (Postel, 1981b) and its amendments for technical details. 70, 104, 130, 234, 239, 240, 263, 289, see UDP & IP

Transport Layer Security (TLS)  A current cryptographic protocol for secure communication, at the time of writing version 1.2 and above are considered secure (enough) for most private and commercial needs. 70, 309, see SSL
Glossary


Universal Postal Union (UPU) Current an arm of the UN for postal system issues and standards. Was initially called the “General Postal Union” but renamed itself a couple of years after its founding in 1874 (the “Treaty of Bern”). 286–288, 290, see UN & ITU

User Datagram Protocol (UDP) High level best-effort (as IP) protocol, adds no major functionality to IP on its own except port-numbers. Commonly used as a fire-and-forget protocol.

This protocol provides a procedure for application programs to send messages to other programs with a minimum of protocol mechanism (Postel, 1980).

See RFC-768 (Postel, 1980) and its amendments for technical details. 69, 70, 130, 234, 239, 240, see TCP & IP

web Not to be confused with the Internet, the web is a service available on the Internet. The web has a similar relationship to the Internet as FedEx trucks have to roads, i.e. they are clearly connected but also clearly conceptually different. 6, 7, 33, 42, 43, 46, 50, 53, 62, 66–70, 77, 104, 110, 126, 130, 132, 134, 136, 152, 153, 161, 167, 189, 191, 192, 195, 214, 217, 226, 235, 244, 258, 267, 301, 313, 314, see also Internet

Working Group on Internet Governance (WGIG) A group closely related to WSIS tasked with defining Internet Governance and trying to find common grounds for Internet policy world-wide. 54, 61, see UN & IGF

World Summit on the Information Society (WSIS) Precursor to IGF, a UN supported discussion forum. 54, 61, 145, see UN & IGF

World Wide Web Consortium (W3C) A non-profit working on web-standards (i.e. explicitly not Internet Standards). 50, 52, 142, 235, see web
Acronyms

ABI Application Binary Interface 272–274, 323
AI artificial intelligence 13, 75, 76, 116, 315
ALAC At-Large Advisory Committee 87, 140, 141, 148, 156, 173–175
AP appointment of person 127, 154–156, 323
API Application Programming Interface 72, 107, 111, 272, 273, 318, 323
ASN Autonomous System Number 59, 65, 143, 145, 204, 211–213, 302, 324, 334, 335
ASO Address Supporting Organization 69, 139, 141, 143, 148, 155, 167, 173–175
BCP Best Current Practice 8, 70, 136, 137, 154, 224, 236, 237, 253, 324, 336
bTLD brand top-level domain 65, 325
ccNSO Country Code Names Supporting Organization 69, 139, 141, 142, 148, 155, 173–175
acronyms

ccTLD  country code top-level domain 53, 57, 59, 65, 69, 123, 126, 136, 139, 142, 148, 150, 155, 158, 159, 167, 171, 173, 174, 325, 328, 332, 337, 338

CDN  Content Delivery Network 73, 151, 210–212, 244, 325

DARPA  Defence Advanced Research Projects Agency 58, 323, 326

DDoS  distributed denial of service 70, 236, 326

DHCP  Dynamic Host Configuration Protocol 71, 72, 327


DNSSEC  Domain Name System Security Extensions 38, 42, 63, 64, 67, 79, 166, 180, 309, 324, 327

DOA  Digital Object Architecture 65, 184, 191, 192, 237, 241, 242, 253, 260

DOI  Digital Object Identifier 184

DONA  Digital Object Numbering Authority 165, 184, 185, 191, 192, 226, 228, 237, 241, 242, 253, 258, 260

