Fredrik Lindeberg

Coordinating the Internet

Thought styles, technology and coordination

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Thought styles, technology and coordination

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Coordinating the Internet

Thought styles, technology and coordination

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The front image represents the Internet in 2000, and the larger image on the back represents the Internet in 2020. The difference in area corresponds to the difference in the size of the Internet. They are according to scale and are generated from announced prefixes and autonomous systems, see Section 2.8 (page 44).

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The significant problems we face cannot be solved by
the same level of thinking that created them.

—Albert Einstein

This is paraphrased from an appeal sent by Albert Einstein, and colleagues, to call for a new way of thinking to solve already existing problems in a new world. Part of the original quote says “to let the people know that a new type of thinking is essential if mankind is to survive and move toward higher levels” in the context of post-war thinking.

At this point, I do not know which of the atomic bomb or the Internet will shape the future of humanity the most. On the one hand, the atomic bomb allows for almost limitless destruction. And on the other hand, the Internet allows technical, economic and social asymmetries at never before seen scale.

POPULÄRVETENSKAPLIG SAMMANFATTNING

När Internet nämns kan det handla om allt från att vara en drivande faktor bakom digitalisering till ett demokratiserande verktyg för samhällen till ett tekniskt nätverk. Dock är Internet som sådant ofta antaget snarare än väldefinierat eller konceptualiserat. Den här avhandlingen diskuterar och avhandlar Internet med hjälp av tre perspektiv, eller tankestilar, som benämns interoperabilitets-, byråkrati- och marknadsperspektiven. Avsikten är att ge en helhetsbild av Internet från flera perspektiv. I den här avhandlingen fångas Internet som fenomen skilt från tjänster ovanpå, som webben, då detta var det explicita syftet med Internets design.

En tankestil kan ses som en korg av värden som guidar eller leder ens tankar. Denna avhandling fokuserar på perspektiv på teknologi och koordinering från dessa tankestilar, och beskriver konflikt och samsyn mellan tankestilar snarare än mellan teknologi och koordinering.

Avhandlingen föreslår att Internet ursprungligen koordinerades av normer i det som jag kallar interoperabilitetstankestilen, vilken strävar efter interoperabilitet i termer av både teknologi och koordinering. Men i modern tid har normerna för det interoperatibla Internet, genom principer som att separera beroenden, blivit utmanade av marknadsintressen och byråkratier. Då centrala Internet-standarder är formulerade för att vara explicit öppna och tillåtande uppstår konflikt och missförstånd med marknadsaktörer som vill fånga värde och byråkratier som vill styra.

Den kommersiella logiken bakom marknadstankestilen förordar att man använder teknik för eget vinstintresse, exempelvis genom att skapa inläsningseffekter eller marknadsbarriärer. Detta går stick i stäv med interoperabilitetstankestilen där målet är teknik som tillåter snarare än begränsar.

Avhandlingen illustrerar konflikter kring både vad Internet *är*, och vad Internet *borde vara*. Dessa konflikter illustreras med hjälp av tankestilarna, även fast de ibland ser så olika på saker att man inte kan enas om att man inte håller med varandra.

En sådan konflikt är nätneutralitet. Interoperabilitetsspektivet ser det som en nödvändighet att trafikens innehåll och själva nätverket är oberoende för interoperabilitetens skull vilken möjliggör framtida innovation och förändring. Det innebär i praktiken nätneutralitet, men inte genom lagstiftning eller direktiv; istället genom god design som ska tillåta gränslös innovation vid Internets kanter.

I samma riktning finns det en grundkonflikt mellan byråkratiperspektivets önskan om reglering och direktiv, och den öppna, tillåtande och interoperabla tanken i interoperabilitetsspektivet, då reglering berör begränsningar och sanktioner för att skydda snarare än tillåta. Liknande är kärnvärden i marknadstankestilen, som bundling, (artificiella) marknadsbarriärer, inläsningseffekter, i konflikt med den inbyggda öppenhet och tillåtenhet som finns i Internets design.

Överlag finns det två typer av marknadsaktörer som drar i olika riktning: de som erbjuder tjänster över Internet, och de som erbjuder Internet-access. De har liknande grundlogik, men olika mål, och reglering och tekniska standarder kan ge för- och nackdelar till dem båda.

Tankestilarna är inte begränsade till utbildning eller titel. Det finns byråkratiska ingenjörer som föredrar regelstyrning över implementation, och det finns byråkrater som föredrar interoperabilitet över regelverk.

Avhandlingen föreslår att Internet kan konceptualiseras som *en arkitektur och uppsättning protokoll för best-effort digital end-to-end kommunikation som kan utförs av användare genom ad-hokratiska processer baserat på interoperabilitetsideal*. Konceptualiseringen är baserat på det Internet jag har fångat. Grunden består av de interoperabla ideal som byggdes in från början, men som idag är utsatta för andra ideal som påverkar hur Internet utvecklas. Överlag är Internet på väg att bli ett mer vertikalt integrerat nätverk med tydligare koordinering från vinstdrivande organisationer som fångar värde och byråkratier som ämnar reglera och kontrollera, vilket är en annan typ av nätverk än det explicit tillåtande och öppna.

Dessa konflikter och skillnader är fångade genom intervjuer, diskussioner, akademisk litteratur, styrdokument, stadgar, routing-data och faktisk internetanvändning.

Den här avhandlingen strävar också till att ge det framväxande forskningsfältet Internet coordination ramar att hållas sig inom, och föreslår sätt att möta komplexa situationer färgade av normer, värden, koordinering och teknologi.

ABSTRACT

The Internet is often mentioned as a driver for digitization or a democratizing tool for societies. However, the Internet is seldom explained, conceptualized or defined. This dissertation elaborates upon and conceptualizes the Internet through three lenses, or thought styles, referred to as the interoperability, the bureaucratic and the market thought styles in an effort to provide an overarching or holistic view of the concept that is the Internet. The Internet, as captured and conceptualized in this dissertation, is separate from services on top, such as the web, by explicit design for an interoperable network which decouples the use of the network from the network itself.

A thought style can be considered a set of guiding values or principles of one's thoughts. This dissertation focuses on different views of technology and coordination depending on thought style, that is conflicts and compatibilities between thought styles rather than conflicts and compatibilities between technology and coordination.

This dissertation proposes that the Internet was, and is to a lesser extent, primarily mediated through norms in what I denote the interoperability thought style, which aims and strives for interoperability of both technology and coordination. In modern times the norms of the interoperable Internet, through principles such as separation of concerns, are challenged by market actors striving for profits and bureaucracies wanting to subject the Internet to laws and regulations. As core Internet standards were formulated with explicit intention of open-endedness, the vertical integration native to value capture by market actors and control by bureaucracies provides an arena for conflict and misunderstanding.

In a sense, the purpose of the interoperability thought style is to limit path dependency, that is to keep all options open for as long as possible. This is contrary to market logic, where an actor might gain an advantage by shaping and therefore premeditating future market decisions.

There are discussions concerning both what the Internet *is*, and concerning what the Internet *should be*. This dissertation illustrates these issues through thought styles, even if the thought styles sometimes are so far apart it is impossible to find compatible common ground for agreement or disagreement.

Net neutrality is an example of such an issue. Seen from the core values of the interoperability thought style, traffic differentiation based on traffic content is not permitted, since traffic content by design should be separated from the implementation of the network to provide interoperability and separation of concerns. This in practice implies net neutrality, but not through regulation or policy, but instead by technical design to ensure open-endedness and permissionless innovation at the edges of the Internet.

In addition, the concept of regulation is in conflict with the interoperability thought style, as regulation aims to control or forbid behavior, whereas the interoperability perspective strives to allow and permit behavior. This is in conflict with the principles of the bureaucratic thought style where regulation is one of the means through which to attain a want. Similarly, core values of the market thought style, such as bundling, market barriers and lock-in effects are in stark conflict with the embedded open-endedness of the Internet and the Internet's architecture.

In particular there are two separate groups of actors with a primary market perspective: the actors selling services on the Internet, and the actors selling Internet-service. Their

logics are similar, but their goals different, and regulation and technical standards could provide an advantage to either of the two types of for-profit actors.

It is important to note that these thought styles are not tied to education or work title. As an example, an engineer can be bureaucratic by preferring consolidating and integrative design for control. Or a manager might be interoperability minded by avoiding a business decision because it would have led to technical lock-in down the line.

This thesis suggests that the Internet today can be conceptualized as *an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhoc processes based on ideals of design for interoperability*. This conceptualization is primarily grounded in the interoperability perspective; however, notions of the bureaucratic and market perspectives are becoming prevalent, particularly in actual and future coordination of the Internet. The Internet is currently in a slow transformation towards a more vertically integrated network coordinated by value capture and regulation; this is different from a network where all components explicitly are decoupled to as large extent as possible.

These perspectives with their compatibilities and conflicts are captured through interviews, discussions, reading of academic literature, bylaws, standards, routing data and exploration of Internet use.

This dissertation also intends to be an introduction to the nascent field of Internet coordination and suggests, through examples, relevant approaches to capture multifaceted arenas colored by norms, values, coordination, and technology.

Preface

In Digitisation and Management, our main focus is where management and IT meet, not least the new, fast-growing, IT-intense 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 — Thought styles, technology and coordination*, is written by Fredrik Lindeberg. He presents it as his doctoral thesis in Industrial Engineering and Management with specialisation in Digitisation and Management at the Department of Management and Engineering, Linköping University.

Saltsjöbaden in May 2021

Alf Westelius
Professor
Digitisation and Management

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Erik, my co-supervisor at Chalmers, thank you for convincing me to finish this thesis when I was quite tired after defending my licentiate-thesis.

Alf, my main supervisor at LiU, who supported me through this entire process, and never shied away from the mess of the Internet and Internet Coordination as a research topic.

And also everyone at the Division of Industrial Management, INDEK, with a special thanks to the diligent fika-group: Martin, Harald, Daniel, and Per. We could disagree on topics due to our different thought styles, such as the purpose of firms and organizations, or the effects of technology, but we always had interesting topics to discuss.

University management, faculty management and student unions; putting PhD students back on the agenda has been interesting but tough. 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.

MIT, the Swedish School of Management and IT, for providing interesting and meaningful PhD courses (not an easy feat) and two occasions per year for me to get feedback on research and texts. In particular, thanks Daniel, Christian, Edward, and Jason for helping me keep the local pubs in business before the pandemic hit!

And finally, I would like to thank the Swedish Internet Foundation for the funding to finish this thesis. In particular Danny and Anne-Marie welcoming me and helping me with hard to reach contacts.

Linköping, May 2021
Fredrik Lindeberg

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1 Introduction

*The principle of constant change is perhaps the only
principle of the Internet that should survive indefinitely.*
— RFC-1958, Carpenter, 1996, p. 1

1.1 The Internet

This thesis discusses and problematizes the [Internet](#)¹. Now, what *is* the Internet? And *who* controls it? *Who* can decide *what* the Internet is? Or is it out of control, *intentionally*?

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 organizations, society, and Internet coordination itself.

Some argue that the Internet is a collection of technical standards or protocols for digital communication, often in need of governance, but the Internet is more than that. I make the case that the Internet is an idea of a network controlled by Everyone, which means that No-one rather than Someone is in

¹This is a linked term, see Section 1.2 for how to return after clicking on a link.

charge. Explicitly not Someone as in the case of many formal governance situations, such as national policy.

I argue that the Internet can be conceptualized as (in the shortest possible form): “*an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhocratic processes based on ideals of design for interoperability*”, where “its users” can be seen as Everyone interested. This means users here include private individuals, firms, lobbying-groups, non-profits, state-level actors, and so forth, and not one single well-defined category of actors. I use the term user, instead of, for example, stakeholder to illustrate the informal nature of potentially interested actors.

The **epistemic communities**, the most active core of a collective with a coherent view on an issue such as the Internet, set their own agendas and lobby onto themselves. 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)**, **nation-states**, 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 flat visualization of the technical Internet in Figure 1.1. It depicts the 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.

The figure, Figure 1.1, represents a **Border Gateway Protocol (BGP)**-topology view of the Internet; it thus includes all involved **Autonomous Systems (ASs)**, such as **Internet Service Providers (ISPs)**, **infrastructure and network operators** and other entities, such as private individuals who have their own AS, and the **prefixes** they announce. In a sense, this is a very high-level technical image of the Internet. The topology does not represent the physical cables in the ground or electromagnetic waves in the air, but the Internet as seen from a **routing** perspective, such as an ISP deciding how to route a particular packet.

Figure 1.1 contains over a million different BGP relevant entities, of which most are announced prefixes. Section 3.7 delves further into the details of the figure and Section 2.8 describes the method for the figure generation.

1.2 Reader service

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 295 for glossary and page 313 for acronyms). When

Figure 1.1: An illustration of the Internet in 2020

Illustrated as a BGP-topology which contains ASs and prefixes. Central well-connected ASs and prefixes are dark blue, and turn green towards white for the lesser connected prefixes and ASs. The image is flat and is not correlated to the geography of the Earth.

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. In the printed version all terms are black.

Before clicking on the examples in the next paragraph, familiarize yourself with the back- and forward-buttons in your PDF-reader (on macOS probably `cmd`+`[` and `cmd`+`]` (i.e., `cmd`+`Alt`+`8` etc on most non-English keyboards), and on Windows `Alt`+`←` and `Alt`+`→`).

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).

This section is present in the printed version as well to ensure that the printed version and the electronic archive PDF have the same page numbers.

1.3 Research questions

This thesis uses broadly stated research questions, which are answered in a combination of **thought styles** (see Cowhey, 1990; Fleck, 1935/1979; Haas, 1992 for the thought style and related concepts.), with the notion that the descriptions are more accurate with a good balance of vantage points (the **interoperability**, **bureaucratic** and **market** thought styles) and coordination levels (here **implementation of technology**, **standards formulation**, **coordination of technology**, and **meta-coordination**).

I use the thought styles to illustrate different perspectives of the Internet. The thought styles are analytical constructs, and do not per se exist, and are designed to illustrate the width of values captured in this thesis, rather than the nuanced thoughts of any one individual.

The overarching question of “what is the Internet?” is answered last, after which I go through the thought styles and their view the Internet and the actual **coordination** I find in relation to the intended actions of the active bearers of thought styles. In terms of process I have looked for compromises, misunderstanding, agreement and conflict. This thesis, however, illustrates particular instances of misunderstanding and conflict between the **interoperability**, **bureaucratic** and **market** thought styles, rather than the agreement of the thought styles.

Research Question I

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

I contribute to the notion of digital communication networks and services by synthesizing three perspectives, thought styles, on digital communications networks. The Internet is the empirical focus of these thought styles.

I suggest three thought styles, in some aspects disparate, with their values and ideals, that shape alternative guidelines and rules for designing and coordinating digital communications networks and services. These thought styles I call the **interoperability thought style** (Δ , represented by a delta-symbol for change), the **bureaucratic thought style** (, represented by a symbol for an institution) and the **market thought style** ($\$$, represented by a dollar-sign for value capture), and they follow different logics, principles, and values in terms of implementation of technology (T), standards formulation (S), coordination of technology (C), and meta-coordination (M). In this thesis the thought styles are explored in the context of the Internet.

The interoperability thought style is characterized by interoperability and planning and preparing for possible change. The bureaucratic thought style is characterized by notions of regulability and legitimate control, and the institutions, constituency and agreements needed for rule based sanctions. The market thought style concerns value-capture and optimization, both optimization in monetary terms and in technical terms.

Each of Chapters 3 to 5 is based on one of interoperability, bureaucratic and market thought styles. I elaborate more on the differences between them in Chapter 6, and their practical consequences in Chapters 7 to 10, and summarize them in Chapter 11.

Research Question II

How is the Internet, as conceptualized here, coordinated?

There is disagreement, in the academic setting, of both what the Internet is, what the Internet should be, and how the Internet is coordinated. Existing literature (for example DeNardis and Raymond, 2013; Liu, 1999; van Eeten and 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, or rather top-down control such as regulation. By using an ecology-view of the Internet actors and technical understanding (which, for example, de Reuver et al., 2017; Hanseth and Lyytinen, 2010 do not explicitly dig into) I present a more nuanced view of the technology and coordination which constitutes the Internet from the thought styles.

The coordination of the Internet is described with the help of the thought styles. In particular this thesis adds nuance to the issue of governing or coordinating services on-top of the Internet contra the notion of coordinating the Internet itself. In particular, an interoperability thought style view of the Internet implies that the services on top-of the Internet are decoupled from the Internet itself. However, this view is conflicted by the bureaucratic and market thought styles in which control of infrastructure should imply control of services on-top.

One purpose of this research direction is to highlight phenomena missed if approaching the Internet from a high-level consumer or customer perspective; the Internet is not only coordinated by large institutional actors but also by individuals who contribute to Internet Engineering Task Force (IETF) processes or run their own authoritative Domain Name System (DNS) servers.

I set out to find out what the coordination of the Internet is, by interviews and reading policy, statutes, bylaws and similar documents with regard to the Internet and telecommunications. This overview is in Chapter 7. Chapter 8 suggests one perspective of Internet Coordination and Chapter 9 goes deeper into the social questions of this coordination (primarily from a social resilience point of view). Chapter 11 summarizes my answer to the research question.

Research Question III

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

The Internet is typically conceptualized or described in terms of its technical infrastructure and the means for transmitting information across this infrastructure (cf. DeNardis, 2012, 2020; Liu, 1999; Raymond, 2013; van Eeten and Mueller, 2012). Often these conceptualizations use the umbrella term of **Internet Governance**, but not always. 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”, rather than governance, 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 leads me to address this shortcoming by proposing a description of the Internet which combines the coordination and technology dimensions into one cohesive conceptualization. This cohesive conceptualization is important because the technical implementation of the Internet influences and depends on how the Internet is coordinated.

Compared with the infrastructure perspective of the Internet that I develop, texts such as Hanseth and Lyytinen (2010), DeNardis and Raymond (2013) and Liu (1999) describe a vertically integrated Internet where services naturally are bundled with the infrastructure itself, and concerns such as cyber-security.

Chapter 8 summarizes the discussion conceptually, and Chapter 11 summarizes my answer to the research question.

Research aims

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.

The thesis is intended to provide enough depth for a policy-maker, a non-profit **Internet Exchange Point (IXP)** engineer, or a product manager at a cloud firm, to understand the values and principles of the other perspectives, or thought styles, of the Internet.

My intention is to not get caught in minutiae of protocol specifications or bylaw wording, and rather go for the greater scope and values 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) here refers to the larger issue of whether the software did the right thing when all developers are *de facto* stuck in details. I aim to contribute to the larger scope of Internet Coordination, and in particular discussions and dialogue between actors who today do not fully understand each other. This lack of understanding is often based on different assumptions of what the Internet is, and what the purpose of the Internet is.

This thesis also suggests that the Internet can be seen as a platform or infrastructure viewed from a societal perspective, rather than a product. The Internet as a platform or the Internet as a product or service is a core conflict explored in this thesis.

As a platform the Internet is comparable to money, road infrastructure, postal systems, and similar (see, for example, de Reuver et al., 2017; Kaartemo and Nyström, 2021; Shapiro and Varian, 1998 for discussions of technology and as platforms rather than products for society). Seen as a product from a market actor, the Internet is comparable to cable-TV, or any other quite unregulated product or service on a market (see, for example, Choi et al., 2015; Choi and Kim, 2010; Economides and Tåg, 2012; Huber, 1987 on how markets for products or services behave).

1.4 Approach

My approach in this thesis started with interaction with practitioners in the Internet sphere as the initial frame. The empirical chapters (i.e., Chapters 7 to 10) are driven, or rather initiated, by semi-structured interviews. I have followed what the Internet is seen as by different actors, rather than looking at what I think is the Internet.

I followed what the actors I engaged with thought was the Internet, or what they wanted the Internet to be, rather than what I assumed the Internet to be prior to this research process.

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. The original research direction “the Internet” span off into two directions, looking for actors in an ecology and, me being a computer science engineer, getting familiar with the technical nature of the Internet. These built on the initial question “what is the Internet, really?”. In short,

I discovered that the Internet is primarily described by three thought styles that I term the interoperability, bureaucratic and market thought styles.

These thought styles discuss technology and coordination. The components are further distilled down to implementation of technology, standards formulation, coordination of technology, and meta-coordination in Chapter 6.

After that I set out to frame actual use based on my understanding of the Internet, and found that the technical aspects of the Internet matter explicitly for actual use, while the coordination of the Internet is implicit in that it formulates and suggests the **Internet Standards** which in turn become the technical Internet. This is described in Chapters 7 and 8.

I also use academic literature as well as online information sources such as IETF **Requests for Comments (RFCs)** (of special importance are Internet Standards and **Best Current Practices (BCPs)** documents) and the bylaws of the **Internet Corporation for Assigned Names and Numbers (ICANN)**, which both remain relatively untouched in academic literature². This is interesting considering that some RFCs are specifically geared towards the coordination of the Internet, such as **Request for Comments (RFC)**-2028, *The Organizations Involved in the IETF Standards Process* (Hovey & Bradner, 1996) and RFC-2026, *The Internet Standards Process – Revision 3* (Bradner, 1996), which go through all organizations involved in Internet Coordination (according to IETF) and how they are intended to coordinate. Several scientific fields have their own take on the Internet, for example the field of policy and law: the Internet as unruly and non-functional because there is no traditional governance model or nation level oversight (see earlier model comparison and Mueller and Chango, 2008; WGIG, 2005 as examples of the Internet as being 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 policy and law approach to handle Internet Coordination (which I agree with).

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. This has given me the opportunity to use Internet “raw data” as well, such as website contents, **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.

²This surprised me. Several texts, including DeNardis (2020), discuss ICANN and the IETF as different formulations of “over-studied open systems”, but I cannot find literature analyzing the bylaws of ICANN (and the large rewrite in 2016), or the coordinating RFCs of the IETF. Note that the IETF essentially puts all documents in the RFC series, even the documents which would have been labeled “bylaws” or “statutes” in other organizations.

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** with thought styles (see Fleck, 1935/1979 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 , which was later shown inaccurate (due to instrument error).

The same is true for qualitative and other approaches as well, the contextual thought style 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 styles) of what scientific fact is. 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 style understanding, measured).

1.5 Results

On a conceptual level I further the argument that the Internet can be seen as a phenomenon consisting of both coordination³ and technology (technical) aspects by logically showing and explaining current and historic events. This duality of the Internet is not novel, but I go further into the values behind the notion of technology and coordination, and by doing that I can show that the larger conflicts of the Internet today are not conflicts between technology and coordination, but rather conflicts between the interoperability, bureaucratic and market thought styles. And in many cases, the bureaucratic and market thought styles can agree at a larger extent than the interoperability thought style can with the other.

I look at the evolvement of the Internet in relation to the interoperability (Δ), bureaucratic ( ) and market ($\$$) thought styles. I show that currently the Internet is de facto mediated by an increased pressure from bureaucratic and market thought styles logics, as illustrated in Figure 1.2 with the -symbol, logics which are likely to shape the future of the Internet.

In Figure 1.2 I use **separation of concerns** and **integration of concerns** to describe the provenance for separation (for separation into several distinct

³Or governance. The reason I studiously avoid governance as a term is that from an engineering thought style “governance” often implies (complete) control, such as technical control, and my intention is to ensure that the thesis is understandable by as many thought styles as possible.

problems in Dijkstra, 1982; Gamma et al., 1996) or integration (for vertical integration of value chains in Huber, 1987; Porter, 2008). Section 3.8 discusses separation of concerns and integration of concerns further.

Figure 1.2: The thought styles and the Internet

The figure illustrates the Internet and its proximity to the thought styles. The early dominance of interoperability thought style values and the over time entry of logics relating to value-capture on markets and control by bureaucracies. The interoperability (Δ), bureaucratic (🏢) and market (\$) thought styles are represented by their respective symbols. The 🌐-symbol illustrates the Internet as a combination of the values of implementation of technology, standards formulation, coordination of technology, and meta-coordination. The yellow fading circle around the 🌐-symbol is the area of the figure captured by the Internet conceptualization of this thesis. The horizontal axis illustrates the importance of integrating or separating concerns. This figure is further divided by its components in Section 8.1.

I use separation of concerns and integration of concerns as a continuum, rather than two distinct and discrete values. The leftmost part of the figure illustrate networks where matters should be decoupled. The rightmost part of the figures implies a digital communications infrastructure where integration is preferable, either for bureaucratic control purposes, or for market and value capture reasons (such as bundling or erecting barriers of entry). The middle

of the figure illustrates a set of networks not necessarily dominated by either integration or separation of concerns.

In general, concerns regarding the Internet have become integrated over time, both in terms of coordination and technology. For example, **QUIC** and **DNS over HTTPS (DoH)** / **DNS over TLS (DoT)** standards changes the market dynamics of the Internet in favor of a few larger actors. Comparably, **Revised Directive on Security of Network and Information Systems (NIS-2)** and similar directives ensures regulation of many Internet functions, which previously could be run by anyone, leading to that they now can only be operated by actors resource rich enough to comply with regulation, which hinders smaller organizations and private individuals to participate on even ground.

Net neutrality is one of the more nuanced issues, and is discussed in Chapter 10, where net neutrality as a practical reality can be seen as a consequence of design for change (Δ), where the concerns of the network should be decoupled from the concerns of one using the network. However, net neutrality regulation implies integration of concerns as the network and the use of the network then become dependent on the formulation of regulation. Similarly, net neutrality is problematic for a market thought style actor inside the network, since net neutrality hampers value-capture opportunities, while for the (large) **edge-actor**⁴ net neutrality can provide effective (cross-)subsidization of their throughput needs.

Figure 1.2 is illustrative rather than fully analytical, and it represents values and perspective I have captured in this thesis.

On a more general level, this thesis shows an example of an ecology which originally functioned quite well without a clear governor or leader under a separation of concerns design. This ecology applies “minimum coordination” by only coordinating unique identifiers and a minimal level of protocols for interoperability, which this thesis calls the *Least Common Internet*.

Organizational literature, for example Coase (1937), Cohen et al. (1972), and Mintzberg (1993), argue that the complexity of planning and decisions makes centralization of power difficult in larger organizations. More recent literature, such as Zammuto et al. (2007), note the lack of modern literature which manages to “marry” organizational science and IT, and Brynjolfsson et al. (2018, a follow-up of the productivity paradox), does not offer further guidance or change the notion that coordination complexity is an issue for large organizations.

Chapter 10 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 ideals.

⁴That is an actor not part of the Internet itself as delimited in this thesis.

1.6 Contribution of studies

In terms of building “new theory” this thesis goes in the direction of packaging already existing theories (and thought styles) together to make sense of events which otherwise are problematic to explain. The major contribution to theory-building is that we already know a lot about domain-specific settings and that to understand more we need to go wider (between thought styles) rather than deeper (within thought styles).

I am embarking on a voyage which many have considered, some have tried, and many considered impossible or a waste of time, for example “we explain why the quest for a single definition for *the Internet* is likely a fool’s errand” (Lehr et al., 2019, p. 1), however Lehr et al. (2019) goes on to suggest three lenses from which to understand the concept of the Internet. The lenses are: the abstract architectural ($\approx$ technology in this thesis), the network complementors ($\approx$ market thought style on the implementation of technology), and the customer experience (high level view of what the Internet can be used for by the customer).

I agree with the general sentiment of “fool’s errand” if the goal is to fully define the Internet from one vantage point. However, this thesis uses three thought styles, and aims to describe and conceptualize rather than define, in an effort to foster nuanced discussion.

DeNardis and Raymond (2013) suggests multistakeholder governance as a lens to capture the peculiar details of Internet Governance. Van Eeten and Mueller (2012) attempts to illustrate the problem of governance, or coordination as I use the terms, in Internet Governance, but does not suggest a practical solution, and rather states the problem that the formal institutions of the Internet are overstudied (also argued in, among others, DeNardis, 2020; DeNardis et al., 2020) and that the day-to-day activities are understudied.

The need to revise the concept of Internet governance is more than an academic problem. Governments, NGOs and other stakeholders often are misled by the assumption that Internet governance is what happens at the IGF. It is perhaps most visible in the fact that the range of issues stakeholders try to put on the agenda at the ICANN and IGF keeps expanding, notwithstanding the actual mandates of those institutions.

(van Eeten & Mueller, 2012, p. 732)

This thesis contributes by focusing on these understudied parts: the Internet itself in its daily interactions, and the values behind these interactions. I have had access to people from **root-zone** operators, **country code top-level domains (ccTLDs)**, Internet Exchange Points, **Internet Service Providers (ISPs)**, ICANN, **Internet Society (ISOC)**, the IETF, legislators, etc, through which I have captured the conflicts of values I illustrate with the interoperability, bureaucratic and market thought styles.

This thesis also contributes by illustrating, with the case of the Internet, that several current large conflicts are conflicts of thought styles rather than conflicts between technology and coordination. Or worded differently, the technology of the Internet was created according to the interoperability thought style with a minimum of coordination required (i.e., Least Common Internet), which inherently clashes with the need of control of the bureaucratic thought style, and the will to capture value of the market thought style.

1.7 Reading guide

If you are only going to read a few parts, I suggest you should read Chapter 8 which nuances the Internet as a concept.

The “frame of reference”-chapters are written so that a reader should focus on areas outside their primary discipline to understand other perspectives and viewpoints. That is, a well-read ideological, rather than market geared, engineer will not find Chapter 3 that interesting, since it aligns with engineering beliefs, and the engineer should probably read Chapter 4 on the bureaucratic thought style instead. And the same is true in other cases, a marketing scholar should focus on the interoperability thought style in Chapter 3 instead to grasp the notion of technology coordinated for a different purpose than value-capture or control.

Chapter 6 contrasts the thought styles and the levels of coordination which might provide a thought-provoking introduction to other ways of making sense of the Internet than your own.

A decorative element consisting of several thin, vertical black lines of varying heights, positioned to the left of the chapter title.

2

Method

*So the problem is not so much to see what nobody has
yet seen, as to think what nobody has yet thought
concerning that which everybody sees.*

— Arthur Schopenhauer

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 frames of reference are 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 in some sense).

The chapter is structured as follows. First I introduce myself and my beliefs, my positioning and my view of science. Second, I have a short discussion on the problems of scientific facts and processes and why I argue, that in this case, it is prudent to use logics from several scientific disciplines to capture the Internet. Third I go through my processes, both for gathering empirical data and for writing the thesis. The chapter ends with a reflection and revisit of my processes and results.

2.1 Background and agenda of the researcher

Writing a PhD-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 and your beliefs and assumptions.

Therefore, it is prudent to spend a page or two to introduce myself and how I (think that I) affected the process and potentially the results.

In essence this thesis is based on a wide set of empirical data; 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 Coordination** (or **Internet Governance** depending on perspective and assumptions held) sliding in on a banana peel. In essence, I was writing a course paper in management where I wanted to compare management systems, frameworks, and principles. I had the intention 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.

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 actually work and spin.

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 which I used to describe the (my?) world and the values that world is set in or by (i.e., my **thought style**, terminology from Fleck, 1935/1979). In my professional life I had worked as a systems engineer for a financial services company for a number of years. During that time I had participated in the transfer from using dedicated lines for financial services, in a time when most trade platforms required a dedicated line, to an era where it was possible to execute all forms of financial trades and send SWIFT-data over the Internet.

As an example, I have never when integrating platforms of any kind had to build special solutions due to issues which could be related to **net neutrality**. As a practical example I have had to package raw application data formatted for **Transmission Control Protocol (TCP)**-transport in SOAP over **Hypertext Transfer Protocol Secure (HTTPS)** to get through firewalls, **Secure Sockets Layer (SSL)** termination proxy policies and application logging frameworks, but they are all related to organization specific setups, not Internet infrastructure and routing policies.

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 practice, I was born and taught in the **interoperability thought style**, that is an idealistic engineer's perspective in some sense, and only in my Master' years got to the **bureaucratic** and **market** thought styles.

I also want to be explicit on that I set out to explain the Internet in a way that would be meaningful to most (curious) people with some interest in the Internet, I did not set out to explain the Internet specifically within the thought style of business studies, marketing or similar. In doing so, I want to bring in the technical understanding of the Internet which my background allows me to explore, and which I find missing in much of the literature coming from **bureaucratic** and **market** thought styles.

Armed with technical understanding and growing thoughts on management and coordination I set out to explain the Internet. I did the first interviews and visited the first conferences which contributed to this thesis in 2017, and I defended my licentiate thesis, which laid the groundwork for this PhD-thesis, in 2020¹.

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.

I do not believe in absolute objective creation of scientific fact as long as social processes are involved in the fact creation. I can appreciate the instrumentalist perspective 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 (1935/1979)² to a large extent captures how I see the world. In essence, your perspectives and facts are decided by implicit assumptions, which you have learned or picked up over time.

Both Fleck (1935/1979) and Kuhn (1962) promote similar ideas in different wraps. The much more known *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 and the norm for what is right changes. Kuhn (1962) avoids the concept of truth in a way Fleck (1935/1979) does not, and Fleck (1935/1979) merely uses it

¹The licentiate thesis is available as Lindeberg (2019).

²A short note is suitable here, Ludwik Fleck wrote the original work in 1935 in German and Polish, I have read and refer to the English translation published in 1979, ergo the citation Fleck (1935/1979). Thus, Fleck (1935/1979) is a precursor to Kuhn (1962) by several decades.

similarly to fact — a socially constructed 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”):

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.

My immediate environment, I would argue, is Fleckian and multidisciplinary, and the notion of absolute fact quite distant.

Going back to Fleck (1935/1979), 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 sometimes **incommensurable** between thought collectives and thought styles, i.e., also scientific fields. As my previous example states, for someone not in a physics thought collective the Newtonian laws might very well be fact. A main difference between Fleck (1935/1979) and Kuhn (1962), is that Fleck (1935/1979) does not assume that changes in thought style lead towards a “better” thought style whilst Kuhn (1962) assumes improvement with paradigm shifts (i.e., Fleck is not a stranger to the idea that science might devolve from some higher goal due to communal or social processes which value another set of values higher).

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. Or as Maslow put it:

I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail. (Maslow, 1966, p. 16)

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!”, 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.

To quickly touch on theory, Fleck (1935/1979) argues that theory is not reality in itself but rather ways to explain the world as seen by a thought style in a thought collective, much like facts but less dogmatic. This view 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 and its 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 to some sense digitization in general). I do this with the help of the levels **implementation of technology** (T), **standards formulation** (S), **coordination of technology** (C), and **meta-coordination** (M) and the interoperability (**Δ**), **bureaucratic** (**🏢**) and **market** (**💰**) thought styles.

I follow the belief in Fleck (1935/1979) and Kuhn (1962) that science is not only cumulative in its accumulation of fact and theory (and theorizing) — shifts in thought styles 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.

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?

Another aspect of science is its generalizability, the topic of 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 (1935/1979). 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 and Spens, 2005; Peirce, 1878) use of grounded theory (i.e., where empirics rather than theory lead the original inquiry). That is, I used both previous literature, 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 (even if *theorizing* is the most important part of *scientizing*³). I mean abductive in the sense of Kovács and Spens (2005) (i.e., “hypothesis” in Peirce, 1878), i.e., with focus on using intuition and creativity along with literature and empirical data, and go back and forth between literature and empirical data, to create new understanding or theory.

In terms of Peirce (1878), *rule* is the logic (if it rains, the grass gets wet), *case* is the context (there is grass, there is rain), and *result* the observation (the grass is wet). An abduction here implies that *rule* (if it rains, the grass is wet) and *result* (the grass is wet) implies the *case* (it is raining or has rained). Most probably, given the result that the grass is wet, there are several ways, or *rules*, in which the grass could become wet. This is the purpose of abduction, out of all the known *rules* in which the grass could become wet, which one is the best explanation in this particular case.

Or as encountered in philosophy of science contexts; abduction is “inference to the best explanation”. See Table 2.1 for an overview of inference paradigms as described in Peirce (1878).

Van de Ven (2016), an essay, describes the deduction and induction approaches as theory-driven and problem-driven research, and what the pitfalls of each are. Van de Ven (2016) notes that neither is inherently better, and describes ways of better grounding research problems.

³An old term essentially equivalent to “do science”.

Table 2.1: Modes of inference
 Traditional modes of inference as described in Peirce (1878). In the original text the term *hypothesis* was used instead of *abduction*.

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

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.

I had the belief that the process would become abductive before my first interviews and literature reading sessions. The Internet and the Internets coordination are inherently complicated, and conflicted matters, as such it was unlikely there would be good models in place (and I have yet found no model given credibility of explaining the Internet, ergo a deductive approach on its own seemed improbable), and similarly I realized that I on my own could not conduct enough empirical evidence gathering in a setting as large and diverse as Internet Coordination to motivate an inductive approach. As such I stumbled between literature and empirics, and confusion and clarity, looking for the best explanations I could find or come up with (the thought styles, given more nuance with the coordination levels).

I describe the process in more detail in Section 2.6.

2.3 Positioning

Being 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 solely 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).

One of the problems with Internet Coordination, or Internet Governance, as a scientific field is that there are no good delimitations, definitions or com-

mon frames of reference. As argued in DeNardis (2020), Internet Coordination draws on:

[...] fields as diverse as law, computer science, communication, science and technology studies, and political science. The rising stakes and increasing visibility of control struggles over Internet governance, as well as the coalescing and increasingly maturing of an interdisciplinary field that epistemically describes what it is doing as Internet governance research, present an important moment of opportunity for this volume. (DeNardis, 2020, p. 2)

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 or 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 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 did I know the norms keeping the network as such functioning.

A comment on terms used: the common term is Internet Governance, but I suggest to use Internet Coordination instead since Internet Governance might lead thoughts and assumptions to the notion that there is explicit governance or a governor in place. This is a normal interpretation of governance is business studies. However, more nuanced academic literature on Internet Governance is explicit on the fact that governance is not only about top-down control:

Governance is not only about governments. It is enacted via technical design, resource coordination, private ordering, and conflicts at control points. (DeNardis, 2020, p. 3)

The term “Internet governance” is, in some ways, an oxymoron. The power to control and govern the Internet is distributed among private industry, global institutions like ICANN and the IETF, and in some cases by civil society, as well as by governments.

[...]

Frankly, it is not yet a well-understood or much-analyzed framework of governance. (DeNardis, 2020, p. 7)

I have tried to write a text that carries meaning for a wider audience from different backgrounds and not only myself. It has been a long and arduous journey with many pages added to be later removed, and some then added back in again.

2.4 Motivation for using thought styles

This section aims to, briefly, explain reasons for using concepts and empirics commonly present in difference research traditions, such as interviews and inspecting raw **Border Gateway Protocol (BGP)** data, when investigating a phenomenon. Also important, is the notion that multiple thought styles 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 (1935/1979) as either a virus or bacterial infection, or as a punishment from God⁴.

First though, let us describe or define a few concepts. Fleck (1935/1979) uses the terms thought style (“Denkstil”) and thought collective (“Denkkollektiv”), where thought collective refers to a collective of persons mutually exchanging ideas or maintaining some form of intellectual interaction. The thought style is characteristic for that collective. Note though, that this interaction need not necessarily be explicit between all members of a thought collective, and that thought styles can be the result of schooling or training. For example, neither of the thought collectives of the **bureaucratic** and **market** thought styles consist of members who all know and talk to each other. These thought collectives (for the purposes of this thesis) rather refer to people with a similar thought style on the topic of the Internet.

Thought collectives and thought styles are also context or phenomena specific, and epoch or time specific. In this thesis I use the Internet as the phenomenon unless another phenomenon is explicitly mentioned. The is epoch modern times unless otherwise mentioned.

Fleck (1935/1979) further distinguishes members of sophisticated thought collectives into the esoteric and the exoteric circle, that is inner and outer members consisting of those forming the thought style and those following the thought style. In this thesis I avoid esoteric and exoteric circles as terms, and rather focus on the **epistemic community** of a thought collective, that is the active, or perhaps activist, part of a larger thought collective which aims to get their will through or recruit more members (as Adler and Haas, 1992; Haas, 1992 use that terms). The difference, as I see it, between esoteric circle and epistemic community, is one of action and visibility outside the thought collective itself, and as I intend to capture view and perspectives on the Internet I use the term epistemic community.

⁴Today the scientific community agrees fully that syphilis is caused by bacteria, but there may still be people in the world who ascribe to other explanations.

Cowhey (1990) describes the epistemic community, that is a part of a thought collective with an agenda to influence those in power to change something (in Cowhey, 1990, 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 community 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 (constituting an epistemic community) set the international agenda on important issues.

An epistemic community is by nature close to a thought collective, but as Haas (1992) points out, epistemic communities are set on influencing and changing something. Fleck (1935/1979) describes the thought collective as those who share a thought style, regardless of their intention of influencing events or others. In that manner, most epistemic communities are the active smaller part of a larger thought collective.

In this thesis I use epistemic community to describe the part of a thought collective which wants to change something to better match their understanding of the world, or those who try to “recruit” others to their thought collective.

I make the argument that to understand the Internet, an understanding of both **technology** and coordination is needed. For example, Section 3.6 makes the case of a technical only Internet as an unacceptable solution, and Section 6.5 argues that the Internet without fully understanding its technological constituency is likely problematic. In essence, I assumed that the Internet had to have both technology and coordination components, which I through an abductive process further distill to implementation of technology, standards formulation, coordination of technology, and meta-coordination. I also assume that there are different ways of understanding, or viewing, phenomena, and I use the theoretical constructs of thought styles and epistemic communities to find (or create?) these as distinct as possible thought styles regarding technology and coordination, which turned into three views, the interoperability, **bureaucratic** and **market** thought styles. For each, I describe their view on implementation of technology, standards formulation, coordination of technology, and meta-coordination.

As illustrated in Table 2.2, the notion is that each additional thought style, 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 inference⁵ nomenclature, each additional thought style can reject additional hypothesis, and possibly the null hypothesis as well.

⁵As opposed to other quantitative thought styles of inference, such as Bayesian or neural networks.

Table 2.2: Pitfalls of thought styles

This table illustrates the notion that many perspectives on science and theory can muddle results and reasoning until there is no longer any form of acceptable agreement.

Thought style B	Thought style A	
	Acceptable solution	Unacceptable solution
Acceptable solution	<i>acceptable solution</i>	<i>unacceptable solution</i>
Unacceptable solution	<i>unacceptable solution</i>	<i>unacceptable solution</i>
Combined thought style		

As such, the notion is that by using multiple ideas of creation of theory and fact (i.e., thought styles) I can distill a, in those thought styles, meaningful conceptualization of the Internet and consequences of that conceptualization. Note that not only the small fact corner in Table 2.2 is interesting, but the entire matrix.

The thought styles of this thesis sometimes overlap, and are sometimes disparate, in terms of actual implementations or solutions. For example, in the case of **Revised Directive on Security of Network and Information Systems (NIS-2)** the market interests of large for-profit actors (**\$**) (including barriers of entry for smaller actors) overlap with the bureaucratic need for control and regulation of essential services (**🏢**). While smaller for profit-actors see the NIS-2 as quite problematic as the directive is quite all-encompassing and adherence requires considerable effort, as such incurring quite significant overhead for a small firm. Similarly, the interoperability and **market thought styles** (for **edge-for-profits**) can agree on the value of **QUIC**, since QUIC technically decouples traffic content from the network (which prevents ossification and supports interoperability **Δ**) and provides an advantage for edge-actors since **infrastructure and network operators** can no longer (meaningfully) differentiate traffic.

In terms of thought styles and this thesis I discuss justified beliefs, in a particular thought style, rather than absolute truth or fact.

I should note here that in order to transfer an argument from one thought style to another a translation might have to be made. It is possible to argue that such a translation can be made in an effort to reach agreement, on an issue such Internet Coordination, but can also be used to (knowingly) deceive.

Huber (1987) is an interesting example of a balanced account of forces pushing and enticing the communications sector.

Here it should be noted that from a critical perspective it is possible to use thought styles as hermeneutic or epistemic tricks knowingly to avoid paradigm shifts (cf. Kuhn, 1962) or enforce a thought style (cf. Fleck, 1935/1979) by

avoiding settings or empirical data which said field or thought collective cannot (or does not want to) explain.

In the light of this thesis, ecology texts (such as Moore, 1993, 2006; Olve et al., 2013; Westelius and Lindh, 2016) are used in conjunction with notion of managing (such as Malmi and Brown, 2008; Simons, 1995), organizing (such as DiMaggio and Powell, 1983; Groth, 1999; Meyer and Rowan, 1977; Mintzberg, 1993; Okhuysen and Bechky, 2009; Simon, 1997) and technical systems design (such as thoughts in Dijkstra, 1982; Gamma et al., 1996; Martin et al., 2003) to illustrate a meaningful ecology perspective of the Internet. In doing this, I mix, to a certain extent, sources from different scholarly traditions to make sense of the object at hand, the Internet.

The general argument here is that the Internet is one area where the technical design, and the principles and values behind the technical design, are of importance to understand the whole.

When reading texts and talking to people from, for example, business studies and law, I often find technical insight missing, or at least technical aspects neglected. My ambition is to help make the importance of technical aspects evident. But in these encounters with business studies and law I also noticed that people coming from the technical side (like me) can benefit from understanding how people with other backgrounds think and reason. I therefore try to draw on and incorporate such aspects, too. The way forward, as I see it, is for people from different backgrounds to understand more of each other's thought styles in order to more constructively engage in the further evolution of the Internet. And, particularly, for people with an interoperability thought style, to understand other thought styles to a sufficient degree to better maintain interoperability thought style character of the Internet also in the future.

The common term for the discussion I contribute to is Internet Governance. However, I in this thesis argue that Internet Coordination is the proper term as the Internet, from its start has not been intended to be convergent outside the best-effort scope and is built on notions of **separation of concerns**.

2.5 Symbols and names of the thought styles

This short section elaborates on the naming and symbolism of the thought styles, as this thesis concerns different perspectives it is of importance to be as explicit as possible when there is room for interpretation. Here I go through the interoperability (Δ), **bureaucratic** ( ) and market ($\$$) thought styles in short regarding how the symbols and names I use relate to their core values. The core values are presented in depth and motivated in Chapters 3 to 6.

The interoperability thought style (Δ) core values include planning for change, with central concepts such as interoperability, separation of concerns, decoupling and modularization. This thought style is represented by Δ , a

delta-symbol, to represent change. The name of the thought style, “interoperability”, is taken from the notion of interoperability, an important part in technical design (software design in particular). The symbol illustrates explicitness of change, the design for possible change, compared to, for example, evolution which can imply non-planned change. The idea is that change is necessary, and since it might be impossible to know what will happen in the future, all possible change should be planned for, which means that structures and systems need to be as interoperable as possible.

The **bureaucratic thought style** ( ) core values include control and verification, with central such concepts such as contracts, agreements, sanctions, and plans are important. This thought style is represented by , a symbol for an institution, to represent control, formalization, and bureaucracy. The name, “bureaucratic”, is chosen since it has an intuitive connection to the formalization this thought style represents and sees as necessary.

The market thought style (**\$**) core values include value capture, where concepts which pertain to value capture in a situation are important. For example, contracts, regulation, policy, etc are of importance as long as they are in favor of the specific market thought style actor. The thought style is represented by **\$**, a dollar-symbol, to represent value capture and the hunt for revenue or profit. The name, “market”, is chosen due to its intuitive connection to the purpose of most markets, to trade services or products, typically for money.

These thought styles are not disjoint by nature, but can be for specific issues. As an example; if the Internet architecture should be redesigned, should it be optimized for interoperability and possibility of a diverse set of applications on-top ( ) , control of the network, such as service guarantees or identity provision in the network itself ( ) , or allow for monetary gain by market participants and optimizations of throughput (**\$**)?

Note that all these thought styles have views on both coordination and technology. And their own notions of value and value capture. Of specific note is that there are engineering design choices grounded in each of the thought styles. In the case of the Internet, is the interoperability ( ) , the value capture potential of the infrastructure and network operators and edge-actors (**\$**) , or the possibility of control and audit the most important ( )?

In terms of my own thought style literacy, the interoperability thought style shaped my software engineering education, and also my career as a practitioner, since interoperability thought style principles are the de facto standard way of organizing software components. I used to build systems to fulfil both interoperability and market thought styles values; interoperable and easy to maintain systems which could also be sold on a market.

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. The research process can be divided into three steps related to the research questions (and illustrated in Figure 2.1): (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 7): (2) 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 9): and finally, (3) in what way does it matter that the Internet is as conceptualized in Chapter 7 with limitations in Chapter 9 (shown through the example of net neutrality in Chapter 10 based on economic and policy literature on net neutrality and on mapping the resources needed for a large selection of websites).

Figure 2.1: Illustration of the research approach of this thesis
The initial query of “what is going on here” early divided into two parallel tracks; capturing the actors involved, and investigating the constituency of the technical Internet.

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.

According to DeNardis (2020, p. 10–12, a chapter in an introductory anthology on Internet Governance), current methodological challenges in Internet Governance (or Internet Coordination) research which researchers should take head to, are:

1. *Making the invisible visible.*
2. *Understanding complex technologies.*
3. *The difficulty in studying the private sector.*
4. *Navigating conflicting values.*
5. *Multistakeholder governance and multistakeholder research.*
6. *Overstudying open systems.*⁶
7. *Research often involves creation of technological tools.*

The next couple of pages describe how I grappled with these challenges.

Both Item 1 and Item 2 concern envisioned problems from a perspective where all technology is complex and opaque. At a technical level the Internet and its coordination is neither invisible nor complex, rather the case is that technical domain specific understanding is needed, i.e., a form of technical literacy. Most parts of the technical Internet are explicitly visible, simple, and decoupled to avoid complexities according to the interoperability thought style. For example, all Internet Standards together are smaller than either the Bluetooth standard or the OpenDocument-format specification⁷. The Internet, in some sense, is one of the least complicated technologies I know of.

Item 3, i.e., access to the private sector (and government) has been an issue, even if the Internet Standards themselves are quite open and the data related to routing, naming and numbering essentially transparent, I have not had the access I would have liked to *both* the private sector *and* government institutions. In particular private actors who consider the Internet a strategic concern and of business interest have denied my formal interview requests. I

⁶DeNardis (2020) here refers to open systems as in not closed or hard to get to systems. In practice DeNardis (2020) argues that the Internet Engineering Task Force (IETF) and Internet Corporation for Assigned Names and Numbers (ICANN) are overstudied. In other literature streams, i.e., organizing and management, *open systems* refers to systems which are hard to delimit.

⁷See Section 7.3 the actual comparison. I compare the document format of the standards to illustrate that not only is the Internet itself interoperable, but the way the standards are stored and distributed is interoperable as well. Compared to, for example, PDF-documents. In terms of disk-space, all Internet Standards together are smaller than this PhD-thesis.

have partially handled this through other forms of interactions with such institutions, such as annual reports, public opinions and statements, etc, which gives an indication of what, for example, a large cloud provider might think of the Internet.

Items 4 and 5 are central objects of study in this thesis, rather than an unfortunate complication. The interoperability, bureaucratic and market thought styles that I identify and discuss, have emerged in my research through the abductive process I have conducted. I also spend several pages in this thesis to come clean on my own assumptions, both ontological and epistemic, in the light of my research.

As noted under Item 3 above, I found some types of stakeholders more difficult to access than others, but believe that insights I have gained from written sources and from people from other but related backgrounds allow me to claim that the three thought styles I have distilled are sufficient to capture the tensions in the Internet multistakeholder setting.

This ties into Item 6, where I have used open systems (such as arenas connected to and documents of ICANN, IETF, Internet Society (ISOC), the Internet itself, etc), but to the best of my ability complemented with interviews and discussions from less open systems.

As I show in Section 2.8 I use a collection of tools I have either created myself from scratch or borrowed from open-source projects to piece together something I can use to make sense of the Internet to grapple with Item 7. This can be a considerable issue for Internet researchers, and I do not see how I could have landed with the conclusions I have unless I had the software engineering experience and education necessary to interact with the Internet itself. As I note in Section 2.7, my background and training allowed me to discuss DNS with DNS people, BGP with BGP people, and so on. For example, in this thesis I show that the four publically available country code top-level domain (ccTLD) zone-files⁸ together have authoritative name servers in more than a hundred countries, a task which requires both significant technical understanding of DNS and the software know-how to write a program to actually resolve all the Fully Qualified Domain Names (FQDNs).

2.7 Collecting data

I have collected data from four conceptually different sources; academic literature, other written sources such as bylaws, interacting in an interview setting with practitioners, and data from the Internet itself.

At a general level I have an including approach (in that I cast a wide net to find texts, and attempted to interpret them in relation to the context they were written in) to texts, such as academic texts, statutes, and news articles. I did not just passively record the statements of the people I interviewed; I

⁸There are only four of them. More on the specifics in Section 10.5.

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). I have also employed a positivist approach to collecting data, such as traceroutes, **Domain Name System (DNS)**-zones, and website resources, of the Internet itself to determine the level of complexity of **Internet Service Provider (ISP)** (or rather, **Autonomous System (AS)** operators) interactions involved in providing services on top of the Internet.

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 changing how the Internet is designed and operated.

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 more or less formal documents in charge of coordinating the Internet. The mentioned documents are of different conceptual character, with different aims and goals which need to be interpreted in their setting.

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 10. This host sampling is akin to drawing a map based on what you see. I have also looked at the already existing map, to the extent that such a map exists, by 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 four, 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 to use all to describe the Internet and its coordination coherently in one text by several thought styles. With a bit of abstraction, engineers discuss technology and technical matters, and governance people discuss coordination and governance.

For example, Sowell (2015), a monograph dissertation, untangles and discusses the naming and numbering of the Internet (using the term NRS for number resource system) using interviews (and interactions with practition-

ers⁹) and literature, but does not include actual Internet data, such as DNS- or BGP-data. Similar can be said of texts such as DeNardis (2012), Hanseth and Lyytinen (2010), Lehr et al. (2020), Liu (1999), and van Eeten and Mueller (2012), in that there is a connection to literature, bylaws and similar documents, and indications of interactions with practitioners, but no Internet data on the Internet itself. In the other direction, there is a vast swath of literature on technical matters of the Internet using Internet data, for example Çetinkaya et al. (2013), Rohrer et al. (2014), Sterbenz et al. (2013), Wu et al. (2007), and Yuan et al. (2008).

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 DeNardis (2020), DeNardis et al. (2020), Mansell (2012), and van Eeten and Mueller (2012), and many fields use different names or terms to describe similar but sometimes different things. In particular van Eeten and Mueller (2012) notes four labels used for Internet Coordination; *Internet Governance*, *Telecommunications policy*, *Information security economics*, and *Cyberlaw*, in the disciplines Communication, Computer science, Economics, Information science, International relations, Institutional economics, Law, Law and economics, Law and technology, and Political science¹⁰.

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

Also problematic, is the term *governance*, which in many areas pertains to the concept of a sovereign or multilateral power governing something. Both the sovereign power and the concept of something needing governance is problematic in an Internet Coordination 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

⁹Sowell (2015) includes a list of interviewees, but does not include a method section on the interviews, as such interviewee selection, interviewee questions, formalism of interviews, etc, is not known.

¹⁰It is worth noting that van Eeten and Mueller (2012) do not list Internet architecture or Internet (protocol) design as a topic which is covered by any of those labels or disciplines. However, the text notes “In most areas, governance of the Internet takes place under very different conditions: low formalization, heterogeneous organizational forms and technological architectures, large numbers of actors and massively distributed authority and decision-making power” (van Eeten & Mueller, 2012, p. 730) and further argues the importance of understanding day-to-day operations of infrastructure and network operators.

was contested, and focuses on institutions rather than actual interaction and coordination. Mainly, the literature which assumed that the Internet was governed to a large extent and went from there, for example assuming that ICANN has fundamental *regulatory power* over the Internet rather than being one of several *coordinating* actors, described a different reality than the one I encountered during interviews with Internet practitioners.

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 does not agree with technical literature on the Internet. Disagreeing because different aspects are considered important and worth reporting on, even though the same aspects were described differently (Is the Internet market based? An exercise of public investment and social policy? Or something else entirely?).

For example, Sutton and Staw (1995) argues that it is important to follow the empirical situation and not hold on to previous literature unnecessarily (i.e., let empirics lead where reasonable), while for example net neutrality literature in economics focuses 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. The general notion is that two-sided markets are useful concepts and that the Internet can be equated to one **Internet Service Provider (ISP)**, or **Autonomous System (AS)**-operator. However, most Internet-activities, such as web-browsing, concerns hundreds of ASs. This is one example of an incommensurable situation, where the thought styles do not find the application of theory acceptable.

To determine what the IETF thought on Internet Coordination and the Internet architecture, I read through those RFCs (IETF published documents) related to the standards-setting processes, of particular interest is **Request for Comments (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.

Similarly, to form an idea of what ICANN's role in Internet Coordination is, I also went through most official documents of ICANN and their **Empowered Community** 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 and data gathering endeavors in the Internet itself than

previous academic literature on the subject (this is in line with texts such as DeNardis, 2012; van Eeten and Mueller, 2012, see Chapter 7).

I also refer to some sources which require more care and nuance due to their activist character. For example, the [Electronic Frontier Foundation \(EFF\)](#), a non-profit pro-open-Internet organization, is responsible for the publication of documents such as Markus (2006), part of *Hepting v. AT&T*¹¹, documents which I would not have found had not an activist organization made them available.

Interviews and discussions

One of the main data collection and sensitizing 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 in an interview setting, 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 further questioned on the topic the interviewee argued that for most people and organizations at the edge of the Internet, the Internet should be coordinated in such a fashion that the coordination of the Internet does not concern them. In other words, the coordination of the Internet should be in such a fashion that the output, the actual Internet architecture, should be as interoperable as possible to avoid the need of additional coordination.

Here follows a few pages on interviewee election and the interview process. Note that with interview I refer to an event where I had a private and recorded one-on-one with an interviewee, either in person or remote via Zoom or Google Meet. With discussion, I refer to an event or setting where I interacted with one or several people outside an explicit interview-context. The discussions are used for sensitizing purposes, such as guiding my inquiries, while the interviews are used as data sources.

¹¹This is a class action lawsuit against AT&T for spying on their customers on behalf of the [National Security Agency \(NSA\)](#), and the particulars of the spying are part of what is commonly referred to as the “Snowden revelations”.

Interviewee selection

When I started to look for interviewees I was initially looking for Internet people, at that stage the people I held to both understand the technical Internet and its coordination, 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 publically I assumed that the junior people just were not publically reachable in the same manner, but it turned out that in many cases there were no junior people (and as I discuss in Chapter 7 several interviewees consider it to be an issue to get new blood in organizations such as ICANN and the IETF). I seem to have conducted interviews while the Internet epistemic community is undergoing a generational shift.

A majority of those I formally asked in the Internet setting agreed to formal interviews (i.e., controlled setting, such as recording the interview) 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 with) people with a different perspective on the Internet and its coordination. I consider that I captured the vast majority of values of people connected to [Regional Internet Registries \(RIRs\)](#), ccTLDs, [Advisory Committees](#) of ICANN, the IETF, etc, but had a much harder time getting access to for-profits and governmental opinions and values.

Potential interviewees in other arenas than the often non-profit organizations were in general more restrictive. Surprisingly, very few ISPs agreed to do a formal interview with me¹². 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 later my thoughts were rather “why should an ISP talk to me?”. This since my investigation led me in the direction that the Internet originally was not, and should not be, that beneficial to ISPs financially due to lack of differentiation possibilities (for fuller argument see Chapter 10).

For initial contact I used cold emails and references (I tried cold calling, but no contact initiated by phone ended up in an interview). Some initial email contact was positive and the potential interviewee asked for some example issues I wanted to discuss. Internet people responses to my example issues

¹²The individuals in ISPs I have done interviews with represent the infrastructure part of ISPs, and I do not think they represent the business end of the organizations adequately. For example, the discussions regarded building technically resilient networks with the available Internet Standards which allows peering with numerous networks in different locations, but none agreed to go on the record on business side of peering.

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 is able to 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 "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 USA, which is what I thought is behind the retraction of the interview offer.

Overall, interviewees who discussed the Internet as a phenomenon rather than a business concern were usually more willing to talk to me. It seems rational that for-profit organizations trying to shape the Internet for their own benefit would be less inclined to discuss the Internet and its coordination than those without a direct financial concern in the architecture of the Internet itself.

Even though I did not get any formal interviews with software and cloud firms, every edge 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 regulatory authority**).

See Table 2.3 roles used by interviewees in interviews. Many interviewees have several roles, and I use one reference per referenced role. Similarly, some interviewees were interviewed several times, the longest interview series spans over fifteen hours in total, and those interview series uses the one same set of references.

Table 2.3: Formal recorded interview roles
These are the referenced roles in the thesis.

Description	References
ccTLD, security officers and CEOs	“ccTLD (1),” “ccTLD (2),” and “ccTLD (3)”
IXP, research directors and senior specialists	“IXP (1),” “IXP (2),” and “IXP (3)”
ISP, research directors	“ISP (1)” and “ISP (2)”
RIR, employee	“RIR (1)”
DNS-expert	“DNS-Expert (1)”
IETF, working group chair and members	“Working Group Chair (1),” “Working Group Member (1),” and “Working Group Member (2)”
ICANN, Advisory Committee	“Advisory Committee (1)” and “Advisory Committee (2)”
ICANN, cryptographic officer	“Cryptographic Officer (1)”
Members of parliament	“Legislator (1)”
ITU Plenipotentiary, delegate	“ITU Delegate (1)”
Root-zone operators, senior staff	“Root-Zone Operator (1)” and “Root-Zone Operator (2)”

The shortest interview was around an hour¹³ and the longest more than three hours. I also conducted a small set of interviews which I ended up not using in this thesis.

Experience varied from a couple of years to experience predating the IETF¹⁴ and ICANN.

The interviewees were selected to span multiple thought styles and perspectives of the Internet, and chosen due to their supposed knowledge and understanding of the Internet, its coordination 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 [Internet Assigned Numbers Authority \(IANA\)](#) Root KSK Ceremonies, i.e., the cryptographic signing of the root-zone, and its effect on the [Domain](#)

¹³I have deleted the recording at the behest of the interviewee, and I only have my written summary left, so I cannot check the actual length of the interview.

¹⁴Both the USA government sponsored entity (until 1993), and the IETF as a part of ISOC. Unless specifically mentioned, I refer to the IETF as the post-1993 organization in the text.

Name System Security Extensions (DNSSEC) system with a trusted Cryptographic Officer, which provides an understanding of the root-signing-process that documents alone cannot provide.

As alluded to above, I also informally talked to or interviewed people in different organizations on different levels, partly to find out who I should talk to but also to get insights which might not have been offered in interview settings. I have also listened to public workshops and presentation to get an understanding of issues at hand and the perspectives present on the issues discussed. For example as a pre-flight test of the synthesis of the thought styles I listened to public workshops on Internet issues, and checked that the (coherent¹⁵) argumentation from different perspectives fit in formulation of the thought styles.

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. The later part of the process I was embedded in the Internet Coordination arena which afforded me insight I would have missed had I been situated outside the Internet Coordination arena itself.

All in all, I have talked to and interacted with representatives and / or employees of ICANN, ISOC, the IETF, the **International Telecommunications Union (ITU)**, infrastructure and network operators, edge firms, infrastructure and network operators, academia, municipal level, EU-level, and governments.

Interview process

The formal 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 structured part, or I knew the interviewee had special competence in.

As an afterthought, it is possible to argue that I conducted two different kinds of interviews, and each with two different levels of understanding.

The two kinds are sensitizing (i.e., general Internet discussion) and specific issue (such as net neutrality or the ITU Plenipotentiary). I also had a different level of understanding during the process. I might be considered the student in my first set of interviews, while later on I was more on equal footing with the interviewees.

I opened every semi-structured sensitizing interview (i.e., first round of interviews) in the same manner, as described and illustrated in Table 2.4. I also ended these interviews in the same manner, asking the questions in Table 2.5.

¹⁵Coherent as in structured and with a clear motivation. For example, I do not see “I do not like ICANN” as a coherent argument, but I see “Why is not ICANN, as the formal governor of the domain system, doing more to prevent DNS abuse during the pandemic?” as a coherent argument since it present why ICANN should do more (since ICANN is the formal governor, in that perspective).

Table 2.4: Start of interview questions
Questions asked at the start of sensitizing interviews in order to have a baseline for all interviews. These questions were followed by questions related to the expertise of the interviewee.

Question	Motivation
A short presentation of me and my research	Answering what am I going to use this interview for. I.e., research, not journalism, etc. I also ensured that I was allowed to record the interview and use it in my research.
Explain that I am looking for the opinion of my interviewee	It is important to make it clear, especially when interviewing on issues which are semi-technical, that I am not looking for the pen-ultimate truth but rather their perspective on it. I also made clear that they are welcome to elaborate as much as they want to.
What is the Internet in one sentence or less?	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.
Shortly, how is the Internet governed today?	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”.
Who are you and which formal bodies are you a part of?	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. Prior to interviews I knew public information about the interviewee, which I wanted to double-check.

Table 2.5: End of interview questions
Questions asked at the end of sensitizing interviews in order to cover the same exit-questions and ensure that each and every interviewee was asked about further interviews.

Question	Motivation
What is the most significant threat to the Internet today?	In the typical interview we discussed this already, but I wanted to ensure everyone was asked this question.
Is there something you expected me to ask about today which I did not?	I went in with the assumption that I did not know everything. Surprisingly I seemed to have met most interviewees perceptions. One notable comment was: "I did not know what to expect of this [interview], but you have made me think" which to me means that at least some discussions gave food for thought.
Would everyone in your organization agree with you on everything you told me today? If no, who and why?	A simple measure to avoid one dissident voice in an organization.
Do you know (of) anyone who would disagree with what you told me today? Who and why?	Since my approach was based on snowballing and grounded theory an important question to allow the inquiry to continue further.

I conducted all interviews, went through all recordings and wrote all summaries. I offered all interviewees a written summary of the interview. Some interviewees wanted to sign off on verbatim quotes.

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 DNSSEC¹⁶, which opened up the interview and the interviewee did no longer hold back from being technically accurate and detailed. Another example: in connection to a short presentation I held I asked a few of the participants afterwards if they would be up for an interview at a later time. More than one commented that I had shown technical understanding in my presentation which made them more inclined to talk to me. Another interviewee commented that since he knew that I use a personal recursive DNS resolver (due to a discussion in proximity to the interview request), he would make time in his schedule to talk to me. However, I do not know if he would have denied an interview request had he been unsure of my technical knowledge.

The importance here is that I apparently passed some gatekeeping process to talk to people involved in the technical core of the Internet, which indicates that there might be other gatekeeping processes I have not managed to pass.

To reinforce that I think it matters who does the interview: I was given the comment during one interview that the old men of the Internet might be too impatient with those who lack knowledge, and might not want to talk to them. This ties into the earlier Item 1 and Item 2 of DeNardis (2020); that if you pass the gate of understanding the Internet at a technical level, some people are more willing to talk to you.

But as alluded to earlier, my technical knowledge also seemed to put off potential interviewees. During one period this happened to such an extent that I considered “playing technically stupid”¹⁷ but chose not to due to ethical considerations. As an example of this: I had at a conference met a high level 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 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 10, which is a technically, or perhaps an interoperability thought style, meaningful discussion on net neutrality in a Western setting.

¹⁶DNSSEC is the secure version of DNS, the protocol used for resolving Fully Qualified Domain Names, such as hostnames as www.dn.se, to a resource record, often (but not only) an IP-address. Chapter 3 mentions the differences briefly. The power transfer here refers to the centralization and importance of the root-zone signing keys, and the change in dynamics between a DNS client and the recursive resolver in use. In essence, the trust relationships are partially rewritten.

¹⁷In the sense of not appearing technically knowledgeable.

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 passed colleagues on the way, sometimes shown a particular piece of important Internet infrastructure, grabbed a coffee, small talked a bit about Internet in general, and then sat on quite equal ground the interviewee's office.

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 interviewee¹⁸. My perception is that calm environments with access to white-boards led to better discussions, and in contrast the interviews done in cafés or restaurants were more formal and held back.

All interviews focused on quality and depth rather than quantity, and are intended as good but not exhaustive starting point for a further inquiry.

All in person semi-structured interviews were recorded using OneNote on a MacBook Pro¹⁹ using the built-in microphone for physical interviews, 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). Remote interviews used either Zoom or Google Meet, either on my work laptop or my personal workstation at home.

In general, interviews prior to the COVID-pandemic were in person while those during the pandemic were remote. Repeat interviews with interviewees I had met previously over Zoom or Google Meet worked well, as good as a physical interview. But the first time remote interviews I did were considerably harder to get going, and sometimes it was a bit problematic to establish a baseline for the interview. Since the remote interviews where at the end of the process I could handle it, but I believe that I would have had issues if I started interviewing remotely from the start due to the width of the topic.

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. This could be interpreted to mean that I understood what they meant, or I was so far off what they meant that they had no interest in correcting my interpretation of what they said. My interpreta-

¹⁸This 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.

¹⁹Model "MacBookPro12,1" and later "MacBookPro14,1" for those interested.

tion judging from the sentiment during the interviews is the former: that I understood their perspective on the matters we discussed.

Regarding language, I have been interviewing both in Swedish and in English. I used Swedish in the cases where Swedish was the native language also for 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.

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 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. For example the business aspects of using the Internet for your own gain.

My initial plan was to create a network of important people in the Internet ecosystem, and use the theories of weak ties (see Granovetter, 1973) and structural holes (see Burt, 2004) to identify individuals or positions of interest, but after conducting several interviews I realized that my approach was faulty. I earlier assumed that there were people in charge who directly could be influenced. As it turns out there are people with more influence than “average” but surprisingly few, and the Internet is not governed top-down, which adds further issues to a weak-ties and structural holes approach.

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. One issue, or one central tenet of the Internet, is that there is virtually no centrality on the Internet, no keeper of truths or fact.

This can be considered problematic in the perspective of repeatability, since repeating the tracing in Chapter 10 unavoidably would give a different picture since the Internet is different depending on where (and when) you are standing and looking at a particular thing. For example looking at something quite static, such as publically available routing tables, gives you the technical standards and policy of the Internet, but not how it is used.

The Internet in a way assumes best-effort through all layers, which means 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 DNSSEC-speaking DNS servers and recursive resolvers

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, 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. Therefore, 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 a hundred or so external resources spread over ten or more networks in five or so countries when I fetched it, I can draw the conclusion that there are services (such as websites) on the Internet which rely on 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 does not make sense to look at the Internet as just a service to deliver packets between two points (this is one of the essential points of Chapter 10).

As a ballpark figure, the data set I used in Chapter 10 consists of ≈ 1.5 TiB (≈ 1500 GiB) of data. In Internet-terms that is not that much data, but gives a good indication of the nature of the websites I explored in Chapter 10.

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 if the question at hand is the Internet itself.

2.8 Code used in thesis

This is a technical section on the code used for this thesis, in essence how I grappled with Item 7 in DeNardis (2020); that as an Internet researcher you usually have to write your own tools.

All code I wrote or composed to be used in this thesis is available on [github.com](https://github.com/flindeberg) under my username *flindeberg*²⁰. In particular *LGL*²¹ and *internet-tools*²² are important. The first generated the large graphs of the Internet based on BGP-data, the second generates the graphs used in Chap-

²⁰I.e. <https://github.com/flindeberg>.

²¹<https://github.com/flindeberg/LGL>, the graph drawing library modified for BGP-data.

²²<https://github.com/flindeberg/internet-tools>, the website visitor and some extra tools.

ter 10. Here follows brief technical overviews of them and technical matters of particular importance.

LGL — Large graph layout

To generate the large graphs of the Internet I revived an old project I found on the Internet²³ which belongs to the Opte-project. The Opte-project in turn is based on the original LGL, which was created for modelling proteins in both 2D and 3D (see Adai et al., 2004, for the original paper). At the time of writing my changes have been pulled by the Opte-project, i.e., they are now using my modifications and have published new images and videos since²⁴.

The Opte-project's LGL implementation is the best library I have found for generating large graphs (i.e., millions of nodes), it seems most software products built for generating graphs break down around tens of thousands of nodes (for example Gephi), and I needed to be able to draw hundreds of times larger graphs.

In practical terms I had to update the code base to use more modern versions of dependencies, for example boost, Perl and Java, while not breaking any of the magic²⁵ used for the graph layouts.

I use BGP-dumps to draw the Internet, that is I *assume* that ASs send mostly correct BGP information to each other so that the data collected at nodes served by [Réseaux IP Européens Network Coordination Centre \(RIPE NCC\)](#) or Route Views get correct information. Due to the fact that the Internet works based on this BGP-data, this assumption can be considered unproblematic. However, I should note that I have no way of verifying that these dumps are not targeted by an actor with malicious intent.

I acquired BGP-dumps from RIPE NCC²⁶ collecting routing information, which can be considered to contain routing data from the entire public Internet.

I also had to convert the BGP-dump-format (as routing data commonly is available as) into something usable by LGL, so I extracted AS paths and prefixes from the BGP-dumps 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 ranges from dark blue (very central vertices and edges), going past dark cyan and green until almost white at

²³<https://github.com/TheOpteProject/LGL> contains the Opte-project modified LGL code base, now with my changes included.

²⁴See <https://www.opte.org/the-internet>.

²⁵Here using magic to denote algorithms I have not taken the time fully to understand and rewrite. A good graphing engine could easily take a couple of thousands of man-hours, hours I was not willing or capable of spending.

²⁶See, for example, <http://data.ris.ripe.net/rrc00/> for raw data. The rrc00-node is the longest serving collection node, and has data from the end of 1999, although in a different (non-bgpdump) format. I used all available nodes, i.e., rrc00-rrc24 at the time of writing.

the furthestmost and least connected vertices. The white edges can serve as a meaningful conceptualization of the concept of the edge of the Internet. All images are publically available²⁷.

Listing 2.1: Example of BGP-data, curated by removing data not relevant to this example, two rows via Netnod, from September 2000

```
# prefix announced # aspath (monitor -> origin)
192.36.144.0/24    4777 2516 6453 2603 8674
192.36.144.0/24    4608 1849 702 2603 8674
```

In Listing 2.1 I illustrate the important contents of BGP-packets, here two packets (one per row) showing the paths to prefix 192.36.144.0/24 announced by AS8674 (Netnod) from two different directions. These two rows give rise to the data in Listing 2.2, which are all the tuples from Listing 2.1 and the amount of times they show up. In this case, both 192.36.144.0/24-8674 and 2603-8674 show up twice, therefore they have a weight of two.

Listing 2.2: Example of BGP-data, curated for ncol format for graphs, September 2000

```
# prefix announced from AS
192.36.144.0/24 8674 2
# paths in the AS path
2603 8674 2
4608 1849 1
1849 702 1
702 2603 1
4777 2516 1
2516 6453 1
6453 2603 1
```

Format-wise the data to draw the Internet graphs is the same as in Listing 2.2. The files used to draw the entire Internet, as seen from BGP, are around 35 MB created from roughly 4 GB of routing data (i.e., BGP-packets).

The assumption I do when I assume that the BGP-data is correct bears some discussion. First, the data I have used is the same data as is being used

²⁷At <https://github.com/flindeberg/LGL/tree/master/resources/images/latests>. If using them or the codebase, reference this thesis and Adai et al. (2004).

by routers all over the Internet, so to some extent the data is correct since the Internet works. Secondly, there is always faulty routing information flying around on the Internet, either by intention or by error, and this information is for better or worse part of the graphs in this thesis.

Figure 1.1 represents the Internet as of September 2020 and took roughly 28 h of CPU-time to process. Important to note is that these graphs show BGP-typologies, which can match, but does not have to, the physical infrastructure.

Internet tools

I wrote the internet-tools repository from scratch to be able to draw the figures used in Chapter 10. I found no other tool available which could draw graphs with this level of detail of the structure of the network used to display a website. In general terms there are tools which illustrate privacy concerns, e.g., “how many actors get my information when I visit this page?”, but I found none which illustrates networks used.

In effort to be efficient I re-used as much code and libraries as possible. For example, I use the Chromium browser²⁸ to visit websites, an open-source **har-capturer** to capture **HAR files** (that is **Hypertext Transfer Protocol (HTTP)**-archives), and graphing libraries (among other **graphviz**) to draw graphs of the data captured.

I had to write my own tracer to properly visit all hosts with resources on them and gather the traced routes. This is a major difference from the LGL-graphs, where I used BGP-data; here I used actual data as experienced by the user. In other words, the LGL-graphs are comparable to maps; they should look like reality, but there is a chance they do not. Here I actually (in the analogy of maps) walked around and drew my own map to the best of my ability.

My initial thought gathering the empirical data for Chapter 10 was: “How can I show how the Internet works?”. I ended up with websites since the web is a very integral use of the Internet, and something most Internet users are familiar with. For this I used a headless Chromium instance²⁹, waited for it to load a website fully and a short grace period to give scripts firing on the load event a chance to finish. I did not “log in” into any of the sites I visited. After the page is fully loaded and the grace period is over I saved the HAR file to disk. The HAR file contains all the HTTP-requests made during page load, as well as their answers.