DS  direct supervision 92, 127, 128, 154, 155, 158, 159, 326


EFF  Electronic Frontier Foundation 35, 57, 233, 327

EMIR  European Market Infrastructure Regulation 288, 327

EU  European Union 122, 154, 248, 266, 327

FQDN  Fully Qualified Domain Name 181, 328

GAC  Governmental Advisory Committee 140, 141, 148, 156, 173–175, 223

GDPR  General Data Protection Regulation 206, 282, 328

GNSO  Generic Names Supporting Organization 69, 139, 141, 142, 148, 155, 173–175

gTLD  generic top-level domain 65, 69, 139, 141–143, 148, 157–159, 247, 328, 338


Acronyms

HTTP  Hypertext Transfer Protocol 43, 67, 70, 239, 240, 328
HTTPS  Hypertext Transfer Protocol Secure 67, 70, 309, 328
IAB  Internet Architecture Board 137, 142, 177–179, 330
IAOC  IETF Administrative Oversight Committee 178, 328
ICMP  Internet Control Message Protocol 70, 223, 234, 239, 240, 330
IESG  Internet Engineering Steering Group 70, 137, 172, 177–179, 236, 237, 239, 259, 260, 330, 331, 335
IGF  Internet Governance Forum 52–54, 123, 145, 166, 331, 339
IIS  Swedish Internet Foundation 148, 158, 337
IoT  Internet-of-Things 54, 65, 165, 199, 220, 228, 253, 276, 280, 332
IRSG  Internet Research Steering Group 178, 331
IRTF  Internet Research Task Force 137, 177, 178, 331
ISC  Internet Systems Consortium 146, 147, 180
ISOC  Internet Society 136–139, 148, 157, 172, 177–179, 185, 192, 242, 245, 246, 330, 331, 335

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### Acronyms

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<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>IT</td>
<td>information technology</td>
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<tr>
<td>ITU PP</td>
<td>ITU Plenipotentiary</td>
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<td>IXP</td>
<td>Internet Exchange Point</td>
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<td>LDC</td>
<td>Least Developed Country</td>
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<td>MA</td>
<td>mutual adjustment</td>
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<td>MC</td>
<td>Management Control</td>
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<td>MCP</td>
<td>Management Control Package</td>
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<td>MCS</td>
<td>Management Control System</td>
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<tr>
<td>MoU</td>
<td>Memorandum of Understanding</td>
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<td>NAT</td>
<td>Network Address Translation</td>
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<td>NomCom</td>
<td>Nominating Committee</td>
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<td>NRO</td>
<td>Number Resource Organization</td>
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<td>NSA</td>
<td>National Security Agency</td>
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<td>NTIA</td>
<td>National Telecommunications &amp; Information Administration</td>
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<tr>
<td>pBFT</td>
<td>practical Byzantine fault tolerance</td>
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<td>PIR</td>
<td>Public Interest Registry</td>
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<tr>
<td>PoS</td>
<td>Proof of Stake</td>
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</table>
PoW  Proof of Work 79–81, 101, 291, 335

PPDR  Public Protection and Disaster Relief 154, 182, 276, 335

PSD  Payment Service Directive 288, 291, 293, 334

PTI  Public Technical Identifiers 65, 140, 222, 335


RIR  Regional Internet Registry 59, 60, 69, 141, 143, 145, 148, 155, 167, 173, 174, 178, 334, 335

RSSAC  Root Server System Advisory Committee 140, 141, 156, 173

SO  standardization of outputs 92, 102, 103, 107, 111, 112, 127, 154, 156, 337

SS  standardization of skills 92, 111, 117, 127, 154, 158, 283, 284, 337

SSAC  Security and Stability Advisory Committee 140, 141, 156, 173

SSL  Secure Sockets Layer 70, 328, 336, 338

sTLD  sponsored generic top-level domain 65, 325, 337

SWP  standardization of work process 92, 102, 111, 117, 127, 128, 154, 155, 159, 161, 283, 284, 337


TEG  Technical Expert Group 142, 337

TLD  top-level domain 63, 65, 69, 158, 167, 175, 181, 191, 237, 325, 326, 328, 337, 338

TLG  Technical Liaison Group 140, 142, 337

TLS  Transport Layer Security 70, 309, 328, 329, 336, 338

UDP  User Datagram Protocol 69, 70, 130, 234, 239, 240, 329, 331, 335, 338, 339

Acronyms

UPU  Universal Postal Union 286–288, 290, 339

W3C  World Wide Web Consortium 50, 52, 142, 235, 339


WGIG  Working Group on Internet Governance 54, 61, 339

WSIS  World Summit on the Information Society 54, 61, 145, 331, 339

xTLD  top-level domain 65, 78, 157


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THESES IN ECONOMIC INFORMATION SYSTEMS

DOCTORAL THESES


LICENTIATE THESES


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Coordinating the Internet

Images represent the Internet in 2000 (small) and 2019 (large)