Everything up to this point was automated with a bash-script. The data in this thesis is based on four thousand (4000) website visits. The reason for not including all visits is that I continuously improved the process to better

²⁸The open-source version of Chrome.

²⁹For more info on Google Chrome / Chromium headless see <https://developers.google.com/web/updates/2017/04/headless-chrome>

simulate a real page visit, and for example for the first thousand or so visits the Chrome cache was not cleared properly between page visits³⁰.

The HAR file itself is a json-formatted file which I parse with a custom Python script. In essence the script does a couple of things:

- Resolves all hostnames queried in a session to IP using Google’s DNS for the 2018 graphs and my own recursive resolver for 2020 and 2021 graphs.
- Traceroutes to all the above hosts, i.e., collect IP-addresses from all hosts answering during a normal traceroute-process. This step was done with a custom traceroute implementation, which assumes that the hosts follow the standards for **Internet Control Message Protocol (ICMP)** (cf. RFC-792, Postel, 1981a).
- Checks of which AS each and every one of the above gathered IP-addresses belong to. This is done via the Python **pyasn**-module and using IPASN-tables based on the MRT/RIB BGP archive of Route Views³¹.
- Statistical summary of the above, that is counting Internet Protocols per request, ASs per request, etc, and providing averages and totals where applicable.

The traceroute is the most problematic of the above to integrate into a repeatable process with the current amount of hosts. There is no operating system built-in tool to accurately do traceroutes of the magnitude I need within a reasonable timeframe. Therefore, I ended up writing my own traceroute implementation which handles concurrent traceroutes which allowed me to trace hosts much quicker. I ended up with a traceroute based on **User Datagram Protocol (UDP)**, rather than half-open TCP or ICMP echo, due to my familiarity with UDP tracerouting. There is no reason to believe that either TCP or ICMP based traceroute would have yielded different results due to all hosts being publically available. In other words, it does not make sense for a host containing resources for a website to be “hidden” in any way, since that would defeat its purpose of being available³².

In most operating systems there are built-in **IPv4** tools for doing a traceroute, for example **tracert** in Windows NT based systems and **traceroute** in Linux, Unix and OSX, as well as their **IPv6** based siblings. The problem with

³⁰<https://github.com/flindeberg/internet-tools/tree/master/resources> contain additional sample graphs of larger collections of hosts, for example the top 100 websites of the Alexa-ranking.

³¹All data available at <http://archive.routeviews.org/bgpdata/>

³²Using UDP, half-open TCP or ICMP echo can be expected to give different results for hosts which are not intended to be as visible. For example private computers or servers, equipment inside corporate networks, or devices part of the Internet infrastructure itself.

these tools is that they seldom, if at all, take height for concurrent traceroutes. The ICMP standard itself, as presented in an RFC-792 (Postel, 1981a), allows for any number of concurrent traceroutes, since the standard itself specifies the format of the response when a packet times out.

This process is fully automated, from starting the script to outputting a L^AT_EX-formatted table, to avoid human error when repeating the process.

There are a couple of folders of interest in the internet-tools repository as well, the RFC parsing tools (which are used in Chapter 7), the zone-resolving tools (used in Chapter 10), and a PDF-scraper (used in Chapter 7). These are, compared to LGL and the website tool, quite small tools which illustrate specific technical details, such as the size of the RFCs, the disconnect between country code and nation state, and the fact that most PDFs at ICANN’s website disregard good archival policy for PDFs (such as including the necessary fonts). These are tools or scripts I have written or composed myself for the purpose of this thesis.

2.9 Generalizability of results

Research as such is often concerned with generalizability, that is how it is 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 10 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 Section 2.8, I use routing-data from the entire Internet as my sample. There, generalizability from the sample to the population is not interesting, but rather generalizability from the samples I have, taken over time, to the Internet as it continuously exists. In this thesis I have two graphs, one representing the year 2000, and one representing the year 2020. I have generated one graph per month for the interval 2000 to 2020, and one graph per day for a month of 2000 to look for interesting or generalizable phenomena. The two included graphs do not deviate from the graphs of the same time period.

Rather, the main part of this thesis, in my perspective, is explaining the coordination mechanisms of the Internet seen from different thought styles.

In the thought styles I have captured the values I have encountered in interviews, and other engagement with practitioners, literature, and standards regarding the Internet. In terms of time periods, I have identified the interoperability thought style, in the context of digital networking, over a period of fifty years, from the early RFCs in 1969 and the Internet Experimental

Notes (IENs) in the seventies up till today. The bureaucratic and market thought styles are representative of ideas which are much older, for example Smith (1776) discuss markets and bureaucracies. In that sense, the values behind the bureaucratic and market thought styles have not changed much over time, but I can imagine that these values on the Internet over time will change with what the Internet is or becomes. The thought styles describe current and captured perspectives and views on the Internet, rather than all possible perspectives.

There are two perspectives in particular I suspect might exist, but which have not shown up coherently in my studies. First, the Luddites, or similar idea of that technology is bad, and as such the Internet should not exist, and second, the idea of disrupting or destabilizing the world order.

The closest to a coherent Luddite view I have encountered is that the Internet is potentially dangerous if left out of control, and as such should the Internet should be in the domain of bureaucracies, and therefore fits under the bureaucratic thought style umbrella.

In terms of political destabilization or disruption, I have not been able to find an instance of destabilization or disruption which does not fit in one of the bureaucratic and market thought styles. Note that many political destabilization or disruption events are targeted at platforms or services using the Internet, rather than the Internet itself.

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.

2.10 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 to roles. 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 described in Markus (2006) (i.e., the nation-wide

spying program orchestrated by the **National Security Agency (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.

I avoided using or directly reference material I have gotten access to without explicit permission. Examples of such material include conversations in social settings and presentations which “were not supposed to be public”. 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. Such documents and information have been used for sensitizing purposes, and I have used them sparingly.

Also, research can be susceptible to unethical use. In my case I have in Chapter 9 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 who himself has changed and developed during this process, 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, important for transparency is that the funding for the later stage of this thesis which came from **Swedish Internet Foundation** who (as an organization) certainly has a stake in what the Internet is and should be seen as, or more succinctly put; if the Internet was to be regulated as a telecommunications service the Swedish Internet Foundation no longer has **raison d'être** (imagine a private institution without oversight allowed to delegate telephone numbers which work globally unilaterally across the globe and charge for them, arbitrarily). I do not believe that my employment at the Swedish Internet Foundation has changed or affected the process or conclusions of this thesis, outside of setting a strict time-frame (my time-limited employment) for finishing the thesis with pay.

3 Interoperability frame of reference

To infinity and beyond

— *Buzz Lightyear*

This chapter goes through literature, theories and theorizing on **technology** in general and the technical side of the **Internet** in particular. This chapter notes the different conceptualizations of the Internet but leaves the discussion of conceptualizing the Internet for the purpose of this thesis to Chapter 7.

I start off with the technical 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 what the Internet technically can be seen as. This chapter is the first of three “frame of reference” chapters, where this focuses on the technical Internet as such, and the **interoperability thought style** way of framing the world in general.

Each of the frame of reference chapters describe one **thought style**, in essence a way of thinking and understanding by a collection of people distilled down to a handful of distinguishing concepts with regard to the other thought styles, where this chapter focuses on an “optimize for change” approach to the world that I call the interoperability thought style.

In addition, all the frame of reference chapters are summarized and contrasted in Chapter 6.

Also, the purpose of this chapter is to explain the technical fundamentals of the Internet in a generic and understandable fashion to readers who are not Internet specialists.

The epigraph of this chapter, “To infinity and beyond”, comes from Toy Story (the movie) and is the catchphrase of Buzz Lightyear. Here I use it as a catchphrase for the interoperability thought style, in that it is meaningful to reason in regard to how to plan for change to reach as far as possible, to build and design with interoperability as lode star. This is intended to distinguish the wants of the interoperability thought style from a view which aims to optimize a system on some kind of performance, such as sent and received packets per second, or margin per unit sold.

3.1 The Internet and the web

In non-academic contexts it is quite common to use the Internet and the **web** interchangeably. I use both terms explicitly. On the one hand this thesis is more or less in its entirety framing the Internet. On the other hand the web is much easier to frame, or even define: those parts of the technical Internet¹ you can visit, see or experience through a web-browser.

This thesis is aimed at problematizing the Internet as separate from the web, from a viewpoint where the web can be seen as using the Internet. This means that when using traceroute to diagnose **routing** issues, you are using the Internet directly, or when your laptop is using *NTP* (a time synchronization protocol) to synchronize its time with the company servers, it is only using the Internet (or perhaps just the local network).

However, even Internet specific texts sometimes 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”. In essence, they then discuss the Internet, rather than the web.

These are indeed troublesome terms in general. Going forward, the Internet refers to the Internet and explicitly not the web. The web is a service on top of the technical Internet, it is distinguishable from the technical Internet.

It is possible to use the Internet without the web, and the web without the Internet. Rather, from the perspective of the web, the interoperability or neutrality of the Internet is important since that allows web-applications to be decoupled from the Internet as infrastructure. And it allows the Internet to be decoupled from services on top.

¹Note the use of *technical* Internet, i.e., the infrastructure and standards, or the material if using **sociomateriality** vocabulary.

3.2 Assuming the Internet

I assume that the Internet is a phenomenon of both **coordination** (of technology) and technology, which is contentious and not an accepted view in most fields. In Table 3.1 I show how a selection of literature and actors relate to the concept of the Internet. In this section I present the assumption behind framing the Internet as I do: Chapter 8 frames the Internet and its conceptual components (in terms of **implementation of technology**, **standards formulation**, **coordination of technology**, and **meta-coordination**).

Table 3.1: Internet Governance and Internet definitions

Comparison of **Internet Coordination** perspectives encountered early in the process which lay the foundations for assumptions held at the start of the process. Note that DeNardis (2012), van Eeten and Mueller (2012), and Zittrain (2008) claim to discuss the Internet and its coordination or **governance**, while Cheng et al. (2011) and Economides and Hermalin (2012) do not.

		Explicit	
		Yes	No
Coordination	Yes	my assumption	Zittrain (2008), DeNardis (2012), and van Eeten and Mueller (2012)
	No	The ITU and the UN	Ex, Economides and Hermalin (2012) and Cheng et al. (2011)

Table 3.1 should be read that I intuitively had an understanding that the Internet must be seen a combination of technology and coordination explicitly, and this is a known bias I bring to this thesis². 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 should be handled in the UN or the ITU³. Texts such as Zittrain (2008) mention that the Internet has governance dimensions, but are not explicit in defining what they are and how they work. Lastly, texts such as Economides and Hermalin (2012) see the Internet as a collection of protocols, even if they are not explicit in saying that the Internet is a technological phenomenon only (they see the Internet as a network and do not reason in regard to its coordination). Table 3.1 is the starting point which led to the conceptualization in Chapter 8.

²This is an intuitive starting point, since currently almost all technology is made by humans in some social process, as is the case with science according to Fleck (1935/1979), Kuhn (1962), and Latour and Woolgar (1979).

³It should however be noted that there are discussions taking place at the UN and the ITU discussing what the Internet is, but at the last **ITU Plenipotentiary** there was yet no other agreement than some form of technology of quite vital importance, see ITU (2018).

3.3 The Internet in practice

In Chapter 7 I broadly state the three missions of the IANA function: coordinating Internet **naming** (i.e., domain-names), coordinating Internet **numbering** (i.e., **Internet Protocol (IP)**-addresses) and coordinating necessary protocol numbers (i.e., **Domain Name System (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, even if they indirectly are dependent on the existence of roads. Important here is that pizza delivery as a concept is not dependent on roads; for example boats or drones work as pizza delivery vehicles in some circumstances. But the specific sub-concept of pizza delivery with a car on roads depends on roads.

This section refers extensively to **Requests for Comments (RFCs)** and **Internet Standards**, which are documents aimed at describing Internet related matters, a bit simplified the former (RFCs) can be seen as submitted research papers and the latter (Internet Standards) as accepted research papers (note that even submitted up for review “research papers” are public in this process, see **Request for Comments (RFC)**-2026, Bradner, 1996, for a detailed overview of the process from the Internet Standard itself, note here that the process of settings Internet Standards is an Internet Standard). All RFCs are given a number (the first one has “1” and so forth, often stylized with zeroes if smaller than one thousand, i.e., “0791” instead of “791”), and this RFC number stays with them even if accepted or “promoted” to Internet Standard or **Best Current Practice (BCP)**. Internet Standards and Best Current Practices have two numbers, one RFC number and one either Internet Standard or BCP number.

The protocols **Border Gateway Protocol (BGP)** and **DNS** can be seen as two ways of organizing records. Where BGP focuses on decentralization and security, DNS focuses on human-meaningfulness and security.

The technical core of the Internet

The most important parts of this chapter, Chapter 3, is the preceding and the next section, Section 3.3 and Section 3.4. They describe the today fundamental Internet functions as seen from the interoperability thought style. These functions are set through standardization processes with and at **Internet Corporation for Assigned Names and Numbers (ICANN)** and the **Internet Engineering Task Force (IETF)**.

Looking up a hostname

When looking up an address, i.e., translating a *URL* or human-readable address into an IP-address, a decentralized “phone catalog” called DNS is used, see Figure 3.1b. The root of the DNS-tree belongs to ICANN and is called the root-zone (this is what the Internet community did not want the UN to control in Weber, 2009), and the tree then spreads out to **top-level domains (TLDs)** (i.e., governors of dot-gov, dot-se, dot-com and so forth) which in turn pass on domains (such as `dn.se`.⁴ and `google.com.`), who in turn can delegate even further (such as `www.google.com.`).

To illustrate this, in the `www.google.com`-case, a DNS-resolver (the entity looking up a DNS-name) would start from the end, reading names from right to left. First, the last part `com.` would tell the resolver to find the dot-com delegate⁵, which can be found by asking the root-zone⁶. Second, to find `google.com.` the resolver would ask the dot-com delegate. Now `google.com.` is resolved. Third, to find `www.google.com.`, the resolver would ask the `google.com.` delegate about its `www`-subdomain. Now `www.google.com.` is resolved as well. Or in other words, `.` (the root-zone) knows where to find `.com.`, and `.com.` knows where to find `google.com.`, and `google.com.` knows where to find `www.google.com.`.

Figure 3.1: Overview of models of coordination

Illustration of three modes of coordination, with examples from core Internet functions.

For clarity, the DNS-system is decentralized, it has a root, a starting point, 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 3.1c),

⁴The period at the end, i.e., the “.” illustrates that the domain-name is a **Fully Qualified Domain Name (FQDN)**. This means that the name is absolute, and should be resolved relative the **root-zone**, and not, for example, within a local context.

⁵A delegate, in **Domain Name System (DNS)**-terminology, is the one which, at a technical level, is delegated the rights for a domain, regardless of level.

⁶For this particular example the root-zone is assumed to be ICANN’s root, but in a technical sense any root-zone can be used.

as in there is no central node or root⁷, or single point of failure. We will get back to BGP later, but it is the protocol in charge of routing 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 **Internet Service Provider (ISP)**) to answer on behalf of the correct actor. This led to the standardization of **Domain Name System Security Extensions (DNSSEC)** in which there is a trust chain. Almost all modern devices (such as computers and phones) come preloaded with a selection of blind trust for a number of actors⁸, and as long as a trusted actor anchors the DNSSEC chain, your device will trust the end result. Note that DNSSEC does not encrypt your queries and make them secret, DNSSEC is made to validate the trust chain from the root-zone to the leaf-node. Other standards, such as **DNS over HTTPS (DoH)** and **DNS over TLS (DoT)** aim to solve the secrecy problem.

Obviously the question of trust deserves a PhD-thesis on its own, is it better with one entity to trust (as in DNS with IANA / ICANN), a set of entities to trust (like certificates and **Resource Public Key Infrastructure (RPKI)**), or a very distributed set of work tasks (like **blockchains**).

Now it is time to go into a bit of gritty detail of DNS-operation which the later parts of this thesis rely on. In general terms the coordination consequences of DNS design are not well explored in a scientific sense, and for me to fruitfully have that discussion later this background is a requirement.

However, it should be noted that the Internet Standards themselves, i.e., RFC-1034 (Mockapetris, 1987a) and RFC-1035 (Mockapetris, 1987b), are explicit on a few points which have coordination consequences, for example extensibility. Example:

Since the domain system is intentionally extensible, new data types and experimental behavior should always be expected in parts of the system beyond the official protocol.

(RFC-1035, Mockapetris, 1987b, p. 1)

⁷However, practically all nodes are not equal, but compared to a hierarchy the nodes are much less unequal. Large **infrastructure and network operators** have a significant advantage in dictating the rules of engagement, but none of them dominates all the others.

⁸This has caused a bit of controversy, since not all preloaded CAs are trustworthy, and not all processes for adding CAs trustworthy. See <https://ccadb-public.secure.force.com/mozilla/CAIdentifiersReport> 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 preload any CA (certificate authority) / list of CAs. In practice there are four major organizations maintaining lists of trustworthy CAs; all four build web-browsers and three also build operating systems: Mozilla (Firefox), Microsoft (Edge, Internet Explorer and Windows), Google (Chromium, Chrome, and Android) and Apple (Safari, macOS, and iOS).

In addition, RFC-1035 (Mockapetris, 1987b) is also clear on that the standard intends to guide inter-system implementations; in your own system you can do as you like.

The domain system has several conventions dealing with low-level, but fundamental, issues. While the implementor is free to violate these conventions WITHIN HIS OWN SYSTEM, he must observe these conventions in ALL behavior observed from other hosts.

(RFC-1035, Mockapetris, 1987b, p. 7)

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`⁹ (an IPv4 address) in an A-record.

Listing 3.1: Lookup of `www.dn.se`

```
$ host -v www.dn.se
Trying "www.dn.se"
;; QUESTION SECTION:
;www.dn.se.                A
;; ANSWER SECTION: # from 2017
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

;; ANSWER SECTION: # from 2020
www.dn.se.                 CNAME
                        -> www.dn.se.edgekey.net.
www.dn.se.edgekey.net.    CNAME
                        -> e12723.a.akamaiedge.net.
e12723.a.akamaiedge.net. A
                        -> 2.18.74.134
```

⁹In 2017 from Sweden; in 2020 it resolves to `2.18.74.134` from Sweden.

Already here I want to explicitly point out two things; (1) the Internet is always changing, and the same hostname might resolve to different Internet Protocols over time, and (2) different networks (and geographic) locations might get different answers when resolving hostnames¹⁰.

In the example of Listing 3.1, ISPs (my provider and others), a **country code top-level domain (ccTLD)** (which SUNET, the Swedish university network, 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 (the information regarding who controls `dn.se.` and subdomains) and in this case a hosting provider, Akamai, having the actual end address of the host.

There were several critics to the early model with ccTLDs and a few **generic top-level domains (gTLDs)**; this critique led to the creation of more generic top-level domains (see Mueller & McKnight, 2004, for arguments, although written before creation of additional generic top-level domains such as **brand top-level domains (bTLDs)**). There were opponents to this, arguing that the DNS-system cannot handle more top-level domains without being bottlenecked, Mueller and McKnight (2004) argued that this was moot point and the system had enough slack (and as it turned out Mueller & McKnight, 2004, were correct, due to the decentralized nature of the system)¹¹. Today there are several more top-level domains, such as dot-xxx (technically a **sponsored generic top-level domain (sTLD)**¹²), dot-xyz (technically a gTLD) and dot-google (also a gTLD, and specifically a bTLD).

ICANN, through IANA, prepares the root-zone which is later made available on the Internet through the DNS system by root-zone-operators. These thirteen operators are often referred to by their technical names, lettered a-root to m-root, and the number thirteen is a consequence of the typical 512-byte limitation on **User Datagram Protocol (UDP)** packets when RFC-1035

¹⁰For example, a user in the USA or China might get completely different answers than Listing 3.1, where the American user might be directed to an Akamai server in the USA, and the Chinese user might just get an error (although I do not know if `www.dn.se` is blocked in China).

¹¹As a technically interesting footnote, I was told by “Root-Zone Operator (2)” that most of the pressure on their root-zone operations today come from Google Chrome (and Chromium) browsers which detect Internet connectivity by forcing a root-zone refresh of their designated DNS-resolver. Technically, the browser requests resolution of a non-existing TLD, knowingly, which forces a cache refresh at the resolver of top-level domains, which is a very expensive operation in terms of time and computational power needed. As far as “Root-Zone Operator (2)” knows, the intention of this is to check if there is anything fishy going on. Refreshing is the correct behavior according to RFC-1035 (Mockapetris, 1987b) when this situation occurs, however, “Root-Zone Operator (2)” cannot decide if the behavior is bad-mannered, since Chrome intentionally puts extra load on the root-zone operators, or cool use of technology.

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

(Mockapetris, 1987b) was written. Each operator in turn operates several actual DNS servers which answers queries to the root-zone.

Weber (2009) argues that there will be a problem in the future if **Internet-of-Things (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-servers themselves. The only way to substantially increase root-server pressure is if all IoT-devices did their own recursive lookup starting from the root-zone rather than to use a more local DNS-resolver.

ICANN is part of both the operational DNS look-up process and the coordination of the domain names for the naming system (i.e., domain names and DNS), but is only part of the coordination of unique numbers for the numbering system (i.e., **Autonomous System Numbers (ASNs)** which are used by BGP). ICANN, and IANA, do not play any part in actual routing.

This is a very short overview of DNS, I would recommend interested readers to go through RFC-1034 (Mockapetris, 1987a) and RFC-1035 (Mockapetris, 1987b) for the actual Internet Standards.

There are several suggestions to replace DNS, since it is not under (inter-) governmental control, a discussion I return to in Section 9.3. Note though, that DNS is used for both technical purposes, such as SPF and DMARC (security extensions for mail), and for human purposes, such as looking up a hostname to an IP-address.

As an example of the interoperability thought style, DNS is extensible both by record-types (TXT, SOA, A, AAAA, etc) and class-types (currently only IN for Internet).

Of importance to understand what the Internet can be seen as from the interoperability thought style is that DNS as a protocol sees the Internet as *one* of many potential use cases. DNS as a standard is by no means limited to the Internet¹³, and is built for extensibility (as argued in explicitly in RFC-1034, Mockapetris, 1987a, RFC-1035, Mockapetris, 1987b, however, any extensions do need additional coordination).

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.

¹³However, as far as I know, DNS is not used for any other network, or set of networks, than the Internet.

In Table 3.2 I show a *traceroute* to `www.dn.se` which shows 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 NORDUNET, 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, NORDUNET and Akamai, are involved at an IP-level, but with a high probability, the jump going outside NORDUNET, i.e., between 9 and 10 goes over an **Internet Exchange Point (IXP)**, which often takes place on another layer than IP¹⁴, so it will not show up in the trace.

Table 3.2: Traceroute example

A *traceroute* to the host `www.dn.se` from Linköping University. Note that traceroutes show hops at an IP-layer; hops at layers below, such as Ethernet-hops at the link-layer, are not shown.

traceroute to e10692.g.a[...] (23.198.17.7), 64 hops max, 52 byte packets			
hop	host	ip	rtt
1	ikp-r-32.ikp.liu.se	(130.236.32.1)	29.611 ms
2	130.236.6.204	(130.236.6.204)	25.144 ms
3	130.236.9.202	(130.236.9.202)	27.940 ms
4	norrkoping-nkg188-r1.sunet.se	(130.242.6.76)	27.850 ms
5	stockholm-fre-r1.sunet.se	(130.242.4.56)	30.641 ms
6	se-fre.nordu.net	(109.105.102.9)	50.594 ms
7	dk-ore2.nordu.net	(109.105.97.130)	35.857 ms
8	dk-ore.nordu.net	(109.105.97.56)	36.428 ms
9	nl-sar.nordu.net	(109.105.97.137)	46.202 ms
10	amsix-ams9.netarch.akamai.com	(80.249.208.168)	46.754 ms
11	a23-198-17-7.deploy.stat[...]	(23.198.17.7)	47.119 ms

So for this example the following three types of actors are involved: ISPs, IXP and hosting providers. I have assumed that all actors are benevolent, which is not always the case, which I expand on in Section 10.6. The BGP protocols have few security mechanisms, which opens up for BGP-hijacking,

¹⁴Most Western Internet Exchange Points exchange traffic at the link-layer, so no IP-layer activities take place.

i.e., fooling the Internet to route traffic through your own network, traffic which you could either drop, modify or just haul along as usual¹⁵.

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, loading it in Sweden, (presumably) get the intended experience. Chapter 10 contains what in essence is 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 argued by others, e.g., DeNardis and Raymond, 2013; van Eeten and Mueller, 2012).

I illustrate data collected using the built-in developer tools in Google Chrome in Table 3.3. Note that I use the same physical connection but simulate slower connections on it. In this case, using `www.dn.se`, it turns out that the browser during 9 seconds on a Gigabit Ethernet-connection load 550 objects from roughly 100 different domains without filters and ad-blockers. The browser also use more than 20 cookies which are filled with data, so it is possible for the creator of the cookies to track my browser in the future.

In Table 3.3 I show different load-times and domains referenced when browsing to `www.dn.se`. The load-times vary from 4.5 seconds on a fast connection while blocking ads, up to 13 minutes (!) on a what is comparable to dial-up. In terms of cookies the connection throughput does not seem to matter, but fewer objects are loaded for slower connections. One of the most important values of Table 3.3 is the *objects* column. It tells that a vast majority of objects fetched are considered spam, ads, or hostile by a default

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 RFC-8205, Lepinski & Sriram, 2017, for full specification), which, as far as I know and indicated by interviewees knowledgeable in the area, is not generally used. However, it is likely that BGPsec based on RPKI is in much more common use at the time of the defense of this thesis.

configured ad-blocker. Also note large discrepancy in amount of data fetched. The blocking-setup was able to view the page as intended, as such the majority of both objects and data by size fetched does not concern the page, or service, itself, but rather the ecology surrounding the website.

Table 3.3: Accessing website on simulated connections
Accessing www.dn.se on different simulated connections using a browser. Uses the web as well as the Internet. Note the differences in both speed and resources fetched. Automated process.

simulated parameters			results				
connection	setup	TP	time	cookies	hosts	objects	data
fibre	AGP	250	4.5s	13	9	124	1.5 MB
fibre	—	250	9s	20	100	550	5 MB
wifi	—	30	10s	20	100	530	5 MB
4G	—	4	13s	20	100	350	5 MB
dsl	—	2	19s	20	100	330	5 MB
3G	—	0.750	58s	20	70	342	5 MB
2G	—	0.050	13m	20	60	428	5 MB

Adblock, Ghostery, Pihole — ThroughPut in Mbit/s

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

From this technical perspective you can say that ICANN coordinates the end-to-end and best-effort principles, but the actual value lies at the [edge](#), through both the website itself and for a different user experience in tools as *AdBlock* and *Ghostery*. This lowers the queried domains (hosts) with 90 % and has a substantial influence on how the page is loaded and viewed. Note that this also effects the other side, as there is, probably, a business intent with the cookies and ads.

In Chapter [10](#) I dig deeper into what this means for issues such as policy.

3.4 The IANA-function on paper

The IANA-function is usually referred to as a function, and not as something else, such as a group or an organization. I dig a bit deeper into the reasons for this in Chapter [7](#), but in short the work done by [Internet Assigned Numbers Authority \(IANA\)](#) was intended as a function rather than an organization.

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 [Public Technical Identifiers \(PTI\)](#), which is an organization which in turn lies under ICANN. Here I present the “on

paper” version of the IANA function in isolation, Chapter 7 discusses the actual IANA function in its ecology context. Essentially, 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 **Autonomous System (AS)** claims a particular IP-address or set of IP-addresses, concerning both IPv4 and **IPv6** (except special technical address ranges, such as local network addresses).

The numbering function is closely connected to the **Address Supporting Organization (ASO)** — **Number Resource Organization (NRO)** constellation and the **Regional Internet Registries (RIRs)**.

The numbering is used for routing information, see **Finding the route** at p. 61 for practical 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 top-level domains.

The naming function is closely connected to the **Country Code Names Supporting Organization (ccNSO)** and **Generic Names Supporting Organization (GNSO)** and through them ccTLDs and generic top-level domains in particular.

See **Looking up a hostname** at p. 57 for practical example.

Protocol specifications are in practice standardized by the IETF, except some specifications which are co-coordinated by the IANA function. These specifications are those connected to the naming and numbering functions, for example DNS specifications such as port 53 as the default UDP port.

Chapter 7 digs a bit deeper into the relationships in play here.

It might be useful to take a step back to consider what the (technical) 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 together with infrastructure. 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 their core technical, coordination issues 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.

The naming function of IANA is the root of the DNS tree. In practical terms this means maintaining the zone-file for the root-zone. In technical terms this zone-file is like any other zone-file; there is nothing in the DNS specification which says that the IANA zone-file should be used as the root-zone.

Rephrased, DNS as a protocol and standard is not bound to ICANN or the IANA-function. Using the IANA zone-file as root is a matter of configuration. For example, I can configure my devices to use another root-zone, perhaps my own, but I would have little interest in doing that since I would not be using the same namespace as the rest of the world.

Similarly, zone-files for domains technically look the same as zone-files for top-level domains. There are practical differences though, and best-practices which state that TLD-zone-files in essence should contain NS-records, required glue-records and DNS-records, see for example zone-cuts and zone-authority descriptions in RFC-2181 (Elz & Bush, 1997).

Zone-files themselves have no limitations as to location of records they delegate to, for example the se-zone-file delegates to authoritative nameservers in ≈ 90 countries (see further discussion in Section 10.5).

3.5 Internet Standards

Today the IETF through their board the **Internet Engineering Steering Group (IESG)** suggests Internet Standards. An early RFC, **Request for Comments (RFC)-2026** (Bradner, 1996), describes the formal process for setting standards. Important standards include but are not limited to IPv4 (RFC-791, Postel, 1981b), IPv6 (first version RFC-8200, Deering & Hinden, 2017), DNS (first version RFC-1034, Mockapetris, 1987a), **Transmission Control Protocol (TCP)** (first version RFC-793, Postel, 1981c), UDP (first version RFC-768, Postel, 1980), BGP (first version RFC-1654, Rekhter & Li, 1994) and **Internet Control Message Protocol (ICMP)** (first version RFC-791, Postel, 1981b). The IETF also standardize several higher level protocols, such as HTTP for

transferring hypertext (first version in RFC-2068, Fielding et al., 1997), and **Secure Sockets Layer (SSL)** and **Transport Layer Security (TLS)** for securing TCP connections (for TLS v1.0 RFC-2246, Dierks & Allen, 1999), 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 HTTP running over either SSL or TLS.

Part of the Internet Standard process but not standards per se are the BCP documents, which are rather process descriptions than technical standards. One example is BCP-38 (also known as RFC-2827, Ferguson & Senie, 2000, since both Best Current Practices and Internet Standards keep their RFC number when accepted) which suggests processes for handling **distributed denial of service (DDoS)** attacks, which have turned out to be a significant problem today¹⁶.

The standard-setting coordination (today RFCs and Internet Standards processes at the IETF) and the coordination of unique identifiers (today the IANA function and processes through ICANN) are essentially what is considered the **Least Common Internet** in this thesis. That is, the least amount of common understanding needed between networks to be able to communicate. This minimum level of understanding is core to the interoperability which is a key aspect of the interoperability thought style.

IPv4 and IPv6

The commonly used version of IP today is version four, usually abbreviated as IPv4, which was standardized in RFC-791 (Postel, 1981b) almost forty years ago. The newer version, IPv6 was specified more than twenty years ago (see RFC-2460, Deering & Hinden, 1998)¹⁷, 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 in RFC-793, Postel, 1981c) or UDP (fire and forget, see specification in RFC-768, 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).

IPv4 is a quite old protocol, and its successor was discussed for a long time, culminating in the “Kobe incident” where IPv6 in practice was chosen. See upcoming Section 7.3 for a deeper dive into the issue.

¹⁶In terms of the interoperability thought style BCP-38 is quite a decent document, but not in terms of the **bureaucratic** and **market** thought styles which I get back to later in Chapter 7.

¹⁷The current Internet standard for IPv6 was set much later, in 2017, in RFC-8200 (Deering & Hinden, 2017), which essentially is the same as RFC-2460 (Deering & Hinden, 1998) except technical details of high specificity (errata, updates to match newer versions of other protocols, etc, but at the conceptual level the same protocol following the same ideals). RFC-8200 (Deering & Hinden, 2017) is standardized as Internet Standard 86.

One important coordination difference between the two protocols is the allocation “object”¹⁸; in IPv4 a home or small businesses 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, where home or small businesses are rather allocated several billions of public IPv6 addresses, in a so called address-block (address blocks are technically known as **Classless Inter-Domain Routing (CIDR)** blocks). The intention behind this is to make IPv6 as use agnostic as possible, so that if a user in fifty years want to assign a IPv6 address to each of his / her nanobots, that would be possible. Note that when IPv4 was specified the address space was for billions of devices, in an age where computers were research equipment for large institutions.

An informational RFC argues on the topic of IPv6 and **Network Address Translation (NAT)**:

IPv6 was designed with the intention of making NAT unnecessary
(RFC-4864, de Velde et al., 2007, p. 1)

Table 3.4 summarizes a short comparison of IPv4 and IPv6. There is one key point related to the interoperability thought style of importance here: 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 **Dynamic Host Configuration Protocol (DHCP)**-servers). This is a key illustration of the notions going into IPv6, even if the address-space is larger than the IPv4 address-space, the protocol itself has less functionality, and is therefore more interoperable.

The best-effort design of IPv4 and IPv6 makes the idea of trust of the Internet quite tricky. The essence of trust of the Internet is that the Internet should not be “trusted” to deliver packets, because the network is dumb and best-effort, not evil. Therefore, smartness such as guarantees of delivery has to be handled at the edges; the protocol of the Internet, IP does not guarantee anything. As per the IPv4 Internet Standard itself:

There are no mechanisms to augment end-to-end data reliability
(RFC-791, Postel, 1981b, p. 1)

In the sense of trust, IP and DNSSEC are quite opposite. IP has no trust mechanisms in itself, while DNSSEC requires some form of pre-existing trust, in the form of identification of trust anchors by cryptographic keys.

¹⁸Technically an address, either IPv4 or IPv6, and a netmask, which is a bitmask signifying which bits, starting from the first bit, of the address are unique. For example, 192.168.1.1 is a simplification of 192.168.1.1/32, where 32 is a simplified form of the bitmask stating that the first 32 bits are relevant, i.e., the entire IPv4-address. Comparably, 192.168.1.1/24 would signify the entire range 192.168.1.0 – 192.168.1.255, i.e., the first 24 bits as specified and the remaining 8 bits could be anything.

Table 3.4: IPv4 and IPv6
Comparison of IPv4 and IPv6 in the context of this thesis. The table does not contain other experimental IP versions. Note the extreme differences of number space and that IPv6 in many cases is a more feature limited version of IPv4, for example fragmentation was removed in IPv6.

Protocol	Address space	Comment
IPv4 (RFC-791, Postel, 1981b)	$2^{32} \approx 10^9$ 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).	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.
IPv6 (RFC-1883, RFC-2460 and RFC-8200, Deering & Hinden, 1995, 1998, 2017)	$2^{128} \approx 10^{38}$, 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 (!).	Has support for stateless client-based addressing and router announcements, i.e., less need for central network governance such as DHCP-servers.

As an interesting side-note; all IPv4 addresses are “known”, since there are only a few billion of them, so it is possible to track them all. Shodan¹⁹ does this, and scans *all* IPv4 addresses and stores 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).

Almost forty years ago the [Internet Experimental Notes \(IENs\)](#) were “civilian” RFCs back when the [Defense Advanced Research Projects Agency \(DARPA\)](#) controlled [ARPANET](#), and [Internet Experimental Note \(IEN\)-48](#) (Cerf, 1978) can be said to describe the precursor to IPv4 and the Internet networking model. This model was then referred to as the “catenet” model, which, according to interviews, stems from “concatenating” (a technical term for putting one after another, i.e., connecting sequentially) network, much like “internet” stems from “*inter*connected” network.

[Catenet] to mean roughly “the collection of packet networks which are connected together.” (IEN-48, Cerf, 1978, p. 1)

3.6 Conceptualizing a technical only Internet

Now I have gone through some central (technical) functions of the Internet. Is it meaningful to then define or conceptualize the technical Internet? That is, without looking into governance or coordination aspects.

The short answer is *no*. Note that this section discusses a technology-only definition of the actual Internet, not a technology based definition of any possible set of connected networks. One reason for this is that it is very hard to define what “being on the Internet” is. A working paper, the presentation of which I attended, aptly named *Whither the Public Internet?* thoroughly goes through and argues that defining the Internet in a technical sense is literally “a fool’s errand”. The conference paper was later published in a journal as Lehr et al. (2019). The reason for viewing it as a fool’s errand, that it would be difficult to pinpoint what it would 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 for the no is that even at a very technical level, namely implementation of technology and standards formulation, 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

¹⁹Shodan (shodan.io) indexes many if not almost all Internet-facing hosts, and shows publicly if they are vulnerable. It is a common tool for penetration testers, and they provide a free [Application Programming Interface \(API\)](#). See for example Scheerer (2018) for a DEF CON presentation on how to use the shodan.io API for penetration testing.

packets are malformed and do not conform to standards, are they still Internet packets? What about using another DNS root?

These are part of the reason I suggest (and assume²⁰) that the Internet must be seen as consisting of both coordination and technology. In comparison, Lehr et al. (2019) suggests three lenses, or three perspectives ((1) abstract architectural, (2) network complementors, and (3) customer experience), in which to make sense of the Internet. This thesis includes parts of all three, and in particular Chapter 10 discusses use of the Internet in light of *net neutrality* in these aspects.

3.7 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 black-box most technical matters, or at least do not delve into the design decisions of the technology, and seem successful in their own right in relevant thought styles (including but not limited to DeNardis, 2012; DeNardis and Raymond, 2013; Liu, 1999; Mansell, 2012, 2017; Zittrain, 2008).

Section 6.3 delves deeper into the particulars of technology as IT in organizations as a coordination problem, and presents a more conceptual argument on why it is of utmost importance to understand technology today to properly understand its meaning.

The focus of the interoperability thought style is to prepare for change. While the *bureaucratic* and *market* thought styles might be argued to optimize on static configurations (on maximizing, and sometimes minimizing, something of importance, for example value capture) the interoperability thought style optimizes on minimizing the need for change of components when overall change is necessary. In the interoperability thought style the purpose of IPv4 is not only to create the best possible best-effort protocol at that time (forty years ago), but also to create the best possible best-effort protocol which can be *replaced* with the least effort in the future. This serves to make the transition from IPv4 to, for example, IPv6 as smooth and easy as possible.

Take Moore's law as an example; in the original formulation the notion that normal²¹ 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

²⁰In practice these are two assumptions; first, the Internet is possible to conceptualize, and second, whatever possible conceptualization exists it must contain at least a technology and a coordination dimension. See further reasoning in Chapter 6.

²¹Normal as in does not have any special features, for example for extreme environments, such as protection from solar storms, military electromagnetic pulses, and so forth, since such circuits normally are much less dense.

cameras, throughput for Ethernet standards, and memory size (see Wikipedia Contributors, 2019, 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, a piece of digital technology could change fundamentally (in terms of use). Handling these fundamental changes is one of the cores of the interoperability thought style.

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 inches 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 for most users over the Internet in 2000, in 2007 YouTube was starting to get big, and in 2014 Netflix was more or less the norm (in younger circles at least) for watching movies.

Or music, the premium Apple device released in 2001 with the slogan “1,000 songs in your pocket” (the first iPod), and in late 2020 the slogan was “60 million songs. On your wrist” (the Apple Watch). This represents an 80 % year-on-year increase²².

In comparison, the complexity of the Internet grows on average $\approx 13\%$ year-on-year, fluctuating from 6 % to 23 %, as illustrated in Table 3.5. This is fast, but not the breakneck pace of Moore’s Law. In Table 3.5 nodes refers to instances of importance in routing, e.g., ASs 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 $O(n \log n)$ to illustrate the increase in complexity of actually managing the network²³, which turns out to be substantially below

²²It should be noted that this is not the change of one specific technology, but the cumulative effect of several technologies changing and improving over time. For example, the 2020 device does not store 60 000 times more songs offline, it uses Internet to have them available on-demand, and allows you to store a hundred thousand or so songs off-line.

²³Most data management problems, such as sorting, scale as $O(n \log n)$. That is handling double the data is a tad more troublesome than double the complexity (or time consumption).

the current velocity of digital technology development (i.e., 42% over time using Moore’s law). Figure 3.2 illustrate the same growth as an area of a figure; the two sub-figures in Figure 3.2 are of the same scale.

Table 3.5: Routing complexity of the Internet

The routing complexity of the Internet illustrated by the number of ASs and prefixes a router potentially needs to keep track of. Nodes refers to the sum of prefixes and ASs found. Peering refers to the connection between ASs and prefixes found. Shows the period 2000 till 2020. Using $O(n \log n)$ to illustrate complexity of network growth. Based on prefixes and AS present in BGP-topologies generated from BGP-dumps from Route Views and RIPE Stats.

Year	Nodes	Peering	$\Delta n \log n$
2000	103 104	112 350	—
2001	124 833	137 586	21.07 %
2002	132 258	146 541	5.95 %
2003	148 845	169 983	12.54 %
2004	171 106	194 528	14.96 %
2005	197 386	225 638	15.36 %
2006	230 261	264 460	16.66 %
2007	271 503	313 275	17.91 %
2008	333 876	384 926	22.97 %
2009	371 158	426 693	11.17 %
2010	409 591	471 670	10.35 %
2011	485 378	565 742	18.50 %
2012	551 433	638 881	13.61 %
2013	610 268	712 743	10.67 %
2014	656 380	768 109	7.56 %
2015	695 616	824 912	5.98 %
2016	771 739	934 128	10.94 %
2017	840 754	1 025 168	8.94 %
2018	960 556	1 175 639	14.25 %
2019	1 038 741	1 325 205	8.14 %
2020	1 109 537	1 475 242	6.82 %

Based on BGP data (see Section 2.8).

Figure 3.2: Comparison of the technical Internet

The change in size of the technical Internet over the years. The figures are of the same scale, and the 2020-figure contains roughly ten times as many nodes as the 2000-figure, at a bit higher concentration.

Huber (1987), talking of an earlier period, tells a similar story to Table 3.5, that is the networks themselves change much slower than the equipment using the network²⁴.

The unit price of electronic capability halves every one or two years; the costs of last-mile, low-density transmission are standing still [i.e., last-mile], at least by comparison. Network functionality will therefore continue to rush out to edges.

(Huber, 1987, p. 1.14)

Note that with the edges Huber refers to both the consumer edge, and the edge at the **Content Delivery Network (CDN)** or other host provider. It is an economic argument for the *stupid* network, i.e., an Internet-like network, where the *smartness* is located at the edges.

²⁴It should be noted that compared to an exponential function, even polynomial functions are comparable to constants over time from a mathematical perspective.

With this conceptual view of digital technology developing rapidly and leading to changes, 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, in Table 3.4, of assigning every atom in human bodies an address (theoretically possible, see also similar approach in April Fool’s RFC-8369, Kaplan, 2018)²⁵.

Important to remember is that in this dissertation, I think of the Internet as the digital communications network capable of handling these both gradual and dramatic shifts of usage and throughput. The Internet, as I argue in this thesis, was originally the technical manifestation of interoperability thought style values applied to a digital communications network.

To sum up:

- Digital technology is rapidly evolving, and therefore fundamental changes often happen
- Therefore a network which should be able to cope with these fundamental changes need to be decoupled from the use of the network to as large extent as possible.

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. By separating and decoupling the Internet as a digital communications network from its use it is possible to avoid such interdependencies. In a non-digital world ideas and implementations might change together naturally, but in a digital world coordinating change is assumed to be more expensive than decoupling and allowing non-coordinated change freely.

Later, in Chapter 10, net neutrality is discussed in detail as an example of a real world consequence of what the Internet is and means.

3.8 Practical interoperability

Interoperability is a tricky concept, and I here illustrate how it is possible to handle interoperability. In short, this section goes through two high level antonyms related to interoperability: **separation of concerns** and **integration of concerns**.

For the technical Internet, separation of concerns is manifested through the use of layers, as the web is a service on top of the Internet, TCP runs

²⁵Far from all RFCs are standards, as mentioned, and every year there seems to be a handful of RFCs with a pure comedic, albeit technical, value. RFC-8369 (Kaplan, 2018) notes that a 128-bit address space is more than enough to assign every human a unique emoji.

on top of 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 according to convention belongs on another layer, which breaks interoperability.

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. That purpose should not change, even if the implementation can. In terms of the Internet, IPv6 separates concerns further than IPv4.

Contrary to separation of concerns, it is possible to integrate concerns, often to attain a current performance or usability goal. For example, Bluetooth and the profiles for hands-free (HFP and HSP) and media (A2DP) each bundle their 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 sound quality. There is probably an old performance reason for this, perhaps there was no business reason for allowing higher quality due to the increased price of the electronics.

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.

As the earlier section on IPv4 and IPv6 (Section 3.5) discusses, the design decision of the **Internet Protocols (IPs)** was to separate concerns, even if there is an efficiency drawback.

Going further into digital communications, another example of integration of concerns in a business context is bundling data communications (such as Internet access / service) with a streaming service, as is the case for most cable-TV services (classic cable-TV, not Internet-access over cable-TV). Among other, Huber (1987) provides a financial and economic argument for integration of concerns in market and business contexts (i.e., market integration of concerns rather than technical integration of concerns).

I use separation of concerns and integration of concerns in this thesis to illustrate the extent to which concerns are separated, not only in terms of technology, but also in terms of coordination. The same way it is possible to design a protocol to be interoperable between networks, it is possible to design organizational processes to avoid what in the interoperability thought style amounts to unnecessary organizational interdependence. Examples include that ccTLDs codes are based on **ISO-3166-1**, rather than any organizational structure and any of relationship with **nation-states** themselves.

Texts such as Dijkstra (1982), Gamma et al. (1996), Kim et al. (2013), and Martin et al. (2003) offers insight into practical management of interoperability through software design and use.

3.9 Chapter summary

This chapter introduces the technical **Internet** and goes through the relevant mechanics for the remaining thesis. This chapter also, more importantly, introduces the **interoperability thought style**, the **thought style** of individuals who optimize on change over all other possible concerns. The interoperability thought style refers not only to **technology**, but a way of viewing the world, where change or interoperability is important above all else, even in terms of **coordination**.

Of specific technical importance is that **Domain Name System (DNS)** and **Border Gateway Protocol (BGP)** solve the problems of keeping records, in slightly different fashions. DNS is hierarchical and based on one common **root-zone** (the one produced by **Internet Assigned Numbers Authority (IANA)**), and BGP is based on your network neighbors.

This chapter also illustrates the differences of **IPv4** and **IPv6** and the values behind the protocols. In general terms, the protocols are designed to be interoperable and open for any future use, rather than optimizing on any particular use at their inception.

In general this chapter forms the (technical) foundations and thoughts used throughout this thesis. This chapter also 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

Bureaucracy frame of reference

með lögum skal land byggja en með ólögum eyða

society should build on law; without, it perishes

— *Njáls saga, proverb*

This chapter is the second of three frame of reference chapters, which each are set within different (scientific) domains. The prior chapter focused on the technical nature of the **Internet**, and also introduces a common mindset in designing complex technical systems, the **interoperability thought style**. The interoperability thought style is focused in interoperability, of both **coordination** and **technology**. This chapter introduces a bureaucratic view of coordination and technology, the **bureaucratic thought style**, and the next chapter give a value-capture perspective on the same, the **market thought style**.

The purpose of this chapter is to frame and explain the epistemic logic behind the bureaucratic thought style, and it also includes theories and reasoning which lies closer to the bureaucratic thought style than either the interoperability thought style (changeability and interoperability above all else) or the market thought style (which focuses on principles of value capture). The bureaucratic thought style as constructed in this chapter focuses on the unique aspects of the bureaucratic thought style relative the other **thought styles**, rather than to provide a nuanced understanding of a bureaucratic mindset in general.

I start off with bureaucracy and legitimacy in general, and continue towards communication networks in general, then the Internet specific context with **net neutrality** as a policy or economic construct, and discuss legitimacy based organizing through a social resilience lens.

The epigraph of this chapter is a proverb from Njáls saga, which is an Icelandic saga. The first part, “með lögum skal land byggja” is the motto of the Icelandic police, is stencilled on the building of the Copenhagen district court (*Københavns Byret*) and was the motto of the Swedish (and Norwegian) King Charles XV (*Karl XV*). The epigraph is translated for the purpose of this thesis, “society should build on law; without, it perishes”, which is a translation of the proverb based on the meaning of the words in the thirteenth century.

This chapter itself does not compare the thought styles in detail; that exercise appears in Chapter 6, which contrasts and compares the thought styles presented.

4.1 Introduction to bureaucracies

The world of bureaucracies depends on and sees different things and values than the interoperability thought style. This chapter focuses on bureaucracies, as seen by Weber et al. (1991) and Beetham (1996), which is distinguishable from the value-capture logics of the market thought style (more on the explicit differences in Chapter 6).

Bureaucracies are based on legitimacy, rather than economic efficiency (as markets are) or preparedness for change (as per the interoperability thought style), and rather concern structures which it should be possible to rely on (for some set of actors). Legitimacy is a returning concept in this chapter, as is audit and policy.

For example, Weber et al. (1991, a collection of essays) concerns bureaucracies as a concept, or rather as legitimate social structures of power, as an almost necessary evil due to the requirement of structure of society. Beetham (1996, a book on the subject of bureaucracies, mostly contrasting Weberian and marxist views), gives a brief introduction to the subject and two classical dominant views (i.e., Marx’ and Weber’s views), on the notions of what the problems of society are and how they should be solved. Summarized to the context of this thesis, both Marx and Weber argue for bureaucracies to solve the inherent conflicts between classes (in Marx’ terminology), which Marx structures around controlling the means of production, and Weber illustrates in more nuance (in, among others, Beetham, 1996; Weber et al., 1991).

The common ground is the bureaucracy as the mediator between conflicting parties, in many countries as the democratically elected parliament and government, but also as military or dictatorial regimes. In the Weberian view the market can be seen as a tool for the bureaucracy; the bureaucracy does

not need to stand on its own (cf. Ouchi, 1980 and employment as a sign of bureaucratic legitimacy) and can rather create markets to do the same work more efficiently (cf. Ouchi, 1980 and market coordination based on price, through some negotiation process).

Going further into this chapter it is important to note the distinction between legitimate and legal. In addition, I find the typology of institutional trespassing (see Table 4.1) 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. 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 style (and sometimes a more narrow leading thought style by its **epistemic community**, cf. Adler and Haas, 1992; Haas, 1992). Thus, both legitimacy and legality is context-dependent rather than absolutes. Further on I refer to this matrix as the institutional trespassing matrix.

Table 4.1: Typology of entrepreneurship
 Typology of entrepreneurship based on institutional trespassing. Illustrates the notion that all activities are not necessarily legal, and not all illegal activities are necessarily frowned upon. Adopted from Lundmark and Westelius (2012).

	Legal	Illegal
Legitimate	Formal	Informal
Illegitimate	Offensive	Renegade

I do not assume that all actors in an ecology are legal and legitimate. As an example, Mueller and Chango (2008) discuss **Internet Corporation for Assigned Names and Numbers (ICANN)** and **WHOIS**, the database of domain owners, where WHOIS is sometimes illegal but legitimate by their users. WHOIS and **General Data Protection Regulation (GDPR)**, and also Schrems II, are still objects of a raging debate at arenas such as ICANN¹.

As a base for the bureaucratic thought style I use a combination of bureaucratic mediation in Ouchi (1980), ideals in Beetham (1996), accountability and audits from Power (1999), discussions with both academics and practitioner², and publicly available documents, such as governance procedures for governments and agencies. The argument in Power (1994, 1999, 2000) can briefly be summarized around the concept that modern society is organized

¹In May 2018 ICANN implemented a temporary specification for **generic top-level domains (gTLDs)** (not including **country code top-level domains (ccTLDs)**), see <https://www.icann.org/resources/pages/gtld-registration-data-specs-en>, which is a bureaucratic action allowing registrars to follow GDPR without breaking contractual relations with ICANN. However, it is still possible to find GDPR protected personally identifiable information in the WHOIS-system.

²Politicians and bureaucrats which I engaged in informal discussion with.

around the concept of audit, that audit is an institution or “constitutive principle”. As such, bureaucracies, and larger organizations, organize themselves to optimally pass audit, rather than to, for example, execute their function to their best of abilities (for example to reach optimal economic efficiency). It is possible to critique the institution of audit described in Power (1999), as for example Maltby (2008) does, and Power himself does to a lesser extent in Power (2000); where he argues that “many of the claims require further empirical support” (Power, 2000, p. 111).

Power (2000) refines the audit-concept and discusses the need for the transparency of audit-processes. Contrary to the interoperability thought style where concerns should be separated, audits bundle and integrate processes. In that sense bureaucratic thought style focuses on aspects which are contrary to, or at least different to, the interoperability and market thought styles.

Power (1999) argues that to some extent decisions (in his context) are taken rather based on how they can be audited than the performance (depending on thought style) of the decision. This means, if the audits are procedural, that the process of the decision matters significantly more than the actual outcome (performance) of the decision. This is contrary to beliefs in the interoperability thought style, where results are deemed more important than the process for reaching them.

Auditability is of importance, and structures are assumed to be built around principles in Power (1999), that is with the undertone that the cost of auditability is, essentially, never too high. For auditability to make sense contracts and agreements are important, as well as means of settling disagreements regarding said contracts.

As a contrast, for communications networks, Huber (1987) describes how networks could go from being meaningful in what I term the bureaucratic thought style (and to some extent the market thought style) to being primarily meaningful in the interoperability thought style. That is, instead of the network as a vessel of bureaucratic reason and legitimacy, or market efficiency, the networks could rather be a product of best-effort engineering adapted for changing environments.

The bureaucratic thought style also draws on DeNardis and Raymond (2013) and Liu (1999) in that the digital network itself is not meaningfully separated from that which runs on top of it. Therefore, traffic should be clearly connected to user, jurisdiction and what service the traffic pertains to.

4.2 Bureaucracies and markets

As earlier mentioned, bureaucracies and markets are closely related, often with a market as the tool of the legitimate bureaucracy to obtain a legitimate goal (e.g., the Weberian view). See for example Coase (1937), which describes firms using the same terms that Ouchi (1980) uses to describe markets and

bureaucracies. The conflict between the bureaucratic and market thought styles is similar to the societal class conflict as described by, among others, Marx (1867/2019) and Weber et al. (1991)³. Also, Smith (1776, with visible and invisible hands) and Marx (1867/2019, with bureaucracy) describe the same fundamental problem (organization of society) and present two different solutions. A more modern version of both the issues at hand and solutions for the problems are presented in the much televised debate of Jordan Peterson and Slavoj Žižek (“Happiness: Marxism vs. Capitalism,” 2019). The later Benkler (2002, 2006) describe the same problem, but adds a third means of production, which is called commons-based peer production. This third means of production bears traits of the values I capture in the interoperability thought style; the fuller comparison is done in Chapter 6.

However, as noted above, markets and bureaucracies do not have to be opposites. For example, Max Weber makes the argument that bureaucracies (as the legitimate actor) can use markets to attain its goals. Texts such as Bachelier (1900/2006), Malkiel and Fama (1970), Mandelbrot (1963), and Samuelson (1973) argue mathematically for the usefulness of using markets to attain such goals, together forming the basis of the “efficient-market hypothesis”, which states that as long as markets function (for example new entrants can enter) all financial goods (assets, products, services, etc) will be priced correctly and efficiently. Note that from a market design perspective, super-profits are a sign of market inefficiencies, since means are not used efficiently. This is a fundamental conflict between the value capture logic of the market actor and the market designer which I will get back to throughout the thesis.

Not explicit in either Marx (1867/2019) or Weber et al. (1991) is the role of money for markets, which Graeber (2012) and Mitchell-Innes (1913, 1914) argue is a concept dependent on a legitimate bureaucracy to function, that is a trusted third-party or arbitrator which ensures the value of, for example, paper monies and digital credit. Here, there is a clear linkage, or dependency, between bureaucracies and markets (even if Smith, 1776 disagree explicitly, and argues that mercantile monies, rather than credit backed by bureaucracy or institution, is the foundation of markets). I bring up money here, in the effort of theorizing, as I find many similarities between the Internet and money as infrastructure for societies and actors in societies (including firms, non-profits, government agencies, etc). This does not fit within the scope of this thesis, or “[h]anc marginis exiguitas non caperet” as Pierre de Fermat⁴ would have said, however I do note that I believe that conceptualizing the Internet as societal infrastructure, such as money, rather than societal utility, such as

³The Marx reference here is a translation of the original “Das Kapital”, I have not read the German original.

⁴Fermat’s Last Theorem was conjectured in the margins of his copy of *Arithmetica*, where he also noted that the proof does not fit in the margin in 1637. The first actual proof was released in 1994 (the more than a hundred pages long proof is available in Wiles, 1995), more than three hundred years after the formulation of the conjecture.

electricity or water, or as a market commodity, such as tomatoes or streaming subscriptions, would add nuance to Internet in societal debate.

4.3 Communication networks

In the era of telegraphs and telephones, networks were usually (e.g., Huber, 1987) described as pyramid based, that is entirely hierarchical in their nature⁵. In contrast, **Border Gateway Protocol (BGP)**, as discussed in Chapter 3, supports multiple possible paths, where no guarantees are given for the actual viability of the path and each network has to decide where to propagate the packet.

The term “geodesic”, as in *The Geodesic Network* (the title of Huber, 1987), refers to the possibility of “the shortest path” networks, cf. Huber (1987)⁶:

When switching is expensive and transmission is cheap, the efficient network looks like a pyramid. One hundred million telephones converge into twenty thousand end-office switches, which converge into a thousand tandem switches, and so on up to a handful of regional master switches at the apex. The system has comparatively few switches; it has many lines. By contrast, when switching is cheap and transmission expensive, the efficient network is a ring. The nodes (switches or computers) are connected along a “geodesic”—a path of minimum length. Switches and other intelligent nodes proliferate; transmission is kept to a minimum. (Huber, 1987, p. 1.3)

Incidentally, this geodesic, or shortest path, approach describes the origin of the Internet quite well. Note that Huber (1987) here does not refer to an explicit ring-like network, and further clarifies the nature of interconnection.

Huber (1987) further acknowledges that switching-cost then (1987) had gone down enormously from the era of human switching operators, and today the costs are even lower. In essence, Huber (1987) argues for the economics of networks to put smartness closes to users:

The inexorable trend is therefore to move switching out toward the end user. Making connections at a distance costs more in increased transmission than it saves in lowering the number of connections needed. (Huber, 1987, p. 1.3)

⁵This is not the same as distributed, as hierarchical networks only have one possible path between any two nodes. Huber (1987) uses the term “dispersed network architecture” instead of distributed.

⁶Page numbers are on the format *chapter.page* in Huber (1987), i.e., 1.3 refers to the third page of the first chapter.

The notion here is that redundancy will be built into the network as long distance lines, in general, are not preferable from an economic standpoint compared to multiple short distance lines.

Cowhey (1990) does a similar analysis, but contrasts the perspective of telecommunications being in the domain of **nation-state** controlled interests, to firms with a clear profit goal instead of a welfare one.

the biggest change is that one coalition of market participants (large users, computer and newer electronics firms, and service companies) has won at the expense of the traditional beneficiaries of the regime (including households, rural users, electronics firms associated closely with the PTTs, and the labor forces of the PTTs).
(Cowhey, 1990, p. 195)

PTTs (postal, telephone and telegraphs authorities), in the quote refers to the common merger of regulator and service provider, where (often) a government entity was responsible for both provision and regulation of postal, telephone and telegraph services. Where, in practice according to Cowhey (1990), international telephone calls by large firms essentially subsidized the other services, and especially postal and telephone service for private individuals.

In the bureaucratic thought style this subsidization of communications services for private individuals by large firms is inherently meaningful. Texts such as Cowhey (1990) and Huber (1987) do not explicitly discuss jurisdictions, and rather implicitly assumes that the networks are governed under rule of law, especially in the early regime where nation-states actors where in charge of both services and regulation. And when international communications norms were set at the **International Telecommunications Union (ITU)** by nation-states and their representative (see description in Cowhey, 1990). This is problematized in Chapter 7 and Chapter 10 which illustrate the disconnect between the current Internet technical and coordination design and nation-state jurisdictions and logic. This illustrates two components of the bureaucratic thought style: (1) it is possible to assume that communications networks follow all laws and regulations (which several interviewees indicate), that (2) communications networks should follow laws and regulation, by for example technically identifying legal or physical entity at protocol level.

Currently, that “switching” is done by your **Internet Service Provider (ISP)**, and it is commonly called routing. Worthy of note is that Huber (1987) notes changes in network structure already in 1987, that is more than thirty years before the defense of this thesis, and ten years ahead of widespread Internet usage:⁷

⁷Assuming, broadly, that the Internet through the **web** gained traction in the late 1990s.

In all of this, regulation has been a large part of the problem and a small part of the solution, often at the same time. It remains so to this day. The MFJ's equal-access mandates, and the FCC's complementary rulings covering CPE and interstate private lines, have sensibly channeled the pro-competitive force of technological change. But the evolution of competition is placing great strains on many vintage regulatory deals, and reactionaries have also made their appearance in some regulatory circles.

(Huber, 1987, p. 1.21)

Compared with the notion that markets might serve bureaucratic ideals, Huber points at how some regulatory moves have harnessed market forces for a development that he views as socially desirable. He also notes that competition which I would label as market thought style can come at odds with the bureaucratic thought style which can add strain to the system. Cowhey (1990), as noted above, does a similar analysis, with the example in the quote earlier.

4.4 A short history of the Internet

Now we turn the focus back to the Internet, one particular instance of a communications network or service as seen from the bureaucratic thought style. This section comes after the previous more general section to illustrate that the assumptions and beliefs in policy and economics in regard to communication networks comes from market and bureaucratic descriptions of circuit switched networks rather than an understanding of packet-switched decentralized networks — the technology of the Internet.

The Internet and the idea of a global network of networks stems from the **Defense 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 place⁸, but for ARPANET the governance and infrastructure organized differently. 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 (see, for example, Zittrain, 2008 for fuller history).

⁸But as noted in Cowhey (1990) and Huber (1987) often organized in such a way that the cost carried by the large firms buying network access between offices subsidized other entities, such as households, and were therefore quite expensive.

Traditional systems for computer communication were based on intelligence and control in the [communication] system itself. The networks were designed [with an explicit and intended] use.

(translated from Swedish Hamngren et al., 2003, p. 14)

Comparably, the Internet is argued to be the result of people thinking differently, and not assuming what the networks are supposed to be used for. That is the notion of interoperability.

[the new generation of network engineers] advice was therefore a design with as little functionality as possible in the networks themselves which did not limit the design of future applications.

(translated from Swedish Hamngren et al., 2003, p. 14)

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 **Internet Engineering Task Force (IETF)** (1993-ish in the current form⁹).

In a sense, 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”, 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).

Here, we have started to look at ideas about how the Internet should be developed and function, issues related to **governance** and coordination. There are several suggested ways of labeling and looking at Internet Governance, one of them shown in Figure 4.1. I consider it an example of the bureaucratic thought style. The common attribute of the labels I have encountered is that they do not capture the power and coordination relationships.

Looking at Figure 4.1, 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 4.1 is rather a table in image format rather than an illustration of the complex connections

⁹The USA semi-controlled IETF is older, but is ostensibly a different organization. More on that in Section 7.3.

Figure 4.1: Overview of Internet Governance.
 Overview of **Internet Governance**, a production of CENTR.org, the European ccTLD trade organization. Updated after the ICANN bylaw rewrite in 2016.
 Used with permission, see [endnotes](#) (page 291).

present. And the **Internet Assigned Numbers Authority (IANA)**-function is missing, and rather **Public Technical Identifiers (PTI)**, the organization, is present instead¹⁰.

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-level domain (TLD)** is operated by the non-profit **Swedish Internet Foundation** in Sweden partly on the basis of a **Memorandum of Understanding** with ICANN (see Aerts, 2007; 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. It is also possible to have a delegated ccTLD domain without any form of recognition from ICANN. In those cases there is only technical con-

¹⁰As noted in Chapter 3 the IANA-function is mentioned as a function instead of an organization in technical literature, such as **Requests for Comments (RFCs)**. Chapter 7 has several more nuances passages on the relation of ICANN, IANA and PTI.

tact between the ccTLD and the IANA-function. Section 7.4 goes over the empirical setting for ccTLDs.

Data of the Internet prior to 2000 is hard to find, and Figure 4.2 depicts the Nordic Internet in 1990, that is prior to widespread acceptance of the BGP standard, when all Nordic countries together consisted of just 3 (!) **Autonomous Systems (ASs)**. Note here that this is prior to wide BGP acceptance and commercialization of the Internet, such services started to pop up in 1993 and 1994 depending on location.

Figure 4.2: The Nordic Internet in 1990
BGP-typology of the Nordic countries in 1990. Illustrates an Internet pre-BGP world. Compare with the millions of entities in BGP-dumps today.

Used with permission, see [endnotes](#) (page 291).

As an example, the last Internet preventing monopoly in Sweden by Televerket (the Swedish **national regulatory authority** for telecommunications back then¹¹) ended in 1992¹² and ISPs became quite common after that. Worth noting is that Sweden has “open-access” regulation in the sense that ISPs might sell Internet access services on top of infrastructure owned by someone else.

¹¹Televerket was in several steps over several years split into Telia (a firm), Post- och telestyrelsen (the current national regulatory authority), Teracom (a firm), Eniro (a firm), etc.

¹²This monopoly did not concern the Internet per se, but rather ownership and maintenance of wired connections.

Comparably, the USA has gone through a similar reform a couple of years before, with the breakup of AT&T into several smaller companies, the “Baby Bells” (effective 1984). This is an example of the changing regimes in Cowhey (1990) where market thought style logics were introduced on the telecommunication arena, in practical terms marking the end of a bureaucratic thought style mediated communications era.

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 [World Summit on the Information Society \(WSIS\)](#) (and later the working group [Working Group on Internet Governance \(WGIG\)](#)) was created by the [United Nations \(UN\)](#) organ on telecommunications, the ITU. Both the WSIS and WGIG can be said to be bureaucratic entities vying for a regime closer to the old regime in Cowhey (1990), a bureaucratic thought style construction.

According to Weber (2009), and several interviewees, 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. The actors providing Internet infrastructure chose to adhere to ICANN, not WSIS. Neither organization had any formal authority. Note that these Internet infrastructure actors are the same market actors as Cowhey (1990) describe and universities, and they chose to be coordinated through ICANN (a loose interoperability thought style constellation to manage the IANA-function) rather than WSIS or similar bureaucratic thought style organizational structure.

In both Chapter 9 and Chapter 10 I go back to naming and [numbering](#) and the discussion of their coordination. For example, the resolutions suggested by the ITU at the [World Conference on International Telecommunications \(WCIT\)](#) 2012 imply greater control by ITU and sub-groups over naming and numbering. That is, similar to the nation-state coordinated telecommunications regime described in Cowhey (1990) and Huber (1987) prior to marketization of telecommunications.

As can be seen from the examples of Huber (1987), Cowhey (1990), and ICANN and WSIS, the history of international telecommunications is fraught with bureaucratic thought style values of organization and coordination which have been run over by other values and ideals. The market thought style in terms of telecommunications, and as I argue in this thesis, the interoperability thought style in terms of coordination of the Internet.

As an introduction to a potential third view, in addition to “hands-off” and public policy similar approaches mentioned in Cowhey (1990) and Huber (1987) and more, Lessig (1999) introduces “NET95” as a representation of what the Internet used to be back in 1995. NET95 is seemingly abandoned later in the text, and in this thesis I make the case that the values of what Lessig (1999) terms NET95 live on, partially through path dependence in [implementation of technology](#) and [standards formulation](#), but also as actual

values of people I interview. Essentially, NET95 aligns with the interoperability thought style.

Lessig (1999) makes the overarching argument that “code” is “law” in cyberspace when he discusses four components or *regulators*; law, markets, social norms, and architecture (Lessig, 1999). These are four different objects of study, in the same way that my thesis focuses on implementation of technology, standards formulation, *coordination of technology*, and *meta-coordination*, where law, markets and social norms are used to discuss what I term coordination, and architecture as a combination of technology and coordination.

Of particular noteworthiness is Post (2000) who, after a main body of text which illustrates every issue where Post and Lessig disagree, states that there is some form of nuance needed, that there are alternatives to public policy and free-markets.

The truth, inevitably if somewhat anti-climactically, lies somewhere in between the rather more extreme positions to which rhetoric often confine [libertarianism and state-control]

(Post, 2000, p. 1459)

Post (2000) reasons in a similar direction as Lessig (1999), and seemingly assumes that NET95 is a bygone era, and that all standard setting “today” (in 2000) is done with market intentions, essentially the market thought style of a few large actors, except when held back by collective power.

The argument in my thesis is that something very similar to what Lessig (1999), Lessig and Lessig (2006), and Post (2000) term NET95 lives on, in what I term the interoperability thought style, both in core architectural decisions of the Internet, and through individuals who partake in coordinating the Internet today.

4.5 Net neutrality and the Internet

As a nation state there are essentially three perspectives on net neutrality as a broad concept of network control; (1) digital communication is a human right and as such net neutrality is needed (cf. Declaration of Human Rights in United Nations, 1948), (2) the state needs to protect its citizens or otherwise be in control of online content (cf. Great Firewall of China), and (3) net neutrality is not a bureaucratic / state level / regulatory issue (cf. the “hands-off”-approach).

The first (1) perspective is representative of most Western states, excluding the USA. See for example Bercé (2017) for the view of the EU-level institution,

or for example the Electronic Communications act (i.e., LEK, 2003) for the regulation particular to Sweden where net neutrality is enforced by law¹³.

The second (2) perspective is common in more totalitarian states; examples include the China, Russia, and Iran, but there are surely more. At an implementation of technology level these countries often have a gateway **Autonomous System (AS)** which all traffic passes through, which filters traffic. These countries networks behave, in a technical sense, like corporate networks. In other words, the difference in operation between nation state level firewall operations and a large corporate gateway is less about *what* is done, and more about *who* does it and *why* it is done.

The third (3) perspective is prevalent in the USA (to varying degrees over the years), and rather implies that net neutrality is a market issue in the discussions I encounter it. That is, if the bureaucracy does not decide, the market will decide. In this thesis, in particular in the net neutrality discussion in Chapter 10, I rather make the case that the standards perhaps decide instead of market forces directly. For example, end-to-end encrypted protocols such as **QUIC** limits any reasonable net neutrality enforcement, both for and against net neutrality. The flow would, from the perspective of the network operator, be opaque, and the only possible alternative to forwarding all packets is to turn off the tap, rather than to control the contents of the flow.

Important here is that net neutrality is not necessarily a want from the bureaucratic thought style, it depends on situation and view of digital communications. Alternative (1) above is for, alternative (2) is against, and alternative (3) is indifferent. The upcoming Section 5.3 discusses net neutrality literature in greater detail, and Chapter 10 discusses net neutrality in light of the thought styles.

4.6 Resilience and disruption

Takeovers in academic literature have historically focused on equity or stock based takeovers (i.e., in the market thought style, see for example Brickley and James, 1987; Grossman and Hart, 1980), that is market-based takeovers, and there are few touchdowns on non-profit, or legitimacy based, takeovers (i.e., those relevant for the bureaucratic thought style). Since ICANN and IETF and connecting structures and organizations are based on voting on democratic grounds rather than equity-based voting, it is of importance to create an understanding of the issues at hand. Reiser (2006, p. 1252) goes as far as to say “The offhand comment, and lament, has often been made that nonprofits are not subject to takeovers” and argues that takeovers are

¹³To a certain extent, **infrastructure and network operators** are allowed to filter traffic which in itself harms the network itself or peers of the network, such as **distributed denial of service (DDoS)** attacks

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 non-profit 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, p. 1252)

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 on non-profit governing boards, 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 as strategy-implementation literature stream).

Worth (2008) suggests three types of boards for non-profits: the elected board (usually by a chapter meeting), the self-perpetuating board (board members elect board members¹⁴) and hybrid boards (which 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.

The 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 daylight¹⁵. 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.

¹⁴According to Worth (2008) self-perpetuating boards are the most common non-profit board constellation in the USA. However, it is less common in the Internet community.

¹⁵According to Malmberg (2005) the objective was to politically connect immigration to higher taxes, i.e., a very political move.

Table 4.2: Comparison of non-profit takeover cases

A summary of several cases, both foiled and successful, which can be considered some form of take-over. In particular the European ccTLD is problematic to categorize.

Case	Board type	Technique	Description
Lobby org	Elected board	Coup chapter meeting	Failed due to publicity, and did not try.
Local political org	Elected board	Coup chapter meeting	Succeeded and surprised the chapter meeting. The opinion of the new board did not match the general opinion of the members.
Pan-Nordic youth org	Elected board	Coup chapter meeting	Failed due to publicity, and did not try.
European ccTLD	Elected board	Call for extra chapter meeting	Partially successful, two resolutions were proposed, one actually brought up, voted on and passed. The board and a few executive positions were replaced.
Pro-environment non-profit	Elected board	Coup chapter meeting	Failed due to publicity, tried the coup at chapter meeting and failed.

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 level of the 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 and 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 and 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.

As a forth example, recently a European ccTLD organized as a non-profit was potentially exposed to a coup. In this case a majority of members at the called for extra chapter meeting voted for one of the two proposed resolutions. The resolutions where proposed by, from the view of the board, a dissident, and based on the votes at the extra chapter meeting, the majority of the members saw the “dissident” as someone who represented the members. The resolution which passed vacated parts of the board, as I understand it those filled by the chapter meeting which could be vacated by the chapter meeting¹⁶. The problem is designating it a coup, since a majority of members voted for the resolution, is it then a coup or mission evolution? Also interesting is that it was not, per se, a reaction to recent events, but a reaction to a slow drift of the focus of the ccTLD (the call for the meeting and the resolutions are available in Blackler, 2021). This vote could have been held at a normal chapter meeting.

This forth example is illustrative of a bureaucratic thought style issue, that in a completely rational world the issue would have been raised at the chapter meeting, as that is the arena for these types of discussions, but for some reason it was not. Similarly, in Section 9.3 I illustrate an ITU context where the same thing happened, where an issue was not brought up at a **ITU Plenipotentiary** (chapter meeting) plenary session, even though the members present at the meeting were likely to have passed the suggested resolution.

A fifth 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 million 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 4.2, I show a summary of the cases, which I use to reason in regard to takeovers concerning Internet non-profits in Chapter 9.

These examples concern the processes in which organizations form their missions and purposes, and some examples of the pitfalls of such processes, in a manner representative of the bureaucratic thought style.

All examples have elected boards, but some later examples (ccTLDs and **Internet Exchange Points (IXPs)**) have hybrid boards. From an external (that is, non-member) perspective, the notion that only non-profits with elected boards have been noted as “taken over” makes sense, since defining “taken

¹⁶This is how Blackler (2021), the call for the extra chapter meeting, describes it, and as far as my legal understanding goes, what is said in the bylaws.

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” is when several board members 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 board members drastically change opinions (due to varying reasons, 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 **Empowered Community** 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) elects 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).

The board of the IETF, called the **Internet Engineering Steering Group (IESG)**, is elected according to **Request for Comments (RFC)**-8318 (Dawkins, 2018) and is to govern through the procedures specified in RFC-2026 (Bradner, 1996). The IESG sets the **Internet Standards**, even though the IETF in its entirety is often stated as the standard setter. Chapter 9 goes through these organizations in detail from a social resilience lens.

The next chapters discuss irrationality, mutiny, and other phenomena in further detail. Here, in this chapter in the bureaucratic thought style it is assumed that formal decrees, contracts, and agreements are followed (at least to some degree).

4.7 Chapter summary

This chapter introduces the bureaucratic thought style as construct of bureaucratic ideals, which focus on aspects such as accountability, legality, legitimacy, and audits rather than change or interoperability (as the interoperability thought style does) or profitability and market position (as the upcoming market thought style does). As with the other two thought styles, the bureaucratic thought style is intended to illustrate its unique properties relative

to other perspectives rather than to provide an exhaustive understanding of all aspects of the perspective.

In addition to the bureaucratic thought style this chapter also went through literature of relevance to policy and economics where aspects of communication technologies are framed from a bureaucratic lens. For example the historical trend of state actors in charge of telecommunication services, such as telephony and telegraphs, to a more market oriented regime at the international arena.

Of particular importance to the interoperability thought style are jurisdictional concerns, that is that the laws (or other regulatory measure) which are agreed on are followed. In Chapter 10 I give examples of website Internet use and how traffic seemingly flows without any jurisdictional constraints.

Internet implicitly is treated as a telecommunications service, cf. the telephone or the telegraph. In a bureaucratic thought style lens, the Internet does not have an intrinsic coordination component, and it is not necessarily meaningful to separate the Internet from the applications or services running on-top.

5

Market frame of reference

*Good companies will meet needs; great companies will
create markets*

Philip Kotler

This is the third of three frame of reference chapters. This chapter introduces the **market thought style** (**\$**), based on market logic and value capture. In comparison to the **interoperability thought style**, the market thought style is concerned with capturing value, for example with the help of **technology**, rather than primarily striving for changeability of technical solutions. In elaborating this **thought style** I draw heavily on literature from marketing and business studies.

There are several disciplines 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 (business) ecology metaphor for studying these interactions. Business ecology here refers to a wide, encompassing view of a business surrounding, including organizational actors near and far, but also, for example, ideas concepts and trends (Cöster et al., 2020; Olve et al., 2013; Westelius & Lindh, 2016; Zott & Amit, 2010). The business ecology perspective here is thus looking to a wider environment than the more business-model centric business ecosystem term as used in a tradition drawing on Moore (1993, 1997), for example Adner (2017).

The epigraph, “Good companies will meet needs; great companies will create markets” (as cited in Crainer, 2002, p. 37), refers to the duality that

firms are exposed to markets and their regulation, but at the same time firms can shape markets. This is referenced several times later in the thesis with the notion that market actions can be disguised as technically motivated, even if the primary purpose is to shape the market to the advantage of a certain actor.

5.1 Markets

This section aim to serve as a short introduction to how markets work, which I later on compare to the lens of business ecologies and also as a base for the market thought style. The introductory markets versus bureaucracies dynamics debate is in Section 4.2, while here I focus on the participants in markets.

At the broader level the market thought style is based on value capture, often by firms, as a meaningful endeavor. This can be contrasted with, for example, Malkiel and Fama (1970) which discusses the efficiency of the market, rather than the performance (in market terms) of the individual actor. It is possible to argue that markets serve a societal function based on the notions of the invisible hand, following Smith (1776). This is in contrast with the *visible hand*, which would be explicit laws and regulations coordinating and controlling actors to modify what the invisible hand would lead to. 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. For example, in this thesis I use the interoperability thought style to describe a non-market based want.

In terms of efficiency problems for the individual actor, Coase (1937, in-house or outsource) describes the fundamental organization internal problem which is commonly referred to as markets and hierarchies. Porter (1989, 2008) further argues for a set of forces shaping markets, or rather the environment of an actor partaking in the market, for example actors such as customers and suppliers. Comparably Adner (2017) views market activity from an individual company as engaging with others in a multilateral interaction. According to Adner (2017), “ecosystems [his favored strategy lens] are concerned with the structure of interdependence”, rather than the bilateral business transactions.

Viewing the increased importance of (digital) data on individuals for the emergence and growth of large and powerful companies, Zuboff (2015) argues that, currently, there is a shift from traditional *market capitalism* to *surveillance capitalism*. The acquisition and use of such data:

[...] is constituted by unexpected and often illegible mechanisms of extraction, commodification, and control that effectively exile persons from their own behavior while producing new markets of behavioral prediction and modification. Surveillance capitalism challenges democratic norms and departs in key ways from the

centuries long evolution of market capitalism.

(Zuboff, 2015, p. 75)

The idea behind surveillance capitalism is based on the implicit aspects of market transactions, that is not all market transactions are explicit, such as signing a contract and exchanging money for a service or product. Zuboff (2015) argues that implicit transactions, the contactless transactions, such as liking a post on Facebook, or using Google to search for something, are not explicit, consented market transactions between user and company, but are nevertheless the basis for surveillance capitalism based on information gathering. With a business ecology lens, this could be viewed as yet an example of how different types of interactions between actors make up our current complex markets where commercial actors strive for value capture. And the surveillance capitalism that Zuboff identifies largely relies on the Internet for its existence.

It should be explicitly noted that in the broader sense markets are based on notions of value capture, and not explicitly value creation. In this text I use the distinction in Santos (2012) that an actor's value capture is not necessarily confined to value that this actor has contributed in creating, and that value creation does not necessitate the capture or realization of said value, a distinction I later use to discuss the dynamics of value creation by network users and value capture by infrastructure and network operators.

5.2 Ecologies

Business ecologies as a term stems from a Harvard Business Review text describing competition as a jungle where only the actors who innovate the most survive (Moore, 1993). Moore later refined the concept in Moore (1997) which carries the explicit idea that businesses (and other organizations) can not be viewed on their own, they must be seen in the environment they are part of (cf. Johanson and Vahlne, 2009 which describes a business analysis approach developed from the 1980s onwards, emphasizing how an enterprise is always a part in a complex web of interrelations with its environment). Note here the similarities to path dependence where prior configurations, or ecological context, is said to be of importance.

Business ecology analyzes (as in Cöster et al., 2020; Moore, 1993, 1997, 2006; Olve et al., 2013 for example) strive to capture not only formal and strong relations but also more informal connections (cf. Johanson and Vahlne, 2009 network model) which turn out to be important over time. It is suggested that business ecology analyzes are a good tool for understanding organizations in a larger setting (Cöster et al., 2020; Moore, 2006; Olve et al., 2013; Westelius & Lind, 2020; Westelius & Lindh, 2016; Westelius & Westelius, 2018), since organizations today to a larger extent are dependent on other entities for existence and value production and are affected also by events and ideas

from afar. I see ecologies as another way of looking at, for example, markets. So instead of focusing on the formal aspects, such as buyers, sellers, 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. Kjellberg and Helgesson, 2007 rather than contemporary economic and completely rational markets).

Viewing the Internet as an ecology creates a complicated picture since there are a slew of organizations of different characters involved, such as standardizers (such as [Internet Corporation for Assigned Names and Numbers \(ICANN\)](#) 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 \(IXPs\)](#) and [Internet Service Providers \(ISPs\)](#)), non-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.

Neither Olve et al. (2013) nor Westelius and Lindh (2016) suggest that business ecologies are a full-fledged theory (cf. Johanson and 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 in DiMaggio (1995) and Weick (1995) earlier in this thesis.

Westelius and Lindh (2016) is written with the explicit purpose of reasoning on what it is (i.e., what the object or artifact is, which) the management control system should control or coordinate, and end up in the notion that ecologies are a good tool for understanding the environment management control systems are part of.

Olve et al. (2013) suggests a number of types of actors to look for in a business ecology and suggest that the ecology lens is a way of looking at or understanding the surrounding in which an organization operates or could operate.

In my research process I encountered actors which I view as belonging to yet other classes than those identified in Cöster et al. (2020) and Olve et al. (2013).

First is *appointers*, constellations or actors who exist with the purpose of appointing someone or something to another constellation, grouping, or organization. Second, *squatters* are those which influence actors in the ecology without actively doing anything explicitly. I return to these two types in Chapter 7.

5.3 Net neutrality

Much communication networks literature in policy and economics fields focus on the topic of [net neutrality](#): the rules of engagement for infrastructure and

network operators to capture value on traffic by end-users. For example, but not limited to, throttling, prioritizing or blocking traffic.

This longer section presents interoperability, **bureaucratic** and market thought styles views on net neutrality, and in some sense concerns the Western issue of whether net neutrality enforced in law increases welfare or not. Net neutrality is one of the main discussions from which it is possible to illustrate opinions of the interoperability, **bureaucratic** and market thought styles clearly, and to do it this subchapter is given several pages.

Net neutrality as a concept is anchored in economics or policy rather than, for example, technology (or **implementation of technology** or the entire interoperability thought style way of making sense of the world). Common terms are “investment incentives”, “two-sided markets”, “vertical integration”, “convergence”, and “price discrimination”. Examples of such literature is Choi et al. (2015), Choi and Kim (2010), Hahn and Wallsten (2006), Lee and Wu (2009), Litan and Singer (2006), Musacchio et al. (2009), Peitz and Schuett (2016), and 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. However, although there is literature on the inclusive view of **Internet Governance** (as vertically integrated) and net neutrality, in which the Internet is portrayed as a technical (but undefined and unexplored) phenomenon governed by regulation and government policy (as markets are). The Internet is treated as a service or product, but not encompassing an idea or a set of values, as I argue in this thesis that it should be viewed as. Examples in this literature stream are Musiani (2012) and Mueller, Cogburn, et al. (2007) who discuss net neutrality as an Internet Governance issue, although not differentiating net neutrality 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 and without actually clearly stating what the Internet is to the authors).

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, that is an interoperable network where all use is decoupled from the network itself, therefore assuming practical net

neutrality in that traffic is always treated the same (for example Amit and Han, 2017; Berman, 2012; DaSilva and Trkman, 2014; de Reuver et al., 2017; Hagberg et al., 2016; Jesse, 2018; Porter, 2001; Subramanian, 2017; Zott et al., 2011).

In my reading, the economics literature tends to agree that a repeal of net neutrality¹ would benefit infrastructure and network operators (in practice ISPs) and hurt content middle men (such as Netflix and YouTube), but I can find no agreement on consequences for Internet users (consequence here would be price per data or a similar metric). The conclusions of texts such as Cheng et al. (2011) and Economides and Hermalin (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. Practically, technically nuanced texts, such as Huber (1987), argue that as the cost of switching goes down the larger the reason for the market to compete at a service rather than infrastructure level, since the barriers of entry are vastly lower (cf. argument in Huber, 1987; Porter, 1989, 2008 for the need of new entrants and the possibilities for existing ones of exiting in a functioning market).

Huber (1987) noted that market entry by new actors is often not promoted by regulators. Judging from my readings, that is not in focus in literature either. Rather, the literature focuses on competition among actors of comparable size and strength.

More fundamentally, regulation has often failed to promote what is most essential to competition — entry by new competitors. For the better part of century, regulators have pretended to promote competition not by attacking monopoly but by institutionalizing it. (Huber, 1987, p. 1.32)

Interestingly not explicitly mentioned in many texts is the progress of time, which should be of interest in a world affected by Moore’s law (see earlier Section 3.7). The rapid increase in throughput over time is due to better equipment at the ends of cables, rather than cable quality improvements. While fiber optic cables themselves have had the same quality the last 20 or so years, the equipment on the ends of the cables have increased throughput thousandfold.

In contrast, Huber (1987) mentions this exponential increase of traffic throughput in inverse, i.e., as a lower cost per unit of traffic, and argues, in a market thought style sense that it is unlikely that the situation is ever reversed, and that vertical integration of layers is the natural outcome for such market constellations (which is the opposite of the values upheld in the

¹Most of the western world used to be in a state of practical net neutrality, even though I would argue that it was not through explicit net neutrality regulation but rather a consequence of implementation of technology and market design. More on this in Chapter 10.

interoperability thought style). Profit seeking under such market conditions leads to vertical integration, as claimed by Huber (1987):

Vertical integration is thus clearly favored by powerful market forces, operating quite independently of the poisonous synergy of monopoly and rate regulation. Indeed, notwithstanding the Modified Final Judgment (MFJ) and divestiture, all the major players clearly see vertical integration as absolutely imperative.

(Huber, 1987, p. 1.9)

Each supplier can independently provide end-to-end service, and yet suppliers as a group can offer universal access, by providing horizontal links among their networks. The operations of vertically integrated firms fit into the geodesic dome like the slices of an orange.

(Huber, 1987, p. 1.9)

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 (cf. Berghel, 2017; Cheng et al., 2011; Choi et al., 2015; Choi and Kim, 2010; Cook, 2014; Economides and Hermalin, 2012; Hahn and Wallsten, 2006; Hylton, 2017; Kourandi et al., 2015; Lee and Wu, 2009; Litan and Singer, 2006; Musacchio et al., 2009; Peitz and Schuett, 2016; Reggiani and Valletti, 2016; Tan et al., 2018; Wallsten and Hausladen, 2009; Wu, 2003), which is a vastly different perspective than the interoperability thought style 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 in Chapter 10, consist of a “starting point” for a service (such as a website) but for actual services the user connects to different networks and hosts to fetch different parts of the service for many websites.

There are services, such as email, firm-to-firm communications, remote collaboration tools, etc, which use comparably fewer networks but still use networks to route over. The point being that not all services available are properly modelled by one sender and one receiver.

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. In other words, protocols such

as Internet Protocol (IP), Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) are not technically preventing price discrimination, but they are not making it easier either (QUIC is making price discrimination high impossible though, more on that discussion of using implementation of technology to shape markets later on). And as shown later in Table 10.2, 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.

Wu (2003) is often seen as the first mention of net neutrality, and although there are technical shortcomings in the article from a interoperability thought style lens (in practice assuming linear change and no paradigm shifts), 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 in Chapter 10. Wu (2003) 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 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)

This definition, or conceptualization, in Wu (2003) is very close to the formulation in the relevant Swedish law (LEK, 2003). I see this as an interoperability thought style conceptualization using policy vocabulary, that is by decoupling the interests of the user and inter-network criteria from how traffic is treated it is possible to achieve technical interoperability.

Economides and Hermalin (2012) uses the model in Figure 5.1 as an example of market behavior of different net neutrality regimes. As shown later in Figure 10.1, I think that model is too simple to properly illustrate the complexity of a network such as the Internet (for example, there are millions of relevant entities from a Border Gateway Protocol (BGP)-perspective). Economides and Hermalin (2012) does not claim to model the actual Internet, but rather a specific case. 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 USA 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. This is in the text a meaningful assumption in the perspective the text is written, since the marginal cost of additional usage up till congestion is zero by market thought style logic.

Neither Wu (2003) nor Economides and Hermalin (2012) discusses the nature of Internet routing or the technical constituency of standards such as IP, Internet Control Message Protocol (ICMP), or BGP, or the technical nature and difference of a routing entity, such as an Autonomous System (AS) with an Autonomous System Number (ASN) compared with an ISP or infrastructure and network operator. This is not problematic per se in their models, but rather that their conclusions are not generalizable to the Internet without contention.

In Chapter 10 I illustrate the vast number of hosts and networks involved in a set of webpages, which illustrates that there is real world Internet use which is considerably more complex than the abstraction in Figure 5.1.

Figure 5.1: A representation of a net neutrality model

A representation of the network models of Cheng et al. (2011) and Economides and Hermalin (2012). The middle node (red) represents the network's owner (i.e., the ISP), the top right (yellow) represents an Internet user connecting to a service with potential competitors (the other three nodes). These models are used as an abstracted model of the Internet. Cheng et al. (2011) and Economides and Hermalin (2012) alter different variables and come to different conclusions regarding net neutrality.

Hylton (2017) is an example of a cross-subsidization view of net neutrality. Hylton (2017) compares net neutrality with a bridge where cars and trucks have to pay the same price even though they cause different levels of maintenance. However, the question touched on in net neutrality in an implementation of technology sense is more accurately 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.

Differentiating car or truck as concepts of size is not problematic under net neutrality. The net neutrality issue is rather one of brand neutrality, should a Volvo and a Škoda pay differently? This is in line with what Wu (2003) described and discusses.

However, that which is socially desirable is not always clear-cut; as framed by Huber, positions might change from administration to administration or day to day:

The FCC still occasionally accepts the view that monopoly is better than competition, and mispricing of services is acceptable if it migrates traffic back on to the public switched network. Today's FCC might perhaps be able to concoct some story to justify such an anticompetitive philosophy, just as yesterday's stoutly believed that the public interest demanded the rigorous protection of AT&T's national monopoly. That the Antitrust Division of the U.S. Department of Justice should adhere to such views, however, is truly bizarre. (Huber, 1987, p. 1.33)

Glass and Tardiff (2019) gives a nuanced view of the USA situation: firstly by admitting that more than the last-mile² is interesting (i.e., the entirety of the network should be looked at), and secondly, 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). Stocker et al. (2020) argues similarly, and after discussing problematic models of net neutrality states in the conclusions:

The paper has further elucidated that answering relevant questions inherently and fundamentally requires an interdisciplinary perspective. What needs to be considered is that insufficiently informed and thus, ill-defined regulatory interventions based on an outdated mental model of the Internet will distort investment incentives and harm innovation. (Stocker et al., 2020, p. 56)

Currently, there are around 10 300 assigned ASs³. Not all of these are used. In particular, the mentioned literature is interesting in how network peering (i.e., interconnectivity between ASs) 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

²In the American debate, last-mile is commonly referred to as BIAS (Broadband-based Internet Access Subscription), i.e., a service perspective.

³See <https://www.cidr-report.org/as2.0/autnums.html>

Table 5.1: Comparison of networks used in models

ASs and entities used or accounted for by different sources. Illustrates the complexity of the actual routed Internet versus scenarios used in a selection of literature. The maximum potential number of ASs is the same as the maximum number of **IPv4**-addresses (32-bit unsigned integer, i.e., in the ballpark of four billion, see **Request for Comments (RFC)**-6793, Vohra & Chen, 2012, for more detail).

Source	Nr of AS	Comment
Economides and Hermalin (2012)	1	Does not include peering, i.e., one ISP is the entire network.
Choi et al. (2015)	2	The model includes peering between two networks for content delivery.
Figure 10.3	19	Visiting a news site and reading two articles requires almost twenty networks even when blocking content such as ads and spam very aggressively.
Figure 10.1	67	Reading two articles as intended required almost seventy networks, i.e., no ad-blocking in browser nor DNS blocking of potentially malicious hosts.
Weekly use	≈1500	A week of Internet use at home required in the ballpark of one thousand five hundred different networks or ISPs. Note that this is based on networks which devices on my home network tried to reach, and not necessarily successfully reached.
All assigned AS	>100 000	More than 100 000 ASN are allocated globally, that is given a number, although there is no listing of ASN selling ISP or IXP services.
Routing relevant entities per Section 3.7	>1 100 000	The Internet according to BGP-announcements, includes ASs and prefixes. See Table 3.5 for numbers and Figure 3.2 for graphical illustration.

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)

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 5.1, 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 is plausible that the models of Cheng et al. (2011), Choi et al. (2015), and Economides and Hermalin (2012) would become too complicated if scaled to the size of the Internet with its several tens of thousands of networks (or millions of networks including routable entities such as prefixes).

As mentioned, there are few texts which concern net neutrality or the Internet which define or conceptualize either.

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 this thesis I make the argument that due to the coordination nature of the Internet it actually is needed, since the Internet is rather coordinated through protocol specifications based on working implementations rather than governance processes.

As a summary, academic net neutrality literature written for policy or economics audiences in general can be said to assume that: network owner and ISP are the same, congestion only happens at the last mile, and (the modelled) services have *one* producer and *one* consumer.

These assumptions are revisited later in Chapter 10 after an overview of a collection of websites and their Internet use. I then show that in a combination of the interoperability, *bureaucratic* and market thought styles the assumptions discussed in the last sections are not without contention.

5.4 Chapter summary

This chapter introduces the epistemic and ontological viewpoints of the market thought style as well as relevant theories close to the area. By and large, the market thought style is based on notions where desired performance is mainly equal to financial success. Instead, the interoperability thought style can rather consider technology designed for substitutability to be good performance, and the **bureaucratic thought style** can consider well-defined governance processes to be more important.

Note that in comparison to the interoperability and bureaucratic thought styles, the market thought style is actor dependent to a greater extent. The wants of an ISP and an **edge**-firm are likely to be conflicting in terms of network issues, such as pricing access and packet propagation.

This chapter also introduces the concept of business ecologies to make sense of interactions of organizations where not all interaction are based on contracts or hard financial values (for example the letters delegating **country code top-level domains (ccTLDs)** are often not formal, see Aerts, 2007; Dolderer and Bäss, 2006; Twomey, 2007 and neither are **Internet Standards** suggested by the IETF enforceable; each actor chooses whether to adopt each standard).

Contrary to Chapter 3 and Chapter 4, there is little literature in the domain of business studies on the Internet itself, as such this chapter rather presents theories useful for studying the actors involved in the Internet ecology, and how net neutrality as a policy issue shapes opportunities for for-profit infrastructure and network operators.

6 Management and coordination

The Internet is not governed, it is coordinated.

— Interviewee

The previous three chapters focused on the three **thought styles**; the **interoperability** (Δ), **bureaucratic** ( ) and **market** ($\$$) thought styles, and this chapter is aimed at discussing and contrasting them.

The **interoperability thought style** is based on assumptions that the possibility to change is important above all, in particular more important than keeping agreements and following laws. Interoperability as a label also signals the importance placed on the idea that the Internet should be operated by a host of independent actors, who coordinate through the voluntary adherence to (technical) standards, rather than by, for example, fiat. In the interoperability thought style interoperability is key; differentiation of key standards is not wanted. A central concept is **separation of concerns**, the notion that all concerns should be separated in such a way that they could be replaced individually, rather than only in bundles, as to not prevent change.

The **bureaucratic thought style** is based on assumption that order is best achieved through general, binding agreements that are enforced. The notions of audit and control imply, opposite to the interoperability thought style, a notion of **integration of concerns**, where centralization, rather than separation, serves the coordination end.

The **market thought style** is based on assumptions that capturing value is the primary end. Adherence to laws is a strategic decision, not a basic

tenet of operation. **Technology** can serve as a commercial product or as a tool or infrastructure for successfully providing commercial products. Differentiation from or adherence to standards could, depending on strategy chosen, be desirable paths; global interoperability is not an end in itself.

This chapter discusses **coordination** in all three thought styles, and divides coordination into several conceptual layers. While some texts focus on coordination as a general mechanism which decides what you do (e.g., Mintzberg, 1980, 1993) other texts see coordination as only the current activities between interdependent processes (e.g., Okhuysen and Bechky, 2009; Thompson, 1967). Groth (1999) and this chapter extends the coordination concept further to include technology.

The purpose of this chapter is to introduce previous literature and thoughts on coordination and digitization to create a frame for viewing the **Internet** context. This chapter uses coordination as “that which decides how to act in and treat a certain situation”, see further discussion in Section 6.1.

Important concepts in this chapter include: ecologies, to study and make sense of the large set of actions in a large setting. Coordination, to study how actors act in certain situations of consequence to others and what makes them act like that, often used as how individuals in an organization act but here expanded to how actors in an ecology (which could be organizations, but most definitely does not have to be) act and behave.

I end up with four conceptually meaningful groups of coordination; **implementation of technology** (T), **standards formulation** (S), **coordination of technology** (C), and **meta-coordination** (M). These groups are not entirely mutually exclusive, and should rather be seen as analytical groupings to illustrate different levels, or parts of the net, of the Internet ecology.

Implementation of technology includes the actual implementation of technology and what it does, such as physical infrastructure. However, the distinction between implementation and standard is not always clear-cut, since sometimes the standard is the implementation.

Standards formulation includes standards and their creation, sometimes not clearly differentiable from the implementation of technology itself, and sometimes not clearly distinguishable from the coordination of technology. For example, the coordination of the **Internet Engineering Task Force (IETF)** is described, or set, in **Request for Comments (RFC)**-2026 (Bradner, 1996), which makes RFC-2026 (Bradner, 1996) a guide for coordination as well as a standard.

A key example of why the difference between implementation of technology and standards formulation is necessary is that the **International Telecommunications Union (ITU)** standards formulation legitimates implementation of technology (i.e., ex-ante standard legitimate implementation) and in the IETF implementation of technology legitimates standards formulation (i.e., ex-post standards are set based on actual implementations).

Coordination of technology includes the actual coordination behind setting standards and designing technology. The previous ITU and IETF examples illustrate different views of coordination of technology.

I use meta-coordination as a meta-concept of the overarching values behind the coordination.

This chapter also contrasts and compares the thought styles to illustrate where they differ significantly. This helps to illustrate where the values behind coordination are changing when there is no difference in the actual coordination itself.

6.1 Coordination concepts

As alluded to throughout the previous chapters the term “**governance**” is quite contentious, and has different meaning in different fields. I therefore primarily use coordination throughout this thesis.

Mintzberg (1993) uses the term coordination, 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. Activities include for example meetings and making plans, but do not include ex-ante activities such as training and background, which Mintzberg (1993) does. In this thesis I use coordination as the broader concept, along the lines of “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). This has the advantage of better handling coordination outside the strictly social current setting. The notion here is that not only work conducted by people is coordinated, but that all work is, even that conducted by technology.

The Internet involved interdisciplinary coordination. Malone and Crowston (1994) states:

However, we believe they [a set of problems which can be approached with coordination] illustrate how the notion of “coordination” provides a set of abstractions that help unify questions previously considered separately in a variety of different disciplines and suggests avenues for further exploration.

(Malone & Crowston, 1994, p. 111)

However, Malone and Crowston (1994) also describes coordination as “managing dependencies between activities” (Malone & Crowston, 1994, p. 101) without any specific mention of time. The time component is of essence for the thought styles as training, beliefs, and planning are coordinated over time rather than between interdependent processes.

6.2 The organizational context

I here spend a couple of pages untangling the organization to put it in the context of ecologies or a larger setting. In Chapter 5 I suggested that markets (and to some extent business ecologies) are based on the *raison d'être* of value capture in economic terms. Here I go further and look at organizations outside only economic rationality, and 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. Neither Chapter 4 nor Chapter 5 explored the organization as a concept.

The term organization is hard to define in a digital 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 organizational actor in an ecology. This makes it meaningful to discuss *Internet Corporation for Assigned Names and Numbers (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).

Coase wrote an early treatise on organizing. His work focuses on formal or contractual relationships, not taking informal relationships into consideration. If we have efficient markets, 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; there is a "transaction cost" when accessing the market, so there can be conditions when employing labor or equipment for a longer period is more efficient than a series of market transactions. Transaction costs may relate to searching and finding the right service, and alternative prices, concluding contracts, etc. Of particular interest in this thesis is that Coase (1937) does not mention training, in either the spot contract or the case of longer employment. I argue in this thesis that training, or education, can be seen as the ground on which you make decisions, and to some extent is what shapes people's thought styles. Comparably, Mintzberg (1993) argues that training is one of the primary standardization mechanisms for coordination because through training people acquire a way of acting.

Coase also notes 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 risking to lead to inefficient resource utilization as a limiting factor 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 for contracting a task. This will be explored in terms of the Internet in Chapter 7, where the notions of keeping the coordination at minimum is described as the concept *Least Common Internet*.

Coase (1937) does not go deeper in on what an organization *is*, i.e., what are the central tenets that define an organization. To help answer the question

of what the Internet would be as an organization I will go through texts such as Cöster et al. (2020), Malmi and Brown (2008), Mintzberg (1993), Simon (1997), Simons (1995), and Westelius and Lind (2020).

Management control

In a management control perspective, Malmi and Brown (2008) presents a framework for looking at and discussing management control. 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) stress the importance of paying heed to interdependencies when designing or revising the set of management control tools in an organization. A consciously designed combination of tools can form a system; a set of tools that are not assembled with attention to their interactions will only be a package. The Malmi and Brown (2008) typology is of interest in this thesis since it suggests ways to change behavior. It is divided into five areas with different focus. These are *Culture*, *Planning*, *Cybernetic*, *Reward / compensation*, and *Administrative*.

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). The typology 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). These texts consider management control in a more hierarchical fashion, where managers are supposed to try to influence the managed.

Simon (1997) maintains 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. As noted by Coase (1937) and elaborated by Simon (1997) management control is not certain to determine organizational action. For example, a subordinate who finds that directions are not clearly part of the agreed contract can choose to not follow a superior's orders, both in the form of a small deviation such as solving a problem differently than specified and in the more extreme example of mutiny. This is interesting from an **Internet Coordination** context since the Internet is built and operated by many organizations and many more individuals, with various ideas, values and opinions, and can not be expected to function as a rationally directed hierarchy.

Soft power and soft values

Coase (1937) and Simon (1997) introduce the idea that people's alternative mind sets and ways of reasoning limit the possibility of controlling an organization and make perfectly coordinated organizational action improbable. A closer look at concepts such as rationality, hierarchy, and meaning in organizing is the MARC model (Meaning, Authority, Rationality, Care) as presented in Westelius et al. (2013), and further elaborated on in Westelius and Westelius (2018). The MARC model aims to distinguish 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).

In short, Westelius et al. (2013) argues that management literature from a historical perspective has focused on the “hard”-side, 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 and voluntary work. Westelius and Westelius (2018) follows up on the same argument and adds a sustainable 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.

The thought styles as presented in this thesis concern different forms of meaning from different perspectives, which is part of the softer values the MARC-model aims to capture.

Simons (1995) also argues for the importance of softer values in organizations. He suggests four levers of control for coordinating behavior in an organization: *diagnostic control systems*, *belief systems*, *boundary systems*, and *interactive control systems*, where belief and boundary systems are about what to strive for and what not to do, and interactive control systems are calibration dialogues.

In a somewhat related tradition, Santos and Eisenhardt (2009) argues that understanding of soft-power and interorganizational power is key to properly modelling behavior of nascent markets. This can be connected to how DiMaggio and Powell (1983) and Meyer and Rowan (1977) argue that without efficiency constraints other rationalities dictate organizational behavior than strictly market thought style based ones.

Organizing for coordination

Mintzberg (1980, 1993) goes through what he calls the *primitives* of organizing, which are five structures of five. Here I summarize three of the structures which I consider to be the most important for this thesis; the elements of an organization, the coordination mechanism of an organization and five struc-

tural configurations for organizations. Groth (1999) argues that in a digital age, it is worth including that agency and coordination do not only lie with the social but could also lie with that which was previously considered material.

The important notion here is that not only people coordinate, also technology coordinates, for example through implemented technology and standards.

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.

I use this primitive element description to label actors of the Internet ecology. Of particular interest is the handling of standards, which in a Mintzbergian view commonly are pushed from the technostructure to the operating core. But, as I argue in Chapter 7, the Internet rather sees standards as a support function than requirements pushed by a central actor. That is, is it more prudent to see the IETF and ICANN as the *technostructure* or the *support staff* of the Internet? As I illustrate in Chapter 7, there is disagreement which I capture with the thought styles.

Mintzberg (1993) argues there are five methods of coordination in an organization, of which three are different forms of standardization. **Mutual adjustment** is when individuals are in charge of their own work and coordinate by communicating informally (concept originated in Thompson, 1967). In **direct supervision** 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** when the performance of the work itself is coordinated by the imposition of standards (typically from the technostructure), **standardization of outputs** when the output of the work is coordinated by the imposition of standards (again typically from the technostructure) and **standardization of skills** 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 normative socialization forces in DiMaggio & Powell, 1983, which turn organizations isomorphic, since skills standardization tends to take place outside the individual organization, and supports many organizations, not just one).

However, there are multiple Internet coordination tasks handled by appointment, which I call appointment of person. I see appointments as potential combinations of **standardization of skills**, appointment done by knowing the background and training of an individual, **direct supervision**, appoint-

ment of an individual under supervision or control, and **mutual adjustment**, appointment of, for example, a back channel contact.

Appointment of person is used to describe the notion of an organization indirectly or directly contributing to constituting another organization or group. For example, the **United Nations (UN)** parliament consists of representatives of most nation states, and the IETF boards consists of representatives elected by the **Nominating Committee**¹. It is also important to differentiate between to notion of appointing someone to a position and the notion of the coordination conducted by the appointee. For example, someone appointed by Google in a standards process might mutiny and actually support the epistemic values of academia or the interoperability thought style rather than the market thought style of Google (along the lines of Coase, 1937; Simon, 1997 that people do what they want rather than what they are managed to).

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 organizations, but rather a tool for understanding how an organization functions or can be designed. Here I go through three, which resemble the thought styles the most.

Adhocracies rely on mutual adjustment for coordination and is in the words of Mintzberg “selectively decentralized” in that power is spread throughout the organization. Power lies with the experts forming the operational core rather than in training or standardization because what needs to be done is rather unpredictable. Adhocracies and the interoperability thought style both bears traits of lack of formal control and interaction and the presence of and the intention to handle unpredictable events. Examples include complex and research heavy organizations such as NASA and universities. Mintzberg (1993) further argues that the adhocracy is one of the more fragile organizational configurations, and has a tendency to become more formalized over time.

Machine bureaucracy follows bureaucratic thought style logic in its focus on ex-ante agreed on standards, processes and planning by (mostly) **standardization of work process** coordination, where power is concentrated at the standardizers in the technostructure. In Mintzberg (1980), the machine bureaucracy is argued to sideline the operating core to the power advantage of the standardizers in the technostructure.

And the *Divisionalized firm* based on market thought style logics based on **standardization of outputs**, where power resides in the middle line. The divisionalized firms share many traits with the adhocracy, such as partial

¹While the **Internet Society (ISOC)** behaves like a membership organization, the IETF has some special quirks since there is no formal membership. More on that in Section 7.3.

independence of units, but the coordination mechanism is different, standardization of outputs over mutual adjustment.

Both DiMaggio and Powell (1983) and Meyer and Rowan (1977) say that as technological change in an organization slows down due to sufficient competitive advantage, organizations become isomorphic in how they act and behave. Meyer and Rowan (1977) argues that formal structures are not just present for efficiency reasons but also due to socialization and external pressures. This is in line with Mintzberg (1993) in that formalization happens when technological change slows down and scaling value capture becomes important.

My understanding of Meyer and Rowan (1977) and DiMaggio and Powell (1983) is then that as long as there is a compelling efficiency reason for an organization to change what it is doing or how it is doing it, that organization would be less formal, less formed by socialized forces, and less isomorphic than an organization of comparable size which has little reason to change from an efficiency standpoint (this, of course, depends on the views of efficiency of the people in that organization as well). 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 has less reason to change.

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).

6.3 Technology and coordination

Concepts for theorizing in regard to technology and coordination, or **IT-artifact** in organizations, include **sociomateriality** (Orlikowski, 1992), sociotechnical systems (Trist & Bamforth, 1951) and developments of these.

In sociotechnical systems and sociomateriality approaches technology is often seen as an artifact, often called IT-artifact, and not that much effort is put into untangling the components of technology (part of the argument in Orlikowski & Iacono, 2001).

De Reuver et al. (2017) also argues in a similar direction, with the explicit example of digital platforms as an arena where the constituency of the material is important (cf. policy and economic perspective of, among other, digital platforms in Mansell, 2017; Tiwana, 2013).

This is an issue of sociomateriality in my perspective since the values behind the material are of importance. As discussed, there are many values and ideas behind good design of technology in the thought styles.

[w]e believe that the lack of theories about IT artifacts, and the ways in which they emerge and evolve over time, and how they be-

come interdependent with socio-economic contexts and practices, are key unresolved issues for our field and ones that will become even more problematic in these dynamic and innovative times.

(Orlikowski & Iacono, 2001, p. 133)

Tilson et al. (2010) and Tiwana et al. (2010) follow up on the same thread, using the terms digital infrastructure and platforms, and argue for an increased understanding of the material. In some sense sociomateriality, and related traditions, have argued for a greater understanding of the material, or implementation of technology and standards formulation and the embedded values, for several decades. I argue that the interoperability thought style helps explain some intrinsic properties of the components constituting the material which might otherwise be hard to catch.

6.4 Aligning technology and coordination

Alignment of technology and coordination is also of importance, in particular as this thesis suggests that conflicts involving coordination and technology should be framed as conflicts between thought styles instead.

In the context of **information technology (IT)**, on specific implementation of technology, IT alignment literature, such as Chan and Reich (2007), Croteau and Bergeron (2001), and Raymond et al. (1995), argues gives that the common approach is to implicitly frame technology as the outcome of strategic choice and action.

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 and standardization of work process) 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). In this sense the literature captures when technology aligns with and helps an organization in, for example, a business context, but does not aim to explain the mismatch in cases of mismatch.

For example, if a piece of technology is developed with interoperability in mind but is measured by its financial success that project could be considered a failure.

As this thesis concerns the case of alignment of the technology of the Internet and coordination of the Internet, additional literature concerning organizations undergoing technological change with the velocities mentioned in Section 3.7 would have been helpful.

However, there are few published texts with empirical data of larger inter-organizational settings. What follows is, mostly conference publications, which I have found with different mixes of search terms such as “technol-

ogy”, “coordination” and “alignment”, and in turn going through relevant references in these.

A typical example is Virmani (2015) which briefly discusses management and coordination of continuous delivery (of software), but without empirical data. Another example is Vassallo et al. (2017) which looks at software builds as seen from the build server, that is what does the build process look like from the perspective of one of the components of a fully automated build system. But Vassallo et al. (2017) does not go deeper into organizing or coordination of the people of the organization, or the business consequences, or legal consequences² of automated software builds.

The above sections are an illustration of the coordination I look for in interviews and literature. For example, in the light of Simon (1997), among others, I look for the differences between formal structures of the Internet and organizations involved, such as hierarchies, actual structure of the same, and coordination of people and technology.

6.5 Internet governance and coordination

This section goes through several texts on **Internet Governance**, both of implicit and explicit nature. It builds on the earlier thoughts in the interoperability, bureaucratic and market thought styles, and reflects on literature from those perspectives.

The common term for discussing the Internet from a coordination or governance lens is Internet Governance (cf. DeNardis, 2020; DeNardis et al., 2020; van Eeten and Mueller, 2012), even if there is no accepted definition of either the Internet or Internet Governance. I argue through this thesis that Internet Coordination is the better term, for example since Internet Governance implies a need for convergence³ and centralization of power and legitimacy, a need which may conflict with the values of some actors involved in the coordination of the Internet.

Even if Internet Governance is used more than Internet Coordination, the vast majority of relevant literature looks at particular parts of the Internet through a lens from some scientific field (as argued in van Eeten and Mueller, 2012). The term Internet Coordination is used sparingly in literature, but is not well-defined (as in “Internet Coordination is [something distinguishable]”). Two texts in particular, Liu (1999) and DeNardis and Raymond (2013), mention the term.

²Compare with the responsibility issues if an autonomous car hits someone. Is it the driver’s or the manufacturer’s fault? The same is true for software, if an automated software patch breaks hospital equipment and someone gets hurt, who is legally responsible? As discussed earlier, the Internet deals with this by intentionally being designed in a way not to be trusted, see argumentation in Section 3.5.

³Note that convergence in the bureaucratic thought style describes essentially the same issue as integration of concerns in the interoperability thought style, but from a quite different vantage point.

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.”⁴ 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 the terms interchangeably.

Another text which utilizes both terms 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” and “Interconnection coordination” receive different labels even though the same kinds of mechanisms are described⁵. 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 I argue are explicitly not part of the Internet and Internet Coordination.

A more recent text, DeNardis (2020), notes that Internet Governance as a term is an oxymoron, and that there have been few studies on the actual governance of the Internet, and that “[f]rankly, it is not yet a well-understood or much-analyzed framework of governance” (DeNardis, 2020, p. 7). This thesis provides an opening for understanding these “frameworks of governance”, through the lenses of the interoperability, bureaucratic and market thought styles. DeNardis (2020), among others, tries to explain Internet Governance through what ostensibly is markets versus bureaucracies, which this thesis argues misses the original *raison d’être* of the Internet and a still dominant force or **epistemic community**, namely the interoperability thought style.

DeNardis (2020) argues that the framework of governance is not well-understood or much-analyzed, and I would argue not well conceptualized either. For example, Lessig (1999) and Lessig and Lessig (2006) makes the argument that (technical) architecture, similar to laws, acts as a *regulator* of the Internet and its use, as such including implicit coordination done by technical standards and their implementations. DeNardis (2020) is not as clear to

⁴Here broadly putting the entire Internet concept in the hands of **Domain Name System (DNS)**, the **naming** standard of the Internet. However, it should be noted how correct the observation in Liu (1999) is here; there is no central governance nor absolute technical power, all power stems from **Autonomous Systems (ASs)** (i.e., **Internet Service Providers (ISPs)** in his perspective) deciding to use that particular root (i.e., the **Internet Assigned Numbers Authority (IANA)**-root).

⁵In many perspectives governance is used as top-down, but in this particular case with cybersecurity governance the mechanisms also include bottom-up coordination.

which extent the technical infrastructure and the coordination exercised at a technical level is part of the Internet Governance concept.

Van Eeten and Mueller (2012) identifies 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 **Internet Governance Forum (IGF)**, ICANN and **country code top-level domains (ccTLDs)** in their discourse and misses issues such as how ISPs wage their wars against botnets and spam (van Eeten & 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, cyberwarfare 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.

In terms of my thesis I cover the Internet Governance category and parts of telecommunications policy, in particular **net neutrality** and ideas behind interoperable interconnection. In terms of information security economics I discuss how the Internet intentionally is designed to avoid such security threats, in essence that the Internet should not be trusted nor guaranteed. I cover Cyberlaw partially, in that the network itself and the standards of

the network are intended to avoid jurisdictional concerns, such as identity or position provision⁶.

Van Eeten and Mueller (2012) goes as far as to state that there is a misunderstanding in many academic and policy debates that ICANN governs the Internet (a view which most of the interviews back up, most explicitly in the statement “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)⁷). An example of this is Kleinwachter (2000) where general speculation is being made on the grounds that ICANN has a central governing role. Yet another example is Weber (2009) who from assuming that ICANN governs the Internet concludes that there is a need for another governor for the **Internet-of-Things (IoT)**. The later parts of my thesis are firmly in the same corner as van Eeten and Mueller (2012), i.e., that there is something missing in the Internet Governance discourse, which I call Internet Coordination, aimed to capture coordinating actions outside of (and including) 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.

(minor spelling corrected Frau-Meigs, 2012, p. 16)

Frau-Meigs (2012) could be read as suggesting that research should take a turn towards a deeper understanding of the Internet and its actual constituency (cf. Orlikowski and Iacono, 2001 and the call for a deeper understanding of the material, or perhaps the values of the material, in sociomateriality). Similarly, DeNardis (2020) and DeNardis et al. (2020) also argue

⁶Such as at a protocol level ensuring some form of identification connected to a physical or legal person, or ensuring a connection between, for example, an **Internet Protocol (IP)** address and a geographic or jurisdictional position.

⁷A note on grammar in this, and some upcoming, quotes. Many interviewees refer to ICANN as “them”, rather than as one (coherent) “organization”.

for a greater understanding of the technical, although not explicitly for values underlying the technical, only the technical itself as a material construct (as I would argue Orlikowski and Iacono, 2001 and sociomateriality does as well).

There are apparent problems with defining what more democratic and more inclusive actually means (in the above quote), since more inclusive might imply closed and controlled if that was the will of the additionally included. And *democratic* is a fuzzy term: does it imply direct or representative rule by the *demos* (people), and according to which principles for solving conflicting goals? The “hands-off” approach as described in the quote is similar to the issue raised in Lessig (1999): should the market or the public (through some set of processes) decide?

Comparably, an interoperability thought style approach would be to coordinate and design as little as possible, in the hopes that the network could be used by either the market or the public (or another constellation).

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 with no central actor. In its infancy the Internet was designed against central control by rather focusing on redundancy of both maintenance and control (Zittrain, 2008), one example being that **Border Gateway Protocol (BGP)**⁸ 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 through governance, then at least through a form of leadership, that ICANN controls the Internet. The scholarly texts DeNardis and Hackl (2015), Mueller and McKnight (2004), and Weber (2009) are all examples of articles presenting a problem which they presume ICANN should solve and asking *how* ICANN can solve it, rather than having a discourse about *who* (or selection of *who*’s) should solve the problem. The Economist is a prime example of a non-academic outlet also presenting a quite explicit view of ICANN as prime governor (see The Economist, 2014, 2016a among others), as well as the, primarily USA, 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** during the fall of 2016.

If we turn to management control, there is no stating literature stating it explains how the Internet works, and it is rather possible to ask if there is enough common understanding to even be able to ask if there is a strategy in place. Prior to doing this study I believed there was more coherence in Internet Coordination thoughts than I found.

⁸In 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 RFC-8212 (Mauch et al., 2017) and work backwards.

Let us go further back from Internet-specific literature into telecommunications policy in general. Prior to the Internet, international telecommunications was in general run by governments (see Cowhey, 1990 for a summarized history), such as telegraphs and the first telephony operators (sometimes through state owned firms). Cowhey (1990) and Huber (1987) notes a shift when private companies entered the telecommunications market and the first anti-trust cases were brought against veritable monopolies on telephony.

The notion in Cowhey (1990) is that for many arenas, there is an epistemic community, a part a larger *thought collective*, who promotes the main view or perspective, An epistemic community might be academic or scientific but does not have to be, and usually consists of a couple of dozen people (see Adler and Haas, 1992; Haas, 1992). The epistemic community might or might not in itself be in charge of setting the agenda, it may just actively influence those who are; Adler and Haas (1992) gives examples of both.

Cowhey (1990) describes a shift from, what I term, the bureaucratic thought style to the market thought style in international telecommunications. Note here the common theme of the bureaucracy / public / hierarchy compared to the market / “hands-off”-approach, etc; in many threads there is this distinct lack of a third perspective, view, party, angle, or similar that would resemble my interoperability thought style.

6.6 Path dependence, technology, and coordination

Path dependency has many suggested views and conceptualizations. In this thesis I use the concept as suggested in David (2007), “history matters”, where the term *path dependence* is a label for a dynamic phenomenon. The concept of path dependence is usually used in contexts where economic rationality (cf. Bachelier, 1900/2006; Malkiel and Fama, 1970; Mandelbrot, 1963 the efficient-market hypothesis) can not fully explain social history.

The concept of path dependency comes from Markov-chains, which are stochastic (mathematical) models for situations where states are (only) dependent on the prior state (Berg & Billoire, 2007). For example, Shapiro and Varian (1998) uses path dependence as a way of describing many of its examples; existing configurations led the way in another direction than newer in some sense technically more advanced or well-designed alternatives.

An Internet example of path dependence is how the widespread adoption of IPv4-only speaking equipment delays the implementation of IPv6, since IPv4 still works satisfactorily in most cases. However, IPv6 is better in almost all dimensions, see earlier comparison in Section 3.5.

In my thesis I use path dependence to illustrate context-dependence, as with the IPv6 example above, and to discuss why the optimal solution for a thought style is not always the actual solution, even if the thought style sets the agenda.

6.7 Levels of coordination

This section revisits and conceptualizes the levels of coordination used in this thesis. Initially I assumed that the Internet has to be both technology and coordination, which over the course of the project was distilled into implementation of technology (T), standards formulation (S), coordination of technology (C), and meta-coordination (M). These dimensions are used orthogonally to the thought styles (i.e., the interoperability, bureaucratic and market thought styles) to illustrate four levels of coordination as seen by three (focused and conceptualized) thought styles.

As is elaborated on in Section 6.1, I use coordination as “that which decides how to act in and treat a certain situation” (similar to Mintzberg, 1993, in terms of usage of the term coordination). I also put how technology acts into the coordination concept, not only how people act. Just as people can be trained or have prior experience, technology can be designed and shaped, and contain random elements.

The levels of coordination represent technology as it exists in *implementation of technology*, standards as formulated in *standards formulation*, actual coordination in *coordination of technology*, and the ideas behind coordination of technology in *meta-coordination*. See Table 6.1 for an overview.

Table 6.1: Levels of coordination

The levels of coordination used in this thesis to further distinguish the larger concepts technology and coordination. The levels, implementation of technology, standards formulation, coordination of technology, and meta-coordination, are further used in conjunction with the thought styles; interoperability, bureaucratic and market thought styles, to illustrate Internet Coordination issues.

Level	Symbol	Description
implementation of technology	T	Actual implementation of technology.
standards formulation	S	Actual formulation of standards.
coordination of technology	C	Actual coordination of technology and standards, that is the practical context in which coordination is done.
meta-coordination	M	Idea and concepts behind the notion of the coordination of technology, the meta-coordination.

This stems from the forms of coordination present in the Internet ecology, from **infrastructure and network operators** to nation states. These levels are not layers on top of each other, and are rather, in an illustrative sense, a wild bush rather than a finely layered cake.

As is shown in Chapter 7 and Chapter 8, there is a wide variety of actors shaping both what I see as the actual Internet and the concept of Internet.

Here I list and go through most to reason that my suggested levels are properly encompassing the important actors, beliefs and their coordination.

The levels are the result of an abductive process, stemming from the assumption of technology and coordination. My earlier interviews indicated that there is a difference between actual coordination (of technology), and the values and the overarching coordination. Therefore, coordination is separated into coordination of technology and meta-coordination.

Until quite late in the process I used one level of technology, in order to keep the arguments of this thesis coherent, but in the end I separated technology into implementation of technology and standards formulation to better illustrate the difference between the idea of how something should work, or a description of how something actually works (i.e., standards formulation), from the actual implementation itself (i.e., implementation of technology).

In particular, the interoperability thought style is based on the notion that implementation of technology predates standards formulation, and that the descriptions, such as the [Internet-model](#) or [Requests for Comments \(RFCs\)](#), describe actual working implementations. The bureaucratic thought style prefers the opposite; it is up to the implementation (implementation of technology) to adhere to the specification (standards formulation), for example the [OSI-model](#) or the Bluetooth-standard.

This difference is quite fundamental, and Chapter 7 explores it further. It can be summarized as this: if the implementation and the standard differ, should the standard be updated, or should the implementation be changed?

In this particular example the market thought style does not have a philosophical standpoint, rather the order which supports value capture for one-self is the preferred one.

6.8 Communities of the thought styles

This short section is a reflection on the composition of the thought styles and perspectives brought forth in this thesis. The interoperability, bureaucratic and market thought styles all refer to ways of making sense of the world, not one's profession per se. There are engineers I consider bureaucratic, and policymakers I consider portraying an interoperability thought style.

Take technology as an example. In the interoperability thought style technology should be divided into independent modules which can be updated or changed at will, this to not hinder future change. In the bureaucratic thought style technology made explicitly to hinder change can be useful, for example to prevent fraud, ensure identity or geographic position. Similarly, technology can be used by the market thought style to create barriers of entry or lock-in effects.

It is likely that all of these technologies would be built by engineers, and not all engineers have a worldview in line with the interoperability thought style. Nor do all bureaucrats align with the bureaucratic thought style, nor everyone employed at a firm align with the market thought style.

6.9 Chapter summary

This chapter discusses the levels: the implementation of technology (T), standards formulation (S), coordination of technology (C), and meta-coordination (M), and discusses the thought styles: interoperability (**Δ**), bureaucratic (**🏢**) and market (**\$**) thought styles.

In the interoperability thought style, implementation of technology legitimizes standards formulation which in turn legitimizes coordination of technology. That is, implementation should predate description, and coordination in turn is legitimized based on implementations and descriptions produced. This is contrary to bureaucratic thought style logic, where coordination legitimizes standards and implementations. The market thought style is less principled in these terms, and rather favors whichever coordination or technology provides the best outlook.

In terms of members and community, the thought styles are diverse. Legislators, engineers, bureaucrats, salespeople, etc, are represented in all the thought styles. For example, the engineers in Cowhey (1990) were focused on designing networks for value capture for large international telecommunications firms (**\$**), not on creating best-effort interoperable networks (**Δ**).

These thought styles; the interoperability, bureaucratic and market thought styles are used to illustrate conflicts and agreements, when they appear, throughout this thesis. They are also used to illustrate areas where the difference in viewpoint is so large that it is hard to even have something to agree on or disagree on to begin with.

7

The Internet ecology

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 and Mueller (2012, p. 729)

The role of the **Internet** has never been as contested as it is now. The USA abolished net neutrality at a federal level in 2018, the EU has since passed directives enforcing copyright policing at the lowest levels on **Internet Service Providers (ISPs)** in 2018 to prevent the Internet to be used for copyright infringements, and the **Internet Corporation for Assigned Names and Numbers (ICANN)** is finalizing its formalized multi-stakeholderism transformation from 2016. In addition, there are political debates and news articles (for example 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, et al., 2007). Other literature, such as DeNardis and Raymond (2013) and Liu (1999), have a more nuanced view of 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 privacy rights and copyrights.

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 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 unintended and unplanned day-to-day operations of Internet-actors, such as ISPs fighting botnets (as noted in van Eeten and Mueller, 2012), dealing with users wanting to set up mail servers or authoritative **Domain Name System (DNS)** servers, **country code top-level domains (ccTLDs)** managing domains or **Internet Exchange Points (IXPs)** peering traffic, have on the **coordination** 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 broader perspective of the Internet in light of these recent policy changes.

This chapter aims to map the practical governance roles, formal and informal, of a number of central Internet organizations, and to use an ecology perspective to further the understanding of how each actor affects the Internet. This mapping serves to introduce and describe the importance, or non-importance, of the many actors involved in shaping the Internet and its ecology.

As a theme-setter for this chapter, van Eeten and Mueller (2012) argue that it is considerably harder and messier to understand the Internet in full, rather than what is just going on at the large meetings, such as ICANN, the **Internet Engineering Task Force (IETF)** and IGF meetings.

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)

This chapter is intended to be a start of an endeavor to identify what is going on outside the central, and sometimes centralized, organizations.

To do this, I use an ecology lens to describe and explain the coordination mechanisms in place on the Internet today. I use coordination rather than governance as a concept to avoid confusion with the top-down perspective. The purpose of this chapter is to show how the Internet can be understood in a coordination perspective, using the levels of coordination previously introduced; **implementation of technology (T)**, **standards formulation (S)**, **coordination of**

technology (C), and **meta-coordination** (M), in this chapter with particular focus on coordination of technology.

I conceptualize coordination in two steps in an ecosystem, a perspective derived from management control and organization design literature such as Mintzberg (1993) and Olve et al. (2013). I discuss actors and actions. Presenting actors of the ecosystem, such as people, organizations, and parts of civil society forms the first step. Second come the actions of specific actors that affect the Internet, such as voicing opinion or collaborating between actors to create standards.

The contributions of this chapter are two-fold: first, the academic contribution will be a 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, and second, practitioners can use the ecology model for better understanding coordination actions of their operations.

The rest of the chapter is organized as follows. First, I go through the assumptions from which this is a meaningful endeavor, which leads way to an overview of institutions involved in shaping the Internet as it is today followed by how they coordinate, ending with my view of how the Internet is coordinated in practice. After that, I summarize the discussion and key concepts.

7.1 The notion of Internet

As stated in Section 3.1, with Internet, I explicitly do not mean the **web** (websites, HTML, JavaScript, etc), one of the many services available on the Internet. In some sense, the Internet is focused on the **Internet Protocol (IP)**-layer, 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 **File Transfer Protocol (FTP)**, **Session Initiation Protocol (SIP)**, **Secure Shell (SSH)** and **Simple Mail Transfer Protocol (SMTP)**.

This chapter goes through the relevant Internet Coordination ecology given this premise, and the upcoming Chapter 8 goes on to conceptualize the Internet based on the findings of this chapter and the assumed notion that the Internet consists of both **technology** and coordination.

7.2 The spheres

The **Swedish Internet Foundation**¹, the ccTLD for *dot-se*, released a book in 2010 describing Internet Coordination (the author, Jonson, uses terms that translate to The control of the Internet) from a Swedish context, without fully

¹Note; this is the organization funding the finalization of this thesis.

detailing what that would entail. Jonson divides Internet Coordination into three universes; the **Internet Society (ISOC)**-universe, the ICANN-universe and the **United Nations (UN)**-universe (see Jonson, 2010). I call these universes spheres and use them as models for dividing Internet actors into different boxes, and therefore each actor can only appear in one box (which is one major difference between my encompassing Internet Coordination model and the spheres as separate boxes). I use this division of spheres as structure for the first part of this chapter 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, but I then explicitly connect the actors to each other, rather than viewing them as three separate groups.

As I go through the organizations and entities, bear in mind that they are a mix of governmental, intergovernmental, non-profits, foundations and for-profit organizations. There is no overarching *raison d'être* for all involved actors, unlike the notion that all firms have a common goal (to capture value). In terms of the *thought styles* most actors present a blend of values, and I illustrate their logics where applicable.

7.3 The ISOC-sphere

The **Internet Society (ISOC)** is an international non-profit organization working for an open, globally-connected, secure, and trustworthy **Internet** for everyone, which in addition to financing large parts of the operations of the **Internet Engineering Task Force (IETF)** also has local chapters all over the world. Jonson (2010) describes the ISOC-sphere, 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 Johnson (2010) points to two forms of *ad-hoc*-standardization documents, **Request for Comments (RFC)** and **Best Current Practice (BCP)**. Jonson (2010) is here a bit inaccurate, since the IETF (and specifically the **Internet Engineering Steering Group (IESG)**), **Internet Research Task Force (IRTF)** and **Internet Architecture Board (IAB)** deal with RFCs, but an RFC fulfilling certain requirements can become an **Internet Standard** or a BCP. Internet Standards are those RFCs of special importance to the Internet (**Request for Comments (RFC)**-2026, Bradner, 1996), and Best Current Practices those RFCs which cannot be considered application standards or technical standards (see RFC-2026, 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 **Internet Protocol (IP)**-packets with inaccurate sender info)².

²The issue with inaccurate sender info is that it is impossible to verify sender info once a packet is on the Internet, the packet has to be identified as containing inaccurate sender

The mission of ISOC is to “Keep the Internet going”, with an end-to-end view of the Internet. The IETF does not formally define 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 in RFC-2026 (Bradner, 1996) agrees with.

The IETF

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 IESG, the editorial board of the RFC-stream, have to pass a consensus process (see RFC-2026, 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, non-academic argumentative text)³ and captured in a number of my interviews.

The setting at IETF is, a bit simplified, more of an academic conference than a standardization forum. However, some interviewees indicate that processes are becoming more formal to be able to handle conflict in a structured manner; some argue that this is problematic, others do not.

The IETF is not a membership organization, and its constituency is not as straightforward as a membership organization. Therefore, some processes can appear a bit convoluted. As quoted in RFC-3233 (Hoffman & Bradner, 2002):

It is important to note that the IETF is not a corporation: it is an unincorporated, freestanding organization. The IETF is partially supported by the **Internet Society** (ISOC). ISOC is an international non-profit organization incorporated in the US with thousands of individual and corporate members throughout the world who pay membership fees to join. The **Internet Society** provides many services to the IETF, including insurance and some financial and logistical support.

[...]

There is no board of directors for the IETF, no formally signed bylaws, no treasurer, and so on. The structure of the IETF (its leadership, its working groups, the definition of IETF membership,

info already at the **edge**, which entails investments from the **Internet Service Provider (ISP)** as the **Autonomous System (AS)** operator.

³Tony Li is a well known engineer at **Internet Corporation for Assigned Names and Numbers (ICANN)** and IETF who has authored 33 RFCs with a long background at Cisco; this is similar to a former parliamentarian publicly criticizing the current government which he might have had a hand in selecting.

and so on) are described in detail in BCP 11. Procedures for choosing leadership are described in detail in BCP 10.

Thus, when RFCs say “the IETF”, they are describing the group that acts in accordance with BCP 9, BCP 10, and BCP 11.

(RFC-3233, Hoffman and Bradner, 2002, p. 2)

Note that the above quote is from a RFC, documents which are the closest documents to bylaws that IETF has.

Internet Architecture Board

Other actors in the ISOC-sphere include the IAB and the IRTF. IAB is currently a committee of IETF and acts as an advisory body of ISOC. Prior, and according to Li (2015, as above), it used to be another functioning old boy’s club which became inefficient and was overthrown during the “Kobe incident”. Earlier, IAB has been involved in producing many of the Internet Standards we have, but during the “Kobe incident” in 1992 the previously independent IAB was in practice disbanded and replaced by a similar, but only advisory, incarnation within the ISOC-sphere. This led to a new version of the IAB including a remodeling of the IETF with more defined processes. Compared to, for example, documents regulating parliamentary proceedings the process documents describing IETF processes are quite loose, and in my discussions with people in the Internet-sphere they have been described as “ad-hoc”.

The Kobe incident serves as a milestone when the Internet community then realized the need for increased oversight of the IAB and the standard setting process. The meeting minutes for the IAB of the “Kobe incident” time period do not indicate the paradigmatic nature of this shift:

A. IAB/IETF NOW PART OF ISOC

Meeting in Kobe, Japan, on June 15, 1992, the Board of Trustees of the Internet Society voted to accept a recommendation from the Internet Activities Board to bring the IAB and all of its activities into the Internet Society, with the IAB serving as a technical advisory group of the ISOC. The IETF will continue to pursue standards-setting and other engineering activities under this new umbrella, and the IRTF will continue to pursue research questions of importance to the Internet.

The IAB was renamed the Internet Architecture Board.

(in appendix of Internet Activities Board, 1992, unnumbered)

Prior to the meeting the IAB was known as the *Internet Activities Board* and had no practical oversight (as described by “IXP (4)”). After the meeting the roles of the IAB, the IETF, the IRTF and ISOC were clearer. And most importantly, according to “IXP (3)” and “IXP (4)”, IAB became advisory

to ISOC rather than a standard setter lacking oversight. This shift of the IAB illustrates a shift further towards the **interoperability thought style**, as the power previously invested in the IAB was distributed to members of the IETF. RFC-1640 (Crocker, 1994) contains a fuller version of the story.

According to “IXP (4)” the **OSI-model** was dropped in favor of the **Internet-model** at Kobe. The OSI-model is an ISO standardized model for building interconnected systems, and is an ex-ante instruction-set for how to build systems. The OSI-model includes protocols such as X.400 and X.25. In contrast, the Internet-model is ex-post and describes how the Internet actually works, rather than trying to define the way forward. Dropping the OSI-model was less about which model to follow, and more about the role of the model. Instead of the OSI-model where **standards formulation** predates **implementation of technology**, the consensus was that standards formulation should describe actual working implementation of technology (Internet-model).

In practical terms, the Kobe incident concerned the next generation IP, and the IAB suggested a path towards the OSI-model which led to a revolt towards an implementation-first approach which resulted in **IPv6**.

IRTF

The IRTF is the research group in the same way the IETF is the engineering group, and is primarily distinguished in that IETF produces standards but IRTF produces research (RFC-4440, Floyd et al., 2006), which I implicitly understand as technical research focused on Internet stability. Compared to the IETF, the IRTF is quite nondescript, and no interviewee mentioned the IRTF except when explicitly asked about it.

Requests for Comments

This subsection gives a quick overview of the RFCs and their organization. There are three streams of RFCs, one by each of the IETF (and IESG), the IRTF and the IAB.

RFCs can be informational (i.e., no intention to become a standard), experimental (could be the seed of a standard, but does not proclaim to be), historic (used to label old and not recommended standards / protocols), unknown (given to RFCs which do not neatly fit into the current status-model), and belong to the standards track (that is intended to become an Internet Standard in the future). The IESG manages the standards track.

The number of streams and possible statuses have changed over the years. It is possible for RFCs to receive the *unknown* status, as well as for streams to be discontinued. For example, there used to be an RFC sub-series called **For Your Information (FYI)** which was concluded in 2011 (see RFC-6360, Housley, 2011).

In this thesis I mostly refer to those which are Internet Standards, Best Current Practices or otherwise considered important RFCs.

As illustrated by Weyrauch and Winzen (2020) the portion of RFCs authored by firms has increased steadily the last decade, and academia is producing significantly fewer. Table 7.1 illustrates the organizations responsible for the most RFCs. For example, Cisco is part of as many RFCs as IBM, Microsoft, Juniper, Google, Apple, Yahoo, and Facebook together. “IXP (1)” does not see a problem with that currently 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 RFCs conforming to your products was (and is?) a common way to market your equipment as the standard, which might be one of the reasons Cisco, Ericsson, Huawei, IBM, and Juniper have authored or co-authored so many RFCs. Noteworthy is that when I discuss RFCs, people usually talk about Cisco, Juniper, IBM and academia, and do not mention Ericsson, Huawei, Facebook, or Apple at all. Facebook and Apple are understandable due to low participation in comparison, but Ericsson and Huawei are the second and third largest contributors (by number of RFCs).

Table 7.1: RFCs per organization
RFCs per organization. Based on information and text-matching of the RFCs themselves.

RFCs	Organization	RFCs	Organization
2715	Cisco	164	Yahoo
639	Ericsson	127	Intel
593	Huawei	119	IEEE
476	Juniper	105	Qualcomm
437	Microsoft	75	Apple
330	Nokia	57	ICANN
304	IBM	49	Harvard
289	ATT	12	Facebook
240	MIT	4	Amazon
177	Google		

“DNS-Expert (1),” “IXP (1),” and “IXP (3)” note that the last years has seen an increase in concentration of participation of a few tech giants, where “IXP (1)” sees this as a part of a cycle, and it is likely to swing back, while “DNS-Expert (1)” is worried to the point where it might in a near future be meaningful to discuss the influence of large actors in the IETF, since standards could be set in such a way that they typically benefit a few

large actors. “DNS-Expert (1)” explicitly does not say “are set” and does not want to go further than “could be set”. Due to the nature of loose processes within **working groups** an easy way to get your will through is to send more people to the IETF meetings. Chapter 9 discusses the internal composition of working groups in more detail.

Several interviewees put great emphasis on the fact that the IETF does not own the RFCs, and neither does the companies employing the people who wrote them, and that if worst should come to worst another group could take over the entire RFC series and continue to publish RFCs.

In total, all RFCs amount to around 33 million words, or around 4.6 million lines (not including empty lines). The Internet Standards, a part of all the RFCs, amount to 890 thousand words and around 120 thousand lines. The Best Current Practices are similar in size to the Internet Standards. This is shown in Table 7.2⁴.

Table 7.2: RFC word and line count

Word and line count for all RFCs and the BCP and Internet Standard sub-sets. Note the relative small size of all the RFCs, and the interoperable format which made this table easy to generate automatically.

	All RFCs	STDs	BCPs
	Request for Comments	Internet Standard	Best Current Practice
Total	9003	94	233
Active	8788	90	225
Words	32 713 073	878 641	1 150 050
Lines	4 628 196	120 219	151 162
Size	466 MB	8 MB	8 MB

The reason these tables are comparably easy to produce is that all RFC content is open, and available in interoperable formats. For example, the entire RFC repository is available via rsync⁵ where all RFCs are available as text and XML-files. This can be compared to ICANN where most documents are PDFs or Word-documents⁶. All in all, the Internet Standards still fit on a handful of floppy drives, being around 8 MB in total. In comparison, the OpenDocument specification format is 19.3 MB in total⁷ and the *Bluetooth 5.0 core specification* measure in at 25.0 MB. This means all the standards

⁴Code available at <https://github.com/flindeberg/internet-tools>

⁵Command / protocol for synchronizing incremental file changes.

⁶Neither are that well standardized compared to XML- or ASCII-text documents. The PDF-standard has in the last decade gotten several standardization improvements for archiving, known as the PDF/A standard, but ICANN does not seem to use PDF/A. To test this I scraped around five thousand PDFs from ICANN and around fifteen passed PDF/A validation checks. Code is available in the same repository.

⁷Version 1.2 of the OpenDocument Format specification, extracted zip-file is 19.3 MB.

necessary to run the Internet, take up less space than the OpenDocument Format specification, and less space than the Bluetooth specification. These 8 MB of Internet Standards represent the standards formulation core of the Internet.

The standards are divided into multiple separate standards which can be modified individually, they are easily accessible (even programmatically available), they are in an interoperable format, etc. This structure and formatting of the Internet Standards is illustrative of interoperability thought style ideals. As a comparison, the Bluetooth standard is one document, one PDF-file, with over 2000 pages and does not contain the fonts necessary to draw the PDF nicely. Disregarding the formulation of the Bluetooth standard itself, just the document illustrates **integration of concerns** by being one document which has several dependencies (such as proprietary fonts).

This also means that it is very easy for *anyone*, even a non-member, to copy all Internet Standards for backup purposes, or to publish a competitive RFC-stream which borrows from the original stream. All of “DNS-Expert (1),” “IXP (3),” “IXP (4),” and “RIR (1)” explicitly said that this ease of starting over is intended. And by having that safeguard, hostile takeovers of the IETF become a non-issue in the long term.

It should not be forgotten that according to RFC-2026 (Bradner, 1996), to become an Internet Standard two separate entities must have implemented the standard, and those implementations should work together (i.e., “running code”)⁸. And to repeat an important point, an RFC is a numbered document in the IESG document series. Not all RFCs are standards or even intended to be standards. In this thesis I mostly use the terms RFC (a numbered document), Internet Standard (an RFC which is intended to be a standard and has reached some saturation and use) and BCP (more of process description than a standardization RFC, and describes a wanted practice).

Standard setting

On the notion of standard setting in a more general sense, standards are set and accepted in manners where actors have to voluntarily start using the standards rather than to force them to do so, especially when intellectual property rights are involved. This is described in RFC-2026 (Bradner, 1996):

If patented or otherwise controlled technology is required for implementation, the separate implementations must also have resulted from separate exercise of the licensing process. [...] indicating a strong belief that the specification is mature and will be useful.

⁸The exact formulation has varied over the years, but the notion that the suggested standard should be good enough for many to want to implement it has stayed the same.

The requirement for at least two independent and interoperable implementations applies to all 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. (RFC-2026, Bradner, 1996, p. 12)

This highlights two concerns, firstly, for something to be made a formal standard (in the perspective of the IETF/IESG) two independent and interoperable implementations need to exist. And secondly, open standards (that is non-proprietary or non-patented) are chosen over proprietary ones.

Anecdotally, I have in several discussions regarding the IETF heard comments similar to “I remember the first time Firm X brought lawyers to an IETF-meeting”, indicating that there is since the mid-nineties money on the table in the standards setting, or coordination, environment. Note though that the most important standards in place today, such as **IPv4**, **IPv6**, **Transmission Control Protocol (TCP)**, **User Datagram Protocol (UDP)**, **Internet Control Message Protocol (ICMP)**, etc all predate the nineties by quite a margin. In interviews, I encounter **QUIC** as the most paradigmatic standard suggestion in decades. **QUIC**, not only as **Hypertext Transfer Protocol (HTTP)** version 3, but as a TCP replacement, rewrites the market dynamics of involved actors by encrypting all traffic, and also changes the possibilities of ASs to prioritize internal traffic.

Judging from, among others, RFC-2026 (Bradner, 1996) and my interviews, the IETF were aware of potential pitfalls of proprietary standards in a **market thought style** setting, as well as the **bureaucratic thought style** idea of ex-ante decision-making, and tried to instill an interoperability thought style process by enforcing ex-post decision-making on already proven solutions. This was here exemplified by the insistence on already existing interoperable solutions being required for standardization, rather than, for example, letting the market or a convened council decide on the implementation ex-ante (as was the case with the old IAB).

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 referring to 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). This can work since suggested standards (i.e., drafts) can get published as RFCs 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).

This problematic use of RFCs is illustrated in RFC-1796, Huitema et al., 1995:

The RFC series includes some documents which are informational by nature and other documents which describe experiences. A problem of perception occurs when such a document “looks like” an official protocol specification. Misguided vendors may claim conformance to it, and misguided clients may actually believe that they are buying an Internet standard.

(RFC-1796, Huitema et al., 1995, p. 2)

Using the notion in Santos (2012) for value creation and value capture, the IETF standards process seems to balance the sometimes opposite forces of value creation for the ecology and value capture for the firm/organization quite well. 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) time-consuming to pass standards and suggestions which can be considered problematic (as implied by “ccTLD (1)”; “ccTLD (2)”; “DNS-Expert (1)”; “IXP (2)”; “IXP (3)”). The by them perceived problem is that not only innovation “on top” is necessary, but also infrastructural innovation to keep the Internet going. “ccTLD (1),” “IXP (2),” and “IXP (3)” argue that perhaps the IETF has become too broad, and too many opinions are involved to allow a consensus-process to work properly.

A technical example of an already existing solution of architectural innovation; instead of patching IPv4 with **Network Address Translation (NAT)** and similar to prevent address exhaustion (as was done), it is better to innovate at an architectural level to suggest a standard such as IPv6.

ISOC financing

ISOC (i.e., not only the IETF) itself is funded mostly through the **Public Interest Registry (PIR)** (“IXP (2),” and corroborated by financial records), 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. It 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 through support and educational programs) and support for IETF meetings and surrounding activities. The **Internet Engineering Task Force (IETF)** have received extra cash infusions the last years due to the IETF’s strained financial situation.

I asked later interviewees about the notion of licensing standards to alleviate the IETF’s strained financial situation, which was partially met with horror (as in the IETF should not sell its soul) and partially with feigned confusion (as in IETF going bankrupt is an inconvenience but not a real problem, the RFCs are still open and around).

Concluding remarks on ISOC and IETF

There is surprisingly little literature commenting on or describing processes at the IETF. For example the IETF is briefly mentioned but not discussed in Raymond (2013), mentioned in Liu (1999), mentioned as a collection of engineers in DeNardis (2012), one of two “homogeneous polyarchies” in DeNardis and Raymond (2013, the other being [World Wide Web Consortium \(W3C\)](#)), mentioned but not problematized in DeNardis (2020, as an accessible organization which potentially might be over-studied since it is easy to access), as a standard setter in Braman (2020), etc. Liu (1999) mentions the IETF in the following context:

There is a general belief that the standards crafted by the IETF are objectively good standards, worth adopting. Moreover, the IETF is widely assumed to have no other agenda than to look out for the best interests of the Internet. (Liu, 1999, p. 587)

The above quote is not followed by any deeper reflection into who might be holding the above position, and is illustrative of the magic involved in penning the IETF as the premier standard-setting organization. Later on in this thesis I make the argument that the organization of the IETF is not important in itself, and that the IETF seems important due to the important Internet Standards attributed to them (i.e., as a standard setter which seems important due to the standards they have already set, rather than for their formal power of setting and pushing new standards). The IETF is in no way an ex-ante standard setter like the ISO, the [International Telecommunications Union \(ITU\)](#) or similar (i.e., important due to the coordination underpinning them, often multilateral, an argument I continue in Chapter 10).

In short, out of implementation of technology, standards formulation, [co-ordination of technology](#), and [meta-coordination](#), the ISOC-sphere, and in particular the IETF through RFCs and the IESG mostly concern the middle two: standards formulation and coordination of technology. ISOC and the IETF should be thought of as separate; ISOC sometimes acts in ways that clash with values held by IETF members, and the IETF does not always follow the will of ISOC (even though it is financially dependent).

7.4 The ICANN-sphere

The [Internet Corporation for Assigned Names and Numbers \(ICANN\)](#)-sphere is described as necessary to bridge the technical [Internet Society \(ISOC\)](#)-sphere to the USA and other states (Jonson, 2010). ICANN is described as being very close to the [Internet Assigned Numbers Authority \(IANA\)](#) function and as having been close as the USA state through the [National Telecommunications & Information Administration \(NTIA\)](#) and the Department of Commerce (Jonson, 2010), up until the IANA-stewardship contract expired and

the formal relation with the NTIA was dissolved (Gruenwald, 2016). Both the NTIA and the Department of Commerce are USA government entities.

ICANN as an organization is bound by its bylaws, which state that “ICANN does not hold any governmentally authorized regulatory authority” (ICANN, 2019) and that their mission is to *coordinate* allocation and assignments of names in the root zone and IP and AS numbers, to *facilitate coordination* of the operation of the **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 “Advisory Committee (1),” “ccTLD (1),” “ccTLD (2),” “ccTLD (3),” “DNS-Expert (1),” “IXP (1),” and “IXP (3),” to name a few, I was given explicit answers that ICANN does not govern the **Internet** but rather facilitates coordination, and that ICANN should not go outside 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 some sense ICANN is not limited to coordinating and has been given a larger mandate by its constituents (the **Empowered Community**) to act on its own.

To contrast, “Legislator (1)” implies that ICANN has governmental-like authority by explicitly stating that it is problematic that there is no governmental regulation of ICANN, and that a multilateral **nation-state** solution might be preferable.

I have read the following versions of the ICANN bylaws: ICANN (1998, 2002, 2016a, 2016b, 2017a, 2019). Illustratively, the original bylaws (ICANN, 1998) contain around 8000 words and the current (ICANN, 2019) contain around 89 000 words⁹. The bylaws of ICANN are comparable in size to this thesis¹⁰.

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 of ICANN.

ICANN, as the bylaws state, is focused on **naming** and **numbering**. Naming can broadly be divided into ensuring a functional domain name system for **country code top-level domains (ccTLDs)** (ISO-3166-1 such as dot-se, dot-de, and dot-uk), **generic top-level domains (gTLDs)** (such as dot-com, dot-org and dot-biz) and others (reserved names such as dot-local, dot-arpa, and dot-onion). Numbering is IP-address allocation to the **Regional Internet Registries (RIRs)** which then are further delegated to operators of **Autonomous Systems (ASs)**, such as **Internet Service Providers (ISPs)**.

⁹Counted with `wc -w` the result is 89 110 and 8245 respectively, however, this includes some pre- and post-matter which strictly speaking is not part of the bylaws themselves.

¹⁰`wc -w` on all TeX-source files of this thesis amounts to around 120 000 words, of which a significant part are related to formatting and layout.

ICANN can be said to be created to handle the problems of naming and numbering which arose from many actors using the standards set by the [Internet Engineering Task Force \(IETF\)](#). This is an [interoperability thought style](#) approach to problem-solving, whereas a [bureaucratic thought style](#) solution would have been to create ICANN, or another organization, before there was an actual existing problem to solve. Several interviewees mention this distinction, and note that “the Internet-way is [in some sense] to only handle significant problems *after* they have become significant problems”, the underlying notion being that it is impossible to know if a problem is worth solving before there is an actual problem.

Empowered community

[Internet Corporation for Assigned Names and Numbers \(ICANN\)](#) can broadly be divided into groups which are part of the multi-stakeholder environment (formally the [Empowered Community](#)) and groups which are not. The [Supporting Organizations](#) (i.e., [Address Supporting Organization \(ASO\)](#), [Generic Names Supporting Organization \(GNSO\)](#), [Country Code Names Supporting Organization \(ccNSO\)](#)) and two [Advisory Committees](#) ([At-Large Advisory Committee \(ALAC\)](#) and [Governmental Advisory Committee \(GAC\)](#)) constitute the Empowered Community which is a Californian non-profit which formally elects the ICANN board (ICANN, [2016a](#), [2017c](#)).

The Supporting Organizations were the constituents of ICANN, while the Advisory Committees were advisory to the board rather than constituents of the organization. That is, in practice ICANN used to only consist of the [naming](#) (GNSO and ccNSO) and [numbering](#) (ASO) community. Prior to 2016 the ALAC (at-large community) and GAC (government) were advisory and were not constituents of ICANN.

The Empowered Community takes the role of a chapter meeting in a contemporary non-profit organization. Worth noting is that the [Security and Stability Advisory Committee \(SSAC\)](#) and the [Root Server System Advisory Committee \(RSSAC\)](#) are *not* part of the Empowered Community, according to “Advisory Committee (1)” and “Advisory Committee (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 since ALAC and GAC, the two other Advisory Committees, are no longer just advisory. That ALAC and GAC now are more than advisory since they have formal power over the ICANN board through their seats on the Empowered Community seems to be a sensitive issue. Some of my interviewees argue that it is problematic that there is more formal influence in ICANN than the original Supporting Organizations, some comment that it is a political question and do not want to answer in a recorded setting, and some seemed unaware that the ALAC and GAC are no longer just advisory. If the RSSAC and the SSAC would want to become part of the Empowered

Community, the Empowered Community would have to change the bylaws of ICANN. Neither RSSAC nor SSAC could make that change on their own.

The Empowered Community 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 **Internet Assigned Numbers Authority (IANA)** function), recalling and appointing board members at any time and selling assets (ICANN, 2016a, 2017c). It is worth noting that ICANN does not have any particular kind of assets, such as equity or properties, except the **root-zone** according to interviewees (which is also backed up by annual reports).

The Empowered Community was created in conjunction with the IANA stewardship transition in October 2016, and it has turned into a powerful structure “lacking members” (“Advisory Committee (1)”) or only made up of professional members (“ccTLD (3)”). “Lacking members” refers to that there are many empty seats in the formal Empowered Community structure. “Professional members” refers to that there are people doing careers as “ICANN-meeting-goers”, albeit usually employed by an organization with an interest in the political side of naming or numbering, so that ICANN meetings in themselves gain **raison d’être**, rather than that which the meetings are meant to coordinate.

Both “Advisory Committee (1)” and “ccTLD (3)” argue that the processes for planning (as described in ICANN, 2017c) are expensive and cumbersome to maintain, and “ccTLD (3)” specifically says that the processes for maintaining ICANN’s overhead take more time than the processes for doing that which ICANN should do. “ccTLD (1)” and “ccTLD (3)” state that, from a **country code top-level domain (ccTLD)**’s perspective, it is important to keep track of what happens in ccNSO and ICANN, but that there is little of actual significance discussed.

It is normal for larger organizations that some form of bureaucratization is needed, and the arguments of the above interviewees is that ICANN should not be that large, rather than a comment on ICANN’s efficiency.

In practical terms the policies set by ICANN are not enforced legally, rather they are recommendations. By the **interoperability thought style** some policy processes can therefore be argued to be unnecessary, while in a **bureaucratic thought style** they can be seen as a calibration coordination process, and way of expressing a changing **meta-coordination** view. That is, a change of values behind the **coordination** without de facto altering the constituency of the **Internet**.

Policy processes include, but are not limited to, discussions regarding processes for new **generic top-level domains (gTLDs)** (a part of the naming system) and recommendations regarding **Domain Name System Security Extensions (DNSSEC)** (a recommendation of a set of standards set by another organization, the **Internet Engineering Task Force (IETF)**).

ICANN board

The interviews highlight that the most important aspect of **Internet Corporation for Assigned Names and Numbers (ICANN)** is ensuring that people and organizations keep talking and that the **Internet Assigned Numbers Authority (IANA)** function remains functional (for example “ccTLD (1)”; “ccTLD (2)”; “DNS-Expert (1)”; “ISP (1)”; “IXP (1)”; “IXP (2)”; “IXP (3)” although it should be noted that even if there is clear agreement here, all of these interviews are with people involved in the day-to-day operation of the technical side of the **Internet** at some level). According to “Advisory Committee (1)”, one implicit purpose of ICANN is to take up space, so there is no vacuum for the **United Nations (UN)** or other organization to rush in and take control of central Internet **coordination** mechanisms (a protection against forces in the **bureaucratic thought style**).

The prevalent view of ICANN as governing, or controlling, the Internet in literature, would require ICANN to be more powerful than they are today (see standards in Chapter 3). For example the current **naming**-power they possess is based rather on active **Internet Service Provider (ISP)** choice to use their root-zone (cf. earlier quote from Liu, 1999), which is not a requirement to be part of Internet the same way **Border Gateway Protocol (BGP)**-compliance is (Mathew, 2016). This can be compared to a road network with cars (BGP and **routing**) and road-signs (**Domain Name System (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.

I know of no commercial ISPs which do not use the IANA **root-zone** by default on its recursive DNS-servers, but there are a few alternate roots available. Most notably OpenNIC (which also resolves the IANA root-zone), Yeti DNS Project (Chinese sovereign root), and National DNS (Russian sovereign root).

ICANN recently (fall of 2020) discussed **Internet Governance** using two terms: (1) Internet Governance (IG) as the policy part, and (2) **Technical Internet Governance** (TIG) as the technical part. The difference is not well-defined, and it is possible that ICANN further intend to nuance the difference. I interpret it as that Internet Governance and **meta-coordination** concerns similar issues, and that Technical Internet Governance and **coordination of technology** concerns similar issues.

ICANN today is primarily funded through reselling of **generic top-level domains (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 the context that ICANN used to be funded by the goodwill of other actors, such as **country code top-level domains (ccTLDs)** and ISPs). In 2010 ICANN had a revenue of \$65 million and in 2016 closer to \$200 million where the absolute majority of the increase comes from gTLD

sales and applications (ICANN, 2010, 2016c). Maintaining the root-zone costs a fraction of \$200 million, which stirs feelings, I return to this in a couple of sections after the entire ecology has been introduced.

IANA-function

The **Internet Assigned Numbers Authority (IANA)** function today lies under **Internet Corporation for Assigned Names and Numbers (ICANN)** via the **Public Technical Identifiers (PTI)** organization (NRO, 2017). The IANA function as a concept predates ICANN by several decades. The concept was first mentioned by Jon Postel in **Request for Comments (RFC)**-322 (Cerf & Postel, 1972) and RFC-433 (Postel, 1972), with the first explicit IANA mention in RFC-1083 (Postel, 1988):

The protocol standards are managed for the IAB by the Internet Assigned Numbers Authority. (RFC-1083, Postel, 1988, p. 11)

Technically, IANA is responsible for the **coordination** of IP-address and ASN allocation globally, which is done via the **Regional Internet Registries (RIRs)** and **Number Resource Organization (NRO)-Address Supporting Organization (ASO)** (NRO, 2017). It is often implied that the IANA function is the most important function of ICANN (cf. both interview and literature Aerts, 2007; “ccTLD (1)”; “ccTLD (2)”; “DNS-Expert (1)”; Dolderer and Bäss, 2006; “ISP (1)”; “IXP (1)”; “IXP (2)”; “IXP (3)”; Oleg and Chahadé, 2015).

For example:

You only need the IANA part [of ICANN] (Interviewee)

In particular, we look forward to further improvements of the IANA function as the core service ICANN provides to ccTLDs (Dolderer & Bäss, 2006)

It is also interesting to note that a twenty-year-old text, Gillett and Kapor (1997), states that the IANA functions will “probably” be governed in a bottom-up participation based model like the rest of the **Internet** (i.e., the **Internet Engineering Task Force (IETF)**, a **coordination of technology** approach in the **interoperability thought style**), but a year later ICANN was formed and the IANA functions firmly stayed within the ICANN organization. This means leaning towards the **bureaucratic thought style** approach to coordination of technology.

The IANA function, in a technical sense, is described in more detail in Section 3.4. At a high level, the IANA function does that which is required for maintenance of the **root-zone** concerns. The IANA function can also re-delegate **top-level domains (TLDs)**, which it historically only has done based on technical concerns, such as unstable operation of a TLD.

The IANA transition brought the IANA function into PTI, a separate organization vis-à-vis ICANN, at least legally. The ICANN board more or less fully controls the IANA function. PTI is a small part of ICANN in terms of turnover and employees. According to “ccTLD (3)” and “Cryptographic Officer (1)” PTI, and the IANA-function, employ roughly 25 people. Even though PTI legally is a separate organization from ICANN, “ccTLD (3)” and “Cryptographic Officer (1)” indicate that the separation in practice is not that substantial.

The IANA function was created based on the need of a process or organizational environment within which to coordinate unique names and numbers, today practically those used for **Domain Name System (DNS)** and **Border Gateway Protocol (BGP)**. “DNS-Expert (1),” “IXP (3),” “IXP (4),” and “RIR (1)” all argue that the need of IANA preceded the organization, and that it was important that the organization was not created before there was an actual unavoidable need for coordination. In terms of **Requests for Comments (RFCs)**, RFC-322 (Cerf & Postel, 1972), RFC-433 (Postel, 1972) and RFC-1083 (Postel, 1988) tell a similar story. “IXP (4)” and “RIR (1)” are both explicit in that coordination, any coordination, should not be done before there is an explicit need for that coordination, and that this is part of the Internet ideology or mindset, an ideal I ascribe to the interoperability thought style.

ccTLDs

This section introduces the first of two primary kinds of **top-level domains (TLDs)**, the **country code top-level domain (ccTLD)**, the second being the **generic top-level domain (gTLD)**.

In general terms, ccTLDs are the national level registries and registrars for **ISO-3166-1** top-level domains, even if there often are no contractual connections between the ccTLD organization and the **nation-state** corresponding to the country code. The actual code for each country is the corresponding ISO 3166-1 two-letter country code (dot-se for Sweden, dot-de for Germany, etc). Most ccTLDs are connected to **Country Code Names Supporting Organization (ccNSO)**, but they are not forced nor do they need to be members. Some ccTLDs do not even recognize the **Internet Corporation for Assigned Names and Numbers (ICANN)** and does not have an agreement with them (an agreement like the one the **Swedish Internet Foundation** has with ICANN in Aerts, 2007 see discussion later on), e.g., the dot-dk registry. Dot-dk does not have a relation with ICANN, and only an indirect relation with **Internet Assigned Numbers Authority (IANA)** to manage their delegated domain. Dot-dk is present in the **root-zone** based on an understanding from the early nineties. Most ccTLDs were created without formal agreements with ICANN, an **International Telecommunications Union (ITU)** report part of the “ccTLD Governance Project” from 2003 notes that out of 44 investigated ccTLDs, 5

had an agreement or an “I-see-you” of some form in place with ICANN. Most **Memorandum of Understandings** were written later, for example the dot-de and dot-se were written in 2006 and 2007 (see Aerts, 2007; Dolderer and Bäss, 2006 for relevant agreements).

ccTLDs are in general not contractually bound to ICANN, and can either be seen as constituents of ICANN (through the ccNSO) (“ccTLD (2)”) or as quite separate (“there is no formal relation between ICANN and ccTLDs [in general], but they have built this social club called ccNSO within ICANN” (“ccTLD (3)”). ccTLD registries are in general funded by ccTLD sales and not limited in their pricing by ICANN (as described by “ccTLD (2)”; “DNS-Expert (1)”, there is local regulation in some jurisdictions though, and in some the **national regulatory authority** is running the ccTLD).

It is quite common in literature to assume that ccTLDs are connected to or belong to sovereign nation states, as argued “Most legal scholars merely *assume* that states have sovereignty rights over their ccTLDs and do not critically assess the justification for, or the implications of, a sovereignty-based model” (Mueller & Badiei, 2016, p. 435). In Section 10.5 in Chapter 10 I illustrate the nation agnostic nature of ccTLD delegations, by illustrating that, for example, the se-zone delegates to name servers in 96 different regions (according to ISO-3166-1).

It should be noted that many ccTLDs were delegated prior to the inception of ICANN, and several ccTLDs do not have a relationship with ICANN, and instead rely on an administrative contact with the IANA-function. All TLDs have administrative and technical contact with the IANA-function for day-to-day, or decade-to-decade, operations. For example to alter **Domain Name System Security Extensions (DNSSEC)** keys, authoritative name servers, or similar.

In contrast, the Swedish Internet Foundation acknowledges that ICANN exists, and that as the performer of the IANA function, they are interested in having a 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)

There are three early documents on some of these issues called ICP or **Internet Coordination** Policy documents (see IANA, 1999, 2001a, 2001b). And there are no current processes for redelegating ccTLDs (“ccTLD (3)”) or even adding more root-zone servers (“Advisory Committee (1)”; “Advisory Committee (2)”; “DNS-Expert (1)”).

They [IANA] do not have a framework which states, for example, if we get 100 000 signatures and a letter from the government, we will do it [redelegate a TLD] (“ccTLD (3)”)

“Legislator (1)” argues that this is problematic, since the root-zone server operators are, seen from where the organizations are incorporated, based in the West. However, they have operations across the globe.

There are attempts to ensure a process of redelegation of ccTLDs, for example ccNSO (2011) which recommends a framework of interpretation (FOIWG, 2014) recommending business as usual per [Request for Comments \(RFC\)-1591](#) (Postel, 1994) with the explicit addition of documentation. The framework, FOIWG (2014), has never been voted on by the ICANN board.

Currently, Niue, a small island self-governing state in free association with New Zealand with the ISO-3166-1 code “nu”, is in conflict with both the Swedish Internet Foundation and ICANN (see redelegation request and summary in Tagelagi et al., 2020) over the ccTLD dot-nu. This is illustrative of a conflict between the [bureaucratic](#) and [market thought styles](#), where Niue sold their ccTLD in the nineties (\$) and now wants it back (relying on a [bureaucratic thought style](#) of jurisdiction and states). I return to this conflict later, since it is illustrative of the different perspectives of the [interoperability](#), [bureaucratic](#) and [market](#) thought styles.

Even if dot-dk does not have a formal agreement with either IANA or ICANN, there is no way to change the delegation, that is to give the domain to someone else, as illustrated above. According to people in the [bureaucratic](#) and [market](#) thought styles it does not make sense that top-level domains, such as dot-dk, do not have a contractual agreement with either ICANN or IANA and are still listed in the root-zone.

As there is no regulation or agreement in place, it is in general possible for ccTLDs to set insane prices, but the structure of most ccTLDs limit them. For example DENIC (the dot-de registry) is founded as an economic association owned by, essentially, the German [Internet Service Providers \(ISPs\)](#) and registrars, which want to keep the price of a dot-de domain low. As worded by an interviewee, “the membership organizations [such as DENIC] have been captured by its members” (“ccTLD (3)”), whose interests are financial (\$). In addition to that, the interviewee continues “the foundations [ccTLDs] do not have the same issues” (“ccTLD (3)”), illustrating one major difference between ccTLDs today, those mostly governed by [interoperability thought style](#) ideals such as foundations who do not keep the prices as low but rather high enough to ensure stable operations, and those governed by [market thought style](#) ideals such as firms and the membership organizations with for-profits as members.

There are also more bureaucratic ccTLDs, for example dot-no (Norway) and dot-fi (Finland), which are organized as a fully owned government firm and as a government agency respectively. Both “ccTLD (1)” and “ccTLD

(3)” argue that, in their experience, the ccTLD as a foundation concept has stayed true to the original mission of the ccTLD-concept and with the most amount of strategic freedom (i.e., the ccTLD purpose as originally envisioned as a regional actor for delegating TLDs with a geographic connection in RFC-1591 (Postel, 1994)).

A more critical argument, by “ccTLD (3)”, is that government ccTLDs lack long-term planning due to yearly budget cycles, when in reality many investments need to be made for ten year or longer periods (such as software systems for domain management), and that governmental ccTLDs end up supporting the short term political interests of the government rather than managing their domain administration stably.

Most ccTLDs, but as previously noted absolutely not all, together constitute the ccNSO, a part of the **Empowered Community** of ICANN. To reiterate, not all ccTLDs recognize ICANN, out of those that recognize ICANN not all are members of the ccNSO and therefore part of the Empowered Community.

gTLDs

In comparison to the umbrella term **top-level domain (TLD)**, **generic top-level domains (gTLDs)** are a subset of top-level domains, such as dot-com and dot-gov, as well as the “new” generic top-level domains such as dot-xxx and dot-google. **Internet Corporation for Assigned Names and Numbers (ICANN)**, and not **Generic Names Supporting Organization (GNSO)**, approves all new generic top-level domains. The generic top-level domains speculated that they would turn a profit by investing in a new TLD, but some generic top-level domains 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 for the first time (“IXP (2)”).

The gTLDs are contractually bound to ICANN differently than **country code top-level domains (ccTLDs)** and almost all gTLDs are firms. There are a few notable exceptions, such as **Public Interest Registry (PIR)**, the non-profit manager of dot-org, dot-ngo, and dot-ong.

At a technical **Domain Name System (DNS)** level there is no difference between any form of TLD. All types of TLDs are technically interoperable, the differences lie in their relationships with ICANN. All TLDs have similar relationships with the **Internet Assigned Numbers Authority (IANA)**.

Regional Internet Registries

The **Regional Internet Registries (RIRs)** are closely connected to the **Number Resource Organization (NRO)** (and **Address Supporting Organization (ASO)**) and their primary activity is distributing IP-addresses and **Autonomous System Numbers (ASNs)** to **Internet Service Providers (ISPs)** and other actors. Regional Internet Registries are distributing numbers and are the key

extended-aspect of the **Internet Assigned Numbers Authority (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)** and the ISP would in effect be isolated from the other networks. Here I broadly use the term BGP to signify relevant routing protocols. The Internet is quite commonly referred to as a *network-of-networks* (e.g., **Request for Comments (RFC)**-2026, Bradner, 1996), which technically can be understood as a network-of-**Autonomous Systems (ASs)**, where each AS needs an ASN for external routing purposes.

Prior to **IPv4** address exhaustion it was practically possible for private individuals to request prefixes and ASNs. For example, according to **Réseaux IP Européens Network Coordination Centre (RIPE NCC)** processes any “legal entity or natural person can become a member of the RIPE NCC”¹¹ and then request **Internet Protocol (IP)** address allocations or ASNs.

The Regional Internet Registries are organized as non-profit organizations.

Technically, the Regional Internet Registries together constitute the NRO through a **Memorandum of Understanding**, as previously mentioned, is virtually the same organization as the ASO, with ASO being the chapter present in the bylaws of **Internet Corporation for Assigned Names and Numbers (ICANN)** and NRO predating ICANN.

ICANN funding

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 **generic top-level domain (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 legal settlements, even though the amount is not known. In general, many of the organizations mentioned are growing, but at a much slower pace.

To put the revenue into perspective, the **Swedish Internet Foundation** and DENIC (the German **country code top-level domain (ccTLD)**)¹² 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 7.3 (absolute values) and Table 7.4 (percentages). In comparison,

¹¹See <https://www.ripe.net/participate/member-support/become-a-member>.

¹²More correctly the ccTLD for the letters corresponding to the alpha-2 **ISO-3166-1** code for Germany. The ccTLD itself as a name in **Domain Name System (DNS)** does not need to have anything to do with Germany as a country or nation state, except that DENIC is incorporated there.

the revenue of the entire DNS-ecology is around \$8 billion (Lehr et al., 2020, p. 16).

In Table 7.3 and Table 7.4 ccTLDs, which often are registries, are for historical reasons the odd man out at ICANN due to lack of contracts and agreements. *Registries* as a term refers to an administrator of a **top-level domain (TLD)** which is not a ccTLD, bound by a more contractual agreement. *Registrars* refer to entities, often firms, selling domain names to end customers (registrars can sell domain names from the registries they have contractual agreements with). Regarding Table 7.3 year 2018 and gTLD app.fees, “Funding from new gTLD Auction Proceeds is (\$13) million due to a cumulative adjustment to the new gTLD application fees recognized in revenue as of 30 June 2018” (ICANN, 2018, p. 45).

Table 7.3: ICANN revenue by source
Compiled from ICANN financial statements and ccTLD contribution statements. Some values are presented by ICANN (years 2014 and 2018), and prior years are calculated from aggregated financial statements and written information in regard to relative sizes and changes between ccTLD, registrar and registry fees.

		2002	2006	2010	2014	2018
ccTLDs	\$	603	1 002	1 605	1 828	2 337
Registries	\$	718	5 830	31 915	47 143	83 282
Registrars	\$	2 368	19 312	30 189	34 831	46 788
gTLD app. fees	\$				36 574	−12 548
Revenue domains	\$	3 690	26 144	63 709	120 376	119 859
Revenue tot	\$	5 965	29 821	65 768	123 384	133 761

Amounts in thousands of \$

This inflow of money sparkts the question 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 TLD inherently is just a cost, and that generic top-level domains will only generate a profit as long as customers see a value in owning them. According to such a reasoning, revenues could drop in the future. One factor could be other “ways of finding your way on the Internet” than using domain names, such as googling instead of using the DNS system, which would decrease the value of owning a TLD.

In terms of costs most increases are personell related (such as travels and salaries), and the increase of employees has been steady since the inception of ICANN. Several interviewees note that IANA today (i.e., the **Public Technical Identifiers (PTI)** organization) is what ICANN used to be twenty years ago in terms of organizational size.

Table 7.4: ICANN revenue by source (percent)

Percentage of total revenue in financial statements of ICANN for given fiscal year.

		2002	2006	2010	2014	2018
ccTLDs	%	10.1	3.4	2.4	1.5	1.7
Registries	%	12.0	19.6	48.5	38.2	62.3
Registrars	%	39.7	64.8	45.9	28.2	35.0
gTLD app. fees	%				29.6	−9.4
Domain names	%	61.9	87.7	96.9	97.6	89.6

Critique of ICANN ecosystem

Compared to the **Internet Society (ISOC)** and the **Internet Engineering Task Force (IETF)** I have encountered significant critique of the ICANN ecosystem and ICANN as an organization, in particular of those leaning towards the **interoperability thought style**. I summarize some of them in this section to illustrate that there is no real consensus in the Internet **epistemic community** that ICANN by necessity is good or even necessary the same way the IETF is. As the quotes are sensitive, I have only permission to use some of them if anonymized.

ICANN does not in a regulatory sense govern the Internet, and ICANN is commonly accused of not doing enough in explaining the actual **Internet Coordination** mechanisms in place. For example:

There is a very general and broad misunderstanding that ICANN governs the Internet [...] and I consider it dangerous that ICANN has not done more to dispel this notion (Interviewee)

This interviewee further argues that the danger comes from ICANN as an organization becoming more important than what ICANN does, which goes against the interviewees beliefs.

In the context of the purpose of ICANN, there is the original notion that ICANN should only coordinate the **root-zone**, and not do anything more than that. This is the original vision of ICANN and IANA in the interoperability thought style. This is brought up in, for example, Memorandum of Understanding between some ccTLDs and ICANN, such as Aerts (2007) and Dolderer and Bäss (2006).

Illustrative quotes in interviews:

It is more like they [ICANN] are manned by professional ICANN-muppets [rather than people with an intention of keeping **coordination** at minimum] (Interviewee)

You only need the IANA part [...a potential] new ICANN should only be PTI [i.e., a minimal organization for the IANA-function]
(Interviewee)

They [ICANN] should coordinate the root, not more, not less
(Interviewee)

On a similar note is opinions of a change from the minimal organization for coordinating the root to a larger bureaucratic institution where processes are as important as results. Several interviewees note that ICANN discusses issues which are interesting rather than needs to be discussed. This implies a conflict between interoperability and **bureaucratic thought styles**. Illustrative quotes:

ICANN is currently more focused on planning the activity than doing the activity
(Interviewee)

ICANN is not at all interesting [today], I try to follow what's going on as damage control
(Interviewee)

You stayed [in the ICANN context] to keep tabs on things [...] but most everyone was disappointed [in the context of a series of decisions which led to ICANN expanding mandate and organization]
(Interviewee)

I think ICANN is becoming quite meaningless [i.e., what they do, ...], and ICANN as an organization is quite meaningless
(Interviewee)

This critique can be summarized as the interoperability thought style observing a drift towards the logics of the bureaucratic thought style. My observation is that current ICANN policies contain a blend of interoperability and bureaucratic thought styles values (and less of **market thought style** logics), and that the drift noted by interviewees rather implies that ICANN is no longer an interoperability thought style coordinator of names and numbers on the Internet but is engaging a wider audience in society. Similarly to how the ISOC engages a wider audience than the IETF, the current ICANN engages a wider audience than the year 2000 ICANN.

Another way of framing these conflicts is that ICANN is the arena where these **thought styles** meet, so the conflicts happen at ICANN meetings where groups of the interoperability and bureaucratic thought styles meet, rather than at the **International Telecommunications Union (ITU)** or the IETF where **incommensurable** thought styles are less likely to meet and collide in public.

At ICANN technology is not discussed, but policy, so I am not interested in ICANN [pause] but policy has to be discussed somewhere, I think ... (Interviewee)

When I follow up on above, the interviewee reasons on the assumption that there are issues of political, rather than technical, character which have to be handled, which is contrary to other interviewees who argue that issues, regardless of political or technical character, should not be handled until they become severe enough to warrant being handled.

Summary of ICANN-sphere

In terms of thought styles, ICANN has gone from the organization started from a need of coordinating unique identifiers (**coordination of technology**), an ex-post need in interoperability thought style fashion, to an organization with an increasing influence from bureaucratic ideals and ex-ante coordination concerns. Interviewees, mainly of an interoperability thought style involved in the technical core of the Internet, indicate a problem with this shift, while others, primarily discussions with representatives governments and governmental agencies, express content with this shift.

7.5 The UN and ITU sphere

Last in Jonson (2010) is the **United Nations (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). This section focuses on the bureaucratic thought style view of the Internet, where values other than technical interoperability are of the highest priority.

Neither the UN nor ITU has a technical or governing role in the Internet infrastructure, but there are interests that want to put the UN in a more central role of the Internet ecosystem ("ITU Delegate (1)"; "Legislator (1)"). As illustrated in interviews; "the ITU is like the UN in general, the same constellations and the same groupings" ("ccTLD (1)").

Both the UN and the ITU are member organizations where members are states recognized by the UN. In practice the ITU acts as the telecommunications arm of the UN (i.e., same members, different representatives, in most cases. Technically the ITU is a specialized agency in the UN-system). 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).

International telecommunications regulations

In the era of digital communications there have been two meetings with the intention of setting **International Telecommunications Regulations (ITRs)** in the UN-sphere. The first one was in Melbourne 1988, called **World Administrative Telegraphy and Telephone Conference (WATTC)**, and the second one was in Dubai in 2012, called **World Conference on International Telecommunications (WCIT)**. In short, *WATTC* agreed on quite loose terms on which nation states and sector members (in practice large telecommunications companies) could collaborate internationally with some semblance of order. According to “ITU Delegate (1)” *WATTC* was quite reasonable as far as bureaucratic exercises go, even from the interoperability thought style (there are multiple narratives, for example Rutkowski, 2020 which support the same story, that *WATTC* managed to make that which is often incommensurable commensurable). In general, those interviewees who mention the International Telecommunications Regulations from *WATTC* are quite fond of them (back then), and see them as having struck a reasonable balance between the wants of the interoperability, bureaucratic and market thought styles.

The CCITT [currently **ITU Telecommunications Standards Sector (ITU-T)**] Plenary Assembly has helped to provide a concrete technological and operational foundation for the orderly development of the network while the World Administrative Telegraph and Telephone Conference (*WATTC*-88) provided a regulatory framework appropriate for the diverse technological, operational and national policy environments which are so rapidly evolving today.

(Butler, 1989, p. 139)

The above quote, from an editorial of the Telecommunications Journal, illustrates the balance of wants of the thought styles; balancing value capture, diverse technology, and a sense of agreement and control. The same is not true for *WCIT*. The treaty at *WATTC* -88 has also recurrently been mentioned in my interviews as the last time the ITU influenced the Internet (most explicitly by “ITU Delegate (1)”). The UN and the ITU are coordinated and governed through bureaucratic thought style ideals.

WCIT was held in 2012, and the role of the UN and the ITU in the Internet was discussed. The member states decided that the Internet should be under greater ITU influence (journalistic overview Dourado, 2012; “ITU Delegate (1)”). “ITU Delegate (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 (according to “ITU Delegate (1)”). There are surely other opinions. Dourado (2012) cites USA Ambassador Terry Kramer as saying “Internet policy should not be determined by Member States, but by citizens, communities and broader society” (Dourado, 2012), implying that member states are not

perfect representations of citizens, communities and the broader society in this particular case. The other opinion, as expressed by “Legislator (1)”, is that since the UN and the ITU are the international multilateral organizations for collaboration, the Internet and its governance should be the responsibility of the UN and the ITU.

Most Western states voted against the resolution, the International Telecommunications Regulations of *WCIT* 2012, following the USA but a majority of all states voted in favor of it (see overviews in Cherryil, 2012; ITU, 2012; “ITU Delegate (1)”; Masnick, 2012).

Compared with the International Telecommunications Regulations of *WATTC*, the International Telecommunications Regulations from *WCIT* 2012 has been met with much harder criticism. The ITU can suggest treaties but the countries themselves have to ratify them. According to the only ITU source I can find (most ITU documents not public), only *nine* (9) countries out of 89 who signed the *WCIT* 2012 treaty have so far ratified the treaty at some level¹³. *WATTC* was ratified by 190 nation states¹⁴.

“ITU Delegate (1)” reasons that the *WCIT* 2012 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? The bureaucratic thought style, as displayed by “Legislator (1)”, rather assumes that the UN (and the ITU) is the legitimate place for such discourse.

Currently, the role of International Telecommunications Regulations is discussed intently. Where some nation states see International Telecommunications Regulations as having played out their role, others see International Telecommunications Regulations as good means of ensuring some semblance of order. The meeting minutes EG-ITRs (2019, 2020, 2021) illustrate the perspectives on a selection of ITU members (nation states) and sector members (firms). Two excerpts regarding Western states illustrate positions of nation states who do not want to regulate telecommunications in fine detail, and are not in line with the agenda actually set at *WCIT* 2012.

[the countries] drew attention to the differences of view that exist regarding another WCIT. [the countries] had not signed the 2012 ITRs and did not intend to do so. [the countries] believed that holding a new WCIT to revise the treaty again would undermine efforts to build capacity and could potentially damage the good reputation of the ITU.

(Austria, the Czech Republic, Estonia, Latvia, the Netherlands, Romania, Sweden, and the United Kingdom in EG-ITRs, 2019)

¹³https://www.itu.int/online/mm/scripts/mm.final-acts.list?_agrmts_type=WCIT-2012

¹⁴https://www.itu.int/online/mm/scripts/mm.final-acts.list?_agrmts_type=WATTC-88

Any attempt to revise the 2012 ITRs to address existing economic conditions and emerging technologies and services will meet the same fate as the current provisions — because of the rapidly changing market and regulatory environment, detailed treaty provisions will perpetually be obsolete.

(USA, Canada, Australia in EG-ITRs, 2021)

Russia and Saudi Arabia serve as examples of nation states with a different will than most Western states.

The position of the Russian Federation is clearly outlined in [selection of documents]. It was stated that the ITRs were necessary; provisions of the 2012 ITRs are flexible and relevant.

It was noted that in many cases, the 1988 ITRs have not reflected the changes that have occurred in the telecommunication/ICT ecosystem since 1988 [and further arguments on why the 1988 International Telecommunications Regulations are not good enough, as an argument for agreeing on new ones]

(Russian Federation in EG-ITRs, 2021)

Saudi Arabia highlighted that the ITRs is one of the four binding treaties forming the foundation of the ITU, the United Nations specialized agency for ICTs. Treaty-level provisions are required for worldwide networks and services.

(Saudi Arabia in EG-ITRs, 2019)

Egypt and South Africa comment similarly to Russia and Saudi Arabia, except not as explicitly.

Telecommunications companies are also represented in the EG-ITRS:

[International Telecommunications Regulations] are neither applicable to the fostering and development of international products and services, neither are they flexible enough to accommodate today's dynamic and innovative marketplace.

(Bell Mobility, AT&T, Verizon, etc in EG-ITRs, 2021)

Here the will of the Western states, at least in writing, seems congruent with the will of Western for-profits. The excerpts provided here are not meant to serve as a full picture of the ITU, rather to illustrate the lack of consensus in the ITU setting with regard to digital communications, including the Internet (even if not mentioned with the term “the Internet”).

The ITU meetings and documentation

Chapter 9 goes further into the administrative structure of the ITU. Above I have focused on the treaty setting mechanisms of the ITU, such as the ITR meetings *WATTC* and *WCIT*. 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). The ITU holds quad-annual chapter meetings called **ITU Plenipotentiary**, where they elect board and set the agenda for the upcoming period.

The ITU also held the **World Summit on the Information Society (WSIS)** set of meetings described by both ITU (2017b) and Jonson (2010) as an informal series of meetings discussing the development of the Internet. After the last meeting in 2005, WSIS was replaced by the **Internet Governance Forum (IGF)**, an annual UN-hosted forum. The interoperability thought style biased interviewees in general consider the WSIS and IGF to be superfluous as they do not concern the technical nature of the Internet per se, and that which ICANN was created as a revolt to.

Even though the ITU is part of the UN and transparency seems to be important (according to process documents and documentation such as ITU, 2017b, 2018), there are still those, such as Dourado (2012), “ITU Delegate (1),” and Lee (2012), who state that the ITU is not transparent enough. Dourado (2012) exemplifies by saying that even though the plenary sessions of *WCIT* 2012 were open, most discussions and decisions were made behind closed doors. This is in contrast with ICANN where “ccTLD (1)” argues that it is not possible to say that ICANN is not transparent (since all documents and most proceedings are in the open), even if you might disagree with some of ICANN’s policy.

Although most ITU and UN documentation is behind closed doors, especially working material, some floats around on the **web** as well. For example, I have accessed internal working documents on “**new IP**” by searching online for documents with certain metadata signatures.

7.6 Other influential organizations and actors

The following sections list actors of varying importance and influence, and starts of with the more recognized actor types. These were either encountered in literature or in interviews. The already mentioned, i.e., **Internet Engineering Task Force (IETF)**, **Internet Corporation for Assigned Names and Numbers (ICANN)**, the **United Nations (UN)** and the **International Telecommunications Union (ITU)**, are the most commonly mentioned organizations by far.

Net neutrality literature in particular mentions the Internet Service Provider (ISP) as the actor type of the marketplace where the Internet service or product is sold.

Internet Service Providers

As stated in Chapter 2, at the start of this process I did not realize the diversity of opinions present, and now at the end of this process I realize that the nature of the ISP is almost entirely defined by the concept of net neutrality, which decides whether (through legal or technical means) it is possible to differentiate value capture at all (\$). I was told that ISPs in general are not interested in Internet Coordination (“IXP (1)”; “IXP (3)”; “RIR (1)”), implying that ISPs are more interested in the Internet as a service to sell (\$) rather than a phenomenon or idea to coordinate (Δ).

Technically, an ISP has one or many Autonomous Systems (ASs), which are the nets together forming the Internet (cf. earlier Figure 3.2 with all prefixes and ASs visible in 2000 and 2020). ASs are closely related to Autonomous System Numbers (ASNs), which are the numbers given to each AS and used for routing purposes, and as mentioned before in Section 2.8, the ASN is one of the unique identifiers coordinated with the Internet Assigned Numbers Authority (IANA) function through the Regional Internet Registries (RIRs).

In the general setting I assume that most ISPs are run as firms, and thus guided by market thought style principles in how strategies are set and executed. However, many, especially European, Internet Exchange Points (IXPs) are run in non-profit settings (such as a firm owned by a foundation or operated as a strict non-profit, see the next section on Internet Exchange Points). I see ISPs as being the vendors of Internet access to Internet-end-users. Not all AS owners are ISPs which sell access to end-users, some are rather wholesalers, such as those providing transit. 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 port 25 (mailserver), 80 (webservers), 443 (secure webservers), etc) technically. 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 in a technical sense. ISPs also own a large part of the Internet infrastructure, i.e., cables and equipment at both edges and inside ASs (in general), and the privatization of this infrastructure has been the topic of many studies, ranging from the earlier Cowhey (1990) to later overviews such as DeNardis et al. (2020).

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 (1)”). Although the main aspect of the laws are in line with net neutrality, there are occasions when traffic operators are

allowed to filter or drop traffic, one example being when a user is exposed to **distributed denial of service (DDoS)** 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).

Later in, and in Chapter 10 in particular through the lens of net neutrality, I will go further with the notion of coordinating the behavior of ISPs (and **infrastructure and network operators** in general), and argue, that net neutrality is a **bureaucratic thought style** approach to achieving that which otherwise, for example the **interoperability thought style**, considers a requirement for good design (i.e., **separation of concerns**), which the interoperability thought style has other solutions to as well.

Internet Exchange Points

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

ISOC (2015c) argues that governments and other entities should help foster Internet Exchange Points since they are vital for a working Internet-infrastructure ecology, and says that ISPs have cost incentives to collaborate and start Internet Exchange Points. Internet Exchange Points 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 economically impossible for IXPs (according to “IXP (1)”; “IXP (3)”) 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 USA, see Markus, 2006).

Huber (1987) argues for the need of Internet Exchange Points (using the term “interexchange services”), to lower the amount of necessary infrastructure in the ground.

And here again, rapid and continuous improvements in electronics are increasing carrying capacity and thus slashing, by about a factor of two every couple of years, the amount of fiber cable actually needed in the ground. (Huber, 1987, p. 1.17)

Literature wise Internet Exchange Points do not seem to be touched from the bureaucratic thought style or the market thought style extensively, and a literature search gives very few relevant results. For example:

All these conditions point to the emergence of a key infrastructure element – the Internet Exchange Point (IXP)
(conference paper Cavalcanti, 2011)

More importantly, we illustrate the important role that IXPs play in today’s Internet ecosystem and discuss how IXP-driven innovation in Europe is shaping and redefining the Internet marketplace, not only in Europe but increasingly so around the world.
(preprint Chatzis, Smaragdakis, & Feldmann, 2013)

Neither of them can be considered refereed journal articles, even though they both point towards the importance of understanding the roles of IXPs in the Internet ecology. The currently almost eight years old preprint, Chatzis, Smaragdakis, and Feldmann (2013) does not seem to be published, or at least I do not have access to it. There is another version of the same paper available, as Chatzis, Smaragdakis, Feldmann, and Willinger (2013), which to a large extent is identical and clearly states “This article is an editorial note submitted to CCR. It has NOT been peer reviewed”. This could be an illustration of that the organizations themselves, except the technical, behind IXPs are not interesting to the technical community. This since there is an abundance of literature on the technical role of the IXP, for example Gupta et al. (2014) and McCreary (2000) who give overviews of the technical history and technical *raison d’être*s for Internet Exchange Points. The reason is one of separation of concerns, and practically that infrastructure and network operators do not trust each other to put equipment in each others facilities (“IXP (1)”; “IXP (3)”), so it is convenient to exchange traffic at a third party (a combination of the interoperability and market thought styles).

Internet Exchange Points do not per se *route* traffic, generally, they *switch* traffic. That is, traffic at an IP layer flows over the IXP rather than routed through it.

Commonly, Internet Exchange Points are either non-profit or for-profit, where the term “European IXP model” seems quite commonly used for the non-profit model. The largest Internet Exchange Points in Europe, including DE-CIX (Frankfurt), AMS-IX (Amsterdam) and LINX (London), are managed as non-profits, either directly incorporated as a non-profit, or as a corporation fully owned by a foundation or another form of non-profit. The for-profit model for Internet Exchange Points is the norm in the USA.

This distinction of non-profit and for-profit IXPs partially explains the business decisions of actors such as DE-CIX, AMS-IX, and LINX, which can be argued to not use their market positions to maintain virtual monopolies. “IXP (1)” and “IXP (3)” mention that the argument of non-profit IXPs is to make the best technical decision which still makes some market thought style sense, rather than trying to use the regional monopolies which IXPs often have.

I find no literature on the competition of IXPs with actual empirical data of the business relations in place, and I have been in discussions with reasearchers explaining that they have been unable to get such data. There are economic modelling texts, such as Jahn and Prüfer (2008), which discuss the economic rationality of different peering-setups.

Internet Exchange Points not only exchange *wired* Internet traffic, the last decade Internet Exchange Points also provide interconnection over distance (i.e., transit) for mobile networks (Chatzis, Smaragdakis, & Feldmann, 2013, note the convergence at a technical level of the Internet and telecommunications).

The non-profit IXPs I have been in discussions with motive that offering transit can technically be seen as problematic as transit used to be the domain of ISPs, but that the profit margins for owning and operating transit infrastructure is decreasing and hard to motive from a business perspective.

Equipment manufacturers

In general, infrastructure and network operators do not manufacture their own equipment, neither boxes, network chips, back-planes, nor fiber optic cables, etc, and are reliant on suppliers for virtually all equipment.

There are a few firms which sell IXP and ISP grade network equipment, most notable according to interviews Cisco, Juniper and Arista¹⁵. In addition to these Huawei and ZTE are increasing their market share, but I have not encountered them in interviews.

These network equipment manufacturers in turn buy network chips from semiconductor companies (Cisco has recently, 2019, started to enter the chip market, see business reporting in King, 2019). I have been told informally by people at both IXPs and ISPs that deciding between Cisco, Juniper and Arista is essentially deciding which logo you want on your Broadcom chip (as Broadcom supplies essentially all the chips).

In particular “ISP (1)” and “IXP (2)” noted that it at first can seem like there is working competition at the network-equipment market but since there is one extremely dominant chip-maker, competition is weak, and prices are (as argued by those I talk to) higher than they would be if there was substantial competition.

7.7 Coordinating the ecology

In the previous sections, I have given an overview of organizations I assume (and later on show) are important for the **coordination** of the **Internet** and

¹⁵Cisco and Juniper are “old giants” while Arista is a newer player with a clearer cost-cutting approach, at least as indicated in interviews.

the coordination of the **technology** of the Internet, and here I focus on how these and others interact and what the consequences are.

In the next chapter I suggest a more formal conceptualization of the Internet wherer I draw on this section (see p. 207 specifically). This section goes through additional coordination which is not pertinent to the Internet itself as I later conceptualize it. This servces to illustrate the entire empirical setting, including which pieces of the puzzle I leave out from the Internet concept and helping to contextualize why I leave them out.

Previously I assumed the Internet as not only containing a set of protocols or technical standards (i.e., **implementation of technology** and **standards formulation**), but also their coordination (through **coordination of technology** and **meta-coordination**). I argue that whether the protocols are governed by the users or some other entity has a large practical impact. Note that *user* in this context 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. Participation can, as examples, practically be using the Internet as an access service for the **web**, as a means of giving others access to your **Domain Name System (DNS)** server, or the opinions voiced in a **Internet Corporation for Assigned Names and Numbers (ICANN)** context.

Internet Coordination, as assumed here, concerns everything that affects how the users might communicate end-to-end with the Internet now and in the future. In Figure 7.1 I show the organizations interesting in an Internet Coordination context.

Figure 7.1 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 **Internet Service Providers (ISPs)** where the largest employ tens of thousands of people. There are also actors which are not organizations, such as the **Internet Assigned Numbers Authority (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 in its physical representation, even if the values behind said representation are complex (and mainly driven by the **interoperability thought style** as I illustrate later in this chapter). The coordination dimension is more complex and includes actors surrounding the technical core, such as ICANN, **Internet Engineering Task Force (IETF)**, the **Internet Society (ISOC)** and their subgroups and constituents, as well as firms, nation states, regulators, and all other potential users.

Figure 7.1, although not exhaustive, highlights how organizations are connected. In Figure 7.1, a harder and darker line implies greater influence, with the strongest lines being from **generic top-level domains (gTLDs)** to **Generic Names Supporting Organization (GNSO)**, **country code top-level domains (ccTLDs)** to **Country Code Names Supporting Organization (ccNSO)** and **Regional Internet Registries (RIRs)** to **Address Supporting Organization**

(ASO), since they are the constituents of the **Supporting Organization**. Currently, the **Empowered Community** is not in the figure due to drawing limitations, but the Empowered Community is GNSO, ccNSO, ASO, **At-Large Advisory Committee (ALAC)** and **Governmental Advisory Committee (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 **International Telecommunications Union (ITU)** and IETF. Important to remember is that ITU is an organization which has states as members and the IETF has anyone as members, per the IETF participation guidelines:

The IETF has no formal membership, no membership fee, and nothing to sign. By participating, you do automatically accept the IETF's rules, including the rules about intellectual property (patents, copyrights, and trademarks). If you work for a company and the IETF will be part of your job, you must obviously clear this with your manager. However, the IETF will always view you as an individual, and never as a company representative.

(IETF, 2021)

Businesses in Figure 7.1 include but are not limited to ISPs and **Internet Exchange Points (IXPs)**. Equipment manufacturers influence both what the infrastructure and network operators can do in practical terms, and influence the standard setting process at the IETF. The important business in maintaining Internet function are the infrastructure and network operators (for example Internet Exchange Points and ISPs) which are given a smaller role in the coordination of the Internet (even though they, if the ISPs wanted to, to the potential dismay of customers, regulators and standard setters, could redefine what the Internet is for almost all users).

In Figure 7.1, the civil society represents not only organizations but also individuals, 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 **United Nations (UN)**, although it should be noted that lobbying usually requires funding and is hard for a single individual to do effectively ("Legislator (1)"). ALAC is the ICANN Empowered Community 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 Internet Foundation** chose not to contribute with funds to ICANN for some fiscal years the last decade. ICANN has historically been funded to a greater extent by its constituents, such as ccTLDs,

Figure 7.1: Internet Coordination ecology
Overview of identified actors and their relationships. Note the lack of connections between nation state fora, such as the UN, the ITU, the IETF, the Internet Governance Forum (IGF), etc., and core Internet functions such as IANA and standards formulation. Thick lines indicated a constituency or similarly strong relation, and thinner lines represents influence.

but is 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) state, the main reason they, as ccTLDs, are contributing funds to ICANN is the operation of the IANA function, and the dot-de-registry 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 & Bäss, 2006)

The letter does not further specify what such an improvement might be. Such a letters of exchange are generally referred to as **Memorandum of Understandings**. 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 legal language and clearly names 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 contrast there is no public paper-trail at all between dot-dk and either of ICANN and IANA.

In practice ccTLDs can influence ICANN through the ccNSO, and ICANN ccTLDs by **naming** policy with indirect concerns since ICANN has very little direct influence on ccTLDs with Memorandum of Understandings. ICANN's influence over ccTLDs with accountability frameworks is contractual in nature and sometimes regulates domain usage. Note that far from all ccTLDs are members of ccNSO. And a few ccTLDs do not have a relationship with ICANN, such as dot-dk, and are listed in the **root-zone** by tradition rather than formal relationships.

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)”; “DNS-Expert (1)”; “IXP (1)”; “RIR (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 over agendas, some meeting issues, and preparatory work.

There are those that see the geographic closeness between both ICANN and IETF to the USA as problematic (for example Lee, 2012; “Legislator (1)”), although it can be argued that similar problems might arise no matter where the organizations are located (as argued by “DNS-Expert (1)”; “IXP (1)”) and the most important issue is that the IANA-function is functional. During the IANA stewardship transition period, there were outcries from Americans against the USA giving up control over the Internet (see Raustiala, 2016 for

a summary of opinions on the topic), even though the USA government had never had control over the Internet in such a direct manner. Prior to the IANA transition the **National Telecommunications & Information Administration (NTIA)** had to approve new **top-level domain (TLD)** delegations, but had no say below the top-level domain (“ccTLD (1)”).

“Advisory Committee (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 the same direction, “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 well known engineer Tony 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)” mentioned that this has slowly changed over the years, with ICANN today reimbursing many of the travels needed for representative duties. Rather than funding yourself you can now become funded by being elected to a significant position (such as the ICANN board, **Nominating Committee**, etc), a clear step from an interoperability thought style approach towards one with legitimate compensation.

Several interviewees are against this shift, since it (supposedly) gives rise to professional Internet Coordination people (for example the previously mentioned criticism of ICANN), rather than people trying to avoid Internet Coordination as much as possible before (an idea based in the interoperability thought style, i.e., keep coordination at a minimum, because coordination over time will otherwise complex and difficult to alter, leading to problems in adapting the system to new circumstances). This shift is also illustrated in many of the quotes the quotes in Section 7.4 earlier. However, “Legislator (1)” argues that funding is necessary to ensure that all voices are heard, which is a fundamental aspect in a democratic **bureaucratic thought style**.

There are actors, in particular at an ITU and EU level, which rather than discuss components of digital communications, such as the Internet, bundle concepts into Information Communication Technologies (ICTs) which include all forms of digital communications rather than to differentiate them. “IXP (2)” suggests that there are two primary reasons for Internet and telecommunications being treated as one and the same (similar is said by “ccTLD (1)”; “ISP (1)”; “IXP (3)” although not as explicit);

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

The difference people like “IXP (2)” want to draw between “telecom” and “Internet” mainly lies in the coordination and the values behind these two communication ideas. “IXP (2)” argues that the position (1) above 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”. Position (2) above is problematic for the Internet as it exists today, since governmental long term pressure is the greatest threat to the Internet today (according to “ccTLD (1)”; “IXP (2)”; “IXP (3)”). 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 (i.e., that no one seems to wear the mantle of Internet champion).

In Figure 7.2, I show the Internet Standards, the IANA-function, and infrastructure and network operators as the most central Internet concepts. Important to note is that the Internet here concerns best-effort end-to-end digital communication and not, for example, the web or other services such as Facebook, Netflix, or YouTube. It is important to put Figure 7.2 in the context of Figure 7.1 to understand the coordination context, which sees the Internet at its concrete technical level as 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, and the Internet Standards creates the need for a coordination function, i.e. IANA.

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 the 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 (🏢) 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. In contrast, “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 technically (Δ). Technically that is correct, there is nothing in **Border Gateway Protocol (BGP)** or DNS requiring ICANN and IANA to be the prime coordinator, it is just a setting or a choice of configuration that has become the conventional one.

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**

Figure 7.2: Central concepts in the Internet Coordination ecology
These are required for the **Least Common Internet**, i.e., that which ultimately is coordinated in Internet Coordination arenas and that which constitutes minimum of coordination required for the practical and technical Internet.

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 where ISPs almost entirely are responsible for all Internet-access components).

One interesting aspect of ISP power is **Best Current Practice (BCP)**-38, an IETF document describing the best practice in regard to a **distributed denial of service (DDoS)** problem where the attacker is spoofing his IP-address (see **Request for Comments (RFC)**-2827, Ferguson & Senie, 2000, i.e., the BCP itself). According to “IXP (2)” and “ISP (1)” the problem is easily solved at the Internet’s edge, and should be in the interest of all, but the twenty-year-old practical 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 in great detail (“IXP (2)”). The only way to find out if the source is address-spoofing is at the edge of the Internet, i.e., at the edge of an ISP’s network; once the packet is on the Internet (i.e., being routed somewhere) it is not possible to distinguish it from any other packet.

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**. “IXP (2)” reasons that given the current design of the Internet, 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. Potential enforcement would change the common bottom-up coordination of the Internet into a more top-down approach.

As illustrated in the previous sections, many of the coordination relations of Internet mechanisms can be seen as done by **mutual adjustment**, that is a quite broad category of coordination where no one side has the explicit upper hand, in particular with regards to the coordination necessary to formulate standards formulation.

In Figure 7.1 both the UN and the ITU are logically quite far from the actual standard setting arena for Internet Standards (the IETF) and the actual DNS root (IANA). There are no direct connection between the IETF and IETF, and only a thin line connection the ITU and IANA. I.e., the UN and ITU coordinates treaties, which then can be ratified and turned into regulation in nation states, which in turn affects digital communications networks such as the Internet. Similar can be said of **World Summit on the Information Society (WSIS)**, **Working Group on Internet Governance (WGIG)** and IGF, even if IGF is important as a discussion arena for, for example, nation states representatives, where issues such as digital economy and regulation are discussed, the IGFs seem to have little or no impact on how standards or unique identifiers are coordinated. This is also noted by DeNardis (2012) and van Eeten and Mueller (2012). Mueller, Mathiason, et al. (2007) explicitly notes:

The main product of WSIS, the Internet Governance Forum, only provides an arena for continued discussion. It provides no basis for negotiating meaningful agreements.

(Mueller, Mathiason, et al., 2007, p. 250)

What happens at the UN, the ITU, WSIS, WGIG and IGF has had little impact on what the Internet is today and the day-to-day activities of the Internet. This is in line with the notion that ICANN and the IETF were created to forestall coordination of the Internet by ITU-like constellations.

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 (partly through path dependence from the origin in academic research settings and rapid, international, decentralised buildout ahead of legislative attention). 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 indicated by interviews “ccTLD (3)”; “DNS-Expert (1)”; “IXP (4)”; “Legislator (1)”) ¹⁶.

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 “ITU Delegate (1)” and 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. That is, even if the UN was bureaucratic the ITU used to be able to focus on solving actual technical problems rather than procedure (i.e., good to bad by the interoperability thought style). Interesting to note, see [International Telecommunications Regulations \(ITRs\)](#) in Section 7.5, is that many nation states, mostly Western, propose an agenda where the ITU is not a forum for international regulation where non-Western states typically hold an opposite view.

This change from a more interoperability-dominated thought style towards a more bureaucracy-dominated is to a certain extent also happening in ICANN meeting settings (according to by “Advisory Committee (1)”; “ccTLD (1)”; “ccTLD (3)”; “DNS-Expert (1)”; “IXP (3)”). In that sense it can be argued that ICANN is slowly changing into that which the founding ideals considered to be one of the problems with the UN and the ITU from the start. It is possible to argue that the original interoperability thought

¹⁶There are some recent examples though, such as RFC-8280 (ten Oever & Cath, 2017) and Cath and Floridi (2017) concerning the interplay of technical and human rights issues.

style and technology focused epistemic community which created ICANN and ISOC is being shifted out by a policy focused epistemic community (see earlier Section 7.4 for ICANN related criticism).

If seen as an organization, the Internet is primarily using mutual adjustment 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 tends to be the one adhered to.

Another important aspect of *adhocracies* is that they are hard to change by 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 on its own change the Internet, 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 9 and Chapter 10.

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. 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. Espoused principles may also be less than strictly guiding. 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”.

This section serves as a revisit and summary of actors and their captured beliefs in terms of the *thought styles*.

The interoperability thought style, in many ways the original mindset of people creating the Internet, I found among the *Requests for Comments (RFCs)*, IETF participants, the mostly European non-profits and foundations (such as Internet Exchange Points and ccTLDs). Few actors are fundamentally adhering to the interoperability thought style, but rather describe their ultimate wants and needs by it. For example, a typical European non-profit IXP acts on a market, under the same market logic as other actors, and the interoperability thought style is rather practically manifested by the best possible solution by the interoperability thought style given that the organization does not lose money.

The main bureaucratic thought style types of organizations are related to the UN sphere, be it the UN or the ITU itself, or nation states or ccTLDs

run as government entities. ICANN, as indicated by interviews, bylaws and other documents, seem to adhere to an increasingly bureaucratic logic over time, at present leading to a conduct that from a bureaucratic thought style is not formal enough, and from an interoperability thought style considered too formal. As previously mentioned, ICANN is quite unique in this sense since ICANN is the arena where different thought styles meet, or can meet, to a greater extent than, for example, the IETF or the ITU.

In my investigations I find that the bulk of the **market thought style** logic actors are divided into three main categories; (1) those part of the physical infrastructure of the Internet such as infrastructure and network operators, (2) those dependent on the Internet as a best-effort solution to their own services (such as **Content Delivery Networks (CDNs)**, cloud firms, etc), and (3) other actors, such as registrars and registries organized as for-profits.

7.8 The genesis of the Swedish ccTLD and IXP

The previous parts of this chapter provided an overview of organizations and forces involved in Internet Coordination, although with a Western bias. This section genesis of the Swedish ccTLD and IXP. As described in Chapter 2 the later parts of my thesis process is funded by the Swedish Internet Foundation an offshoot of the process I describe in this section. The story thus both provides a example of the development of institutions along the evolution of Internet growth, and the background of the current financier of my thesis work.

The early Swedish Internet coordination was dominated by the technical community and related organizations (such as the local ISOC chapter ISOC-SE and universities) and slowly formalized into foundations, in the second half of the 1990s.

Principally the initial central Swedish Internet infrastructure was run at Kungliga Tekniska Högskolan (KTH, The Royal Institute of Technology) divided into two “functions” or “operations”; KTHNIC¹⁷ and KTHNOC¹⁸. KTHNIC became the dot-se ccTLD and today the Swedish Internet Foundation, and KTHNOC became Netnod, an IXP fully owned by the foundation Stiftelsen för Telematikens Utveckling (TU).

In interviews, I have been told slightly different stories about what and why that which actually happened to KTHNIC and KTHNOC happened, and below I tell the story as I have inferred it from multiple interviews and discussions. There are documents backing up “what happened” but not “why

¹⁷Spelling and capitalization done by me, I have not been able to find KTHNIC in text and by description it does not seem to have been as formal as KTHNOC, and could also be seen as a sub-unit of the larger KTHNOC. KTHNIC was mentioned by interviewees involved in KTHNOC at that time, used by these interviewees to differentiate the network operations and the TLD registry.

¹⁸Today there is a lab / research group called KTHNOC, which as far as I have been able to elicit is the same lab as KTHNOC except without the business and peering side.

it happened”, see for example Hamngren et al. (2003), ISOC-SE (2003), and Mirtorp (2000) for an overview of the Swedish setup.

In the mid 1990s the vice chancellor of KTH became aware that they were running both the local registry (i.e., the dot-se zone) and the large switch that telecommunications operators (and universities) were connected to (i.e., the IXP). This was considered problematic since they steadily grew in size and resources needed, and there was a belief that KTH was at risk of a lawsuit if something went wrong with the commercial operations of the telecommunications operators. The revenue model for the registry was not set in stone, but there was a general understanding that the domain registry could become a cash cow. This prompted KTH to look for new organizational solutions to hosting the two functions. There were a few voices who wanted to just shut everything down, but the clear majority wanted to keep the functions running in some form.

KTHNIC was converted first, since it was problematic that a university employee could dictate who could register a dot-se address, and the idea of a firm governed by a foundation was born. Born was the Swedish Internet Foundation and its firm NIC-SE (and also two smaller controlling and auditing organizations), with NIC-SE being fully owned by the Swedish Internet Foundation (see Stadgar för Stiftelsen för Internetinfrastruktur, 1997 for the bylaws which state that all proceeds should go to Internet promoting activities).

Around the time of the dissolution of KTHNIC, KTHNOC also encountered issues due to the increasing amount of commercial customers and KTHNOC had to grow beyond just providing IXP services to universities. Commercial actors wanted to connect via KTHNOC instead of directly to each other because they did not fully trust each other, and rather trusted the university sponsored third-party KTHNOC. KTHNOC and surrounding personnel investigated several organizational forms for the business side of KTHNOC (i.e., commercial customers) and came to the same solution as for KTHNIC, that is a firm (Netnod) owned by a foundation with the controlling (and full) stake (i.e., the TU-foundation, see the bylaws Stadgar för stiftelsen för Telematikens utveckling, 1997 which in formulation are quite close to the bylaws of the Swedish Internet Foundation).

Major reasons (as mentioned by interviewees) for the foundation and firm solution is that the foundation provided a stable environment within which a for-profit entity could be released (i.e., by limiting the for-profit enterprise to doing one thing and one thing only it was thought that it would be reined in rather than to become a veritable monopoly, as there was little limiting regulation in place). Both the Swedish Internet Foundation and TU-foundation initially had auditing components as well, but when the **national regulatory authority** was tasked with ensuring compliance to relevant regulation the internal auditing units were dropped.

After the introduction of the Swedish law for national top-level domains in 2006 (i.e., Topppdomänlagen, 2006) the Swedish national regulatory authority for telecommunications took over the regulatory responsibility for dot-se and the board of the Swedish Internet Foundation decided that the separation between foundation and firm was no longer needed and the operational part of maintaining the dot-se zone was moved to the foundation itself (NIC-SE as a firm still exists but is marked as inactive in public records).

Comparably, the electronic communications directives in Sweden (i.e., LEK, 2003) is meant to regulate ISPs and Internet Exchange Points (to a lesser extent) but the TU-foundation is still separate from Netnod. This, according to interviews, is to separate the business side from the foundation, so there are two boards for the IXP side, one at the TU-foundation, and one for Netnod, while the Swedish Internet Foundation has one board.

Both the TU-foundation and the Swedish Internet Foundation fund research to different extents. I am (currently) employed by the Swedish Internet Foundation to finalize this doctoral thesis.

7.9 Chapter summary

The primary conclusion regarding the actual **coordination** of the **Internet** 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 in the Internet ecology. Rather, coordination is attained through an invisible hand, which this chapter presents a glimpse of. And it is not only the invisible hand of market forces, there is also other sets logic in place.

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 (and the principles behind them) do not get enough attention.

The Internet users, here taken to include all types of users, including private individuals, **Internet Service Providers (ISPs)**, governments, etc, are the de facto Internet coordinators through a multi-stakeholder approach in **Internet Corporation for Assigned Names and Numbers (ICANN)** setting for policy and **naming**, and an **adhocracy** setting in **Internet Engineering Task Force (IETF)** setting for **Internet Standard**, although there is pressure towards a top-down multilateral governance system. This is evident through such events as the **World Conference on International Telecommunications (WCIT)** meeting and its suggested **International Telecommunications Regulations (ITRs)** treaty and the formalization of ICANN coordination processes into formalized multi-stakeholderism which allow for ex-ante, or more bureaucratic, decision-making and organization.

Over time, the Internet and its governing mechanisms have changed from being bottom-up and self organized, where decisions are taken where necessary, from the pre-ICANN and pre-IETF era, a **mutual adjustment** adhocracy to use the terms of Mintzberg (1993), to becoming more formal and standardized today, and specifically after the **Internet Assigned Numbers Authority (IANA)** transition in 2016. One example of this is ICANN's detailed policy process through the **Empowered Community** which puts the organization of ICANN more into the **standardization of work process** in the Mintzberg-typology. Instead of ICANN as *support staff* of the Internet, ICANN can be argued to be moving in the direction of becoming *technostructure* instead.

In particular the **International Telecommunications Union (ITU)** and **United Nations (UN)** settings 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.

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 tend to create their own **raison d'être**. A 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.

The next chapter continues on to suggest a meaningful, to all the **interoperability**, **bureaucratic** and **market thought styles**, conceptualization of the Internet, even if the thought styles might disagree on how the Internet should develop.

8

Internet concepts

Maybe we should call it [the Internet] something else to indicate that we are entering a new, different, phase

— Interviewee

While the previous chapter focuses on actual organizations, views and opinions, this chapter takes the conceptual step of suggesting a framing of the **Internet** with the intent of being understandable in all of the **interoperability**, **bureaucratic** and **market thought styles**. However, the thought styles disagree on what the Internet should be.

This chapter is based on the assumption that it is meaningful to capture the Internet as a combination of **coordination** and **technology**, and from that initial assumption, by drawing on interviews, discussions, bylaws, and academic literature, concludes that the Internet can be seen and thought of as:

an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhocratic processes based on ideals of design for interoperability

This should be thought of as a combined view on **implementation of technology**, **standards formulation**, **coordination of technology**, and **meta-coordination**, written as to *make sense* from all of the **interoperability**, **bureaucratic** and **market** thought styles. *Make sense* is emphasized to indicate

that the thought styles do not necessarily agree, as the description is clearly conforming with **interoperability thought style** ideals, but rather explained in such a way that it is possible to agree to disagree. My discussion, based on this description of the Internet, strives to propose a novel way of framing Internet issues, as a balance of ideals and notions from the interoperability, **bureaucratic** and **market** thought styles.

This chapter describes the current Internet as revealed in my interviews, in bylaws, **Requests for Comments (RFCs)**, and via my own exploration of the technical structure of the Internet; the description is not trying to shape what the Internet should be in the future. In terms of the narrative of this thesis, earlier chapters introduced data points which lead to the description of the Internet provided in this chapter, while later chapters build on this chapter.

The epigraph, “[m]aybe we should call it [the Internet] something else to indicate that we are entering a new, different, phase”, appeared in an interview on the topic of where the Internet is headed. The interviewee noted the bureaucratization of several technical functions close to the interviewee’s heart, and argued that fundamental parts of that which is the Internet is changing. The interviewee was explicit in that he / she did not like these changes, but further argued that “only time will tell” if the current shifts are actually “good or bad”. What is considered good and bad will naturally depend on the thought style of the assessor.

8.1 Conceptualizing the Internet

The purpose of this chapter is to conceptualize, or loosely define, the Internet and **Internet Coordination** (and **Internet Governance**) meaningfully in the thought styles using one coherent conceptualization. I now return to the formulation:

an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhocatic processes based on ideals of design for interoperability

This conceptualization focuses on the current Internet, which might be used by a user while the user retains some form of control, in contrast to a network where the user is more limited by the composition of the network itself. A network built for a specific purpose supports that purpose, but also limits possible function available through or over the network to a greater extent than the more open-ended design of the Internet does.

This chapter suggests that it is meaningful to have a conceptualization of the Internet. One reason is that it is important to agree on what things are when they are discussed. In this regard the idea of the Internet should be conceptual rather than merely including artifacts, and by looking also to the

ideas behind the values of the **Internet Standards** rather than stopping at the Internet Standards themselves.

In both a general setting and in academic settings the Internet in itself is not often defined, and in different contexts it seems to have different meanings. Here I suggest that the Internet is separate from that on top, such as the **web**, and also that which is below, such as the canalization and link-layer protocols. I argue that this is by design; the design of the architecture of the Internet is meant to be interoperable, that is decoupled as much as possible from potential dependencies, such as services on top or the infrastructure it is run on. The Internet can run on top of different kinds of infrastructure, be it fiber optic cables, cellular links or copper wires in an office.

In Figure 8.1 I show one way of illustrating the Internet, as a large network of interconnected networks of a digital character. The image is based on **Border Gateway Protocol (BGP)**-data.

Figure 8.1: An illustration of the Internet in 2020
Illustrated as a BGP-typology which contains **Autonomous Systems (ASs)** and **prefixes**. Central well-connected networks and prefixes are dark blue, and turn green towards white for the lesser connected prefixes and ASs. The image is flat and is not correlated to the geography of the Earth.

In Tables 8.2 to 8.4, I show a selection of Internet definitions or descriptions, which are condensed down to the two primary views in Table 8.5. Tables 8.2 to 8.4 are based on previous literature and interviews, where I previously saw the Internet as a technical phenomenon (due to my engineering background), but my 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. Tables 8.2 to 8.4 consist of quotes and descriptions from various sources and if they are explicit (i.e., clearly mentioning a dimension), implicit (i.e., mentioning a dimension in passing or in a description but not beyond all doubt) or not mentioning (marked in the table by a dash) either an implementation of technology and standards formulation (merged in column “T”) or a coordination of technology and meta-coordination dimension (merged in column “C”). Symbols (Δ , ⌘ and $\text{\$}$) are used to indicate the thought style the ideas belong in, if applicable, and how clear or explicit they are. A not-sign ($\neg$) preceding a symbol indicates that the source clearly positions itself against ideas that I see as central in a thought style.

In general, within sources the views on implementation of technology and standards formulation tended to be similar, and likewise views on coordination of technology and meta-coordination. Therefore, Tables 8.2 to 8.4 contain one technology column representing implementation of technology and standards formulation, and one coordination column representing coordination of technology and meta-coordination. If implementation of technology and standards formulation differ, or if coordination of technology and meta-coordination differ, it is explicitly noted in the description column.

As an example, “ Δ ” in column “T” indicates that the source considered the Internet to have a technical dimension, which is manifested by the interoperability thought style (which implies, for example, that the web and the Internet are separate concepts), and “($\text{\$}$)” in column “C” that the source implied that coordination is a dimension of the Internet, manifested through market-like conditions, although not explicitly (such as saying that the Internet “is technical” and companies are behind it, rather than the Internet “is coordinated by market forces”). See Table 8.1 for more examples of the use of these symbols.

Tables 8.2 to 8.4 contain both references discussing the “Internet” directly, and those who do it indirectly via “Internet Governance” constructs. Some sources have an opinion of what the Internet *is*, and some sources rather discuss what the Internet *should be*.

Sources marked with an asterisk (“*”) are based on discussions, observations, and interactions with practitioners outside of a recorded interview setting, and are included where the opinions expressed differ from the set that I have found in interviews and written sources. The point of including such opinions is to present more of the width of values present in the area.

Table 8.1: Interpretation guide
Interpretation guide to upcoming Tables 8.2 to 8.4.

Column	Label	Description
T	or \$	Integrated technology set to serve either market (\$) or bureaucratic ( ) purpose.
T	Δ	Technology by norms of separation of concerns.
C		Explicit coordination component characterized by multilateral or similar governance.
C	( )	Description where, for example, regulation or policy plays a role in coordination.
C	\$	Coordinated by market like forces.
C or T	$\neg$	Explicitly not by bureaucratic ideals.
C or T	—	Did not mention that this particular dimension exists.

Tables 8.2 to 8.4 are ordered by thought style, and internally by source type in the order (1) interview, (2) written non-academic source, (3) academic source. The informally expressed opinions, when included, are placed at the end of the tables.

Table 8.2 contains sources who primarily see the Internet, and Internet Coordination, as an interoperability thought style construct. Tables 8.3 and 8.4 continue on with the **bureaucratic** and **market** thought styles.

As illustrated in Table 8.2, the Internet can be seen as only technology, or as a combination of both technology and coordination. No interoperability thought style source argues for a coordination-only Internet. However, when questioned if the Internet could be only coordination “RIR (1)” argues that such a framing might be interesting to a researcher, but not in practical terms due to the importance of the resulting architecture.

When discussing what I term technology (implementation of technology and standards formulation) interoperability thought style leaning sources in general discuss standards formulation above actual implementation in infrastructure, and the values behind those formulations (for example “ccTLD (1)”; “IXP (2)”; “IXP (3)”; “RIR (1)”). “IXP (1)” explicitly sees implementation of technology as a market consequence of good standards formulation (that standards should be implemented by market actors because the standards

themselves are good and serve as a basis for varied commercial activity). All the interoperability thought style leaning interviewees argue that the Internet and, for example, the web are separate, while a few explicitly mention that the Internet is also separate from that which it runs on (mentioned explicitly before I asked by “ISP (1)”; “IXP (2)”). Both “ISP (1)” and “IXP (2)” argue that the Internet *runs on top of* telecommunications services and infrastructure, and that the Internet is *not a part of* telecommunications, but rather in a technical sense on a layer above.

Regarding what I term coordination, many interoperability thought style sources mention explicitly something of the form “the Internet is not governed, it is coordinated” (mentioned by “ccTLD (1)”; “ccTLD (3)”; “DNS-Expert (1)”; “IXP (1)”; “IXP (3)”; “RIR (1)” who all used almost exactly this expression). Some, in particular “ccTLD (1),” “DNS-Expert (1),” “IXP (1),” and “RIR (1),” mention that this coordination is based on a different set of values than either market or bureaucratic logic. Through the abductive process of this thesis these values became part of those values which form the interoperability thought style.

The interoperability thought style sources focus on what the Internet *is* in terms of what I term technology, and in terms of coordination some sources are most explicit on what the Internet *should not be* (for example, “not governed by the **International Telecommunications Union (ITU)**”).

Table 8.2: Internet descriptions of the interoperability thought style
Internet descriptions, a selection from interviews, written sources and informal communication. Contains conceptualizations closer to the interoperability thought style.

Primarily interoperability thought style			
Source	T	C	Quote/Description
“ccTLD (1)”	Δ	Δ	The essence of the Internet is the standardized collaboration of networks, both in terms of infrastructure and ideology. Single actors in general have little influence, and “that is kinda the point”.

(continues on next page)

Table 8.2: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Contains conceptualizations closer to the interoperability thought style.

Primarily interoperability thought style			
Source	T	C	Quote/Description
“ccTLD (2)”	Δ	(Δ) $\neg$	The notion of a “commons” digital network governed by its users. Explicit in that the applications on top are not the Internet. Explicitly mentions that organizations such as the ITU are built on different values than those I include in the interoperability thought style.
“ccTLD (3)”	Δ	(Δ)	“the Internet is the great opportunity where <i>everyone</i> [empha-size added] can contribute [to the larger context] with their own networks” which illustrated the original notion of collaboration between already existing networks. No mention of why existing networks would want to work together.
“IXP (1)”	Δ	Δ $\$$ $\neg$	The notion of a network for digital communication coordinated by its users. Explicit in that applications and concerns on top are not the Internet. Indicates that market forces are behind sending people to meetings (such as IETF).
“IXP (3)”	Δ	Δ $\neg$	Discusses the actual coordination of the Internet as something different from “common governance processes [as by government agencies]”, although is not explicit on the current ideals of the Internet.

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Table 8.2: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Contains conceptualizations closer to the interoperability thought style.

Primarily interoperability thought style			
Source	T	C	Quote/Description
"ISP (1)"	Δ	(Δ)	"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 RFCs themselves and how they are implemented (practice).
"DNS-Expert (1)"	Δ	Δ	Discusses the Internet (and its history) in depth and contrasts (with nuance) the different principles behind the Internet (and naming in particular) and similar initiatives governed by multilateral constellations.
"RIR (1)"	Δ	Δ $(\$)$	Argues that the Internet is almost impossible to define, and in essence it is more of a way of doing things with maximum interoperability, rather than only designating technical infrastructure. Market intentions are mentioned but not given as large focus as good design. The Internet by design puts power at the edges to prevent a controllable network (i.e., the network should be so stupid that it cannot be regulated, so regulation and policy naturally would be targeted at the edges rather than the Internet itself).

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Table 8.2: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Contains conceptualizations closer to the interoperability thought style.

Primarily interoperability thought style			
Source	T	C	Quote/Description
Markus (2006)	Δ ($\$$)	($\$$) ( )	<p>“It is perhaps also worth noting that AT&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 communication’s stratum.” (p. 23)</p> <p>Describes that even if the network at its core is technical and built by ideals close to interoperability, both market forces and bureaucratic ideals (mentioned elsewhere in the text) affect how the networks actually are run.</p>
Netnod (2019)	(Δ)	($\neg$)	<p>The “Internet-access definition report” (Netnod, 2019) separates the Internet from applications using the Internet, but does not further problematize its coordination except acknowledging that the Internet is not built to fit legal constructs.</p>

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Table 8.2: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Contains conceptualizations closer to the interoperability thought style.

Primarily interoperability thought style			
Source	T	C	Quote/Description
“Internet”-entry, ICANNWiki (2016a)	Δ	–	“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 ‘The Web.’” Keeps to the technical perspective of the Internet, not mentioning the coordination level in the sense of this table.
“Internet”-entry, Wikipedia Contributors (2020)	Δ	(Δ)	“The Internet is the global system of interconnected computer networks that use the Internet protocol suite (TCP/IP) to link devices worldwide.” I.e., mostly the technical perspective of the Internet. Notes certain ideas (e.g., “voluntary”, “without central governing body”) but does not go into actual detail.
RFC-2026 (Bradner, 1996)	Δ	Δ ¬	“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” (p. 3), explicitly technical, explicit in voluntary adherence, and a defined set of Internet standards (i.e., not the web).

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Table 8.2: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Contains conceptualizations closer to the interoperability thought style.

Primarily interoperability thought style			
Source	T	C	Quote/Description
RFC-4949 (Shirey, 2007), a glossary RFC	Δ	(Δ) (🏢)	“The Internet is the single, interconnected, worldwide system of commercial, governmental, educational, and other computer networks that share (a) the protocol suite specified by the IAB (RFC 2026) and (b) the name and address spaces managed by the ICANN” (p. 157).

Zittrain (2008)	Δ	(Δ)	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. Is explicit on actual technology and ideals, but not on actual coordination. Acknowledges the concept of a layer model, but does not explicitly separate the Internet.

The next table, Table 8.3, continues with sources closer to the **bureaucratic thought style** as described in Chapter 4. Common for these sources is that they indicate that the Internet should be under legitimate control or governance. DeNardis (2012) is here a problematic text to place within one category; it is nuanced and notes, for example, the interoperable nature of the **Domain Name System (DNS)**, but discusses the Internet as a public – private conflict. Similarly, Lessig and Lessig (2006) contrasts logics for the Internet and concludes that a market-logic based Internet is problematic, and argues for social policy. Benkler (2006) contrasts hierarchical, or firm, production with market based production and suggests a third mode of production in the digital age; commons-based peer production, which is distinguished as follows:

Rather, the inputs and outputs of the process are shared, freely or conditionally, in an institutional form that leaves them equally

available for all to use as they choose at their individual discretion
(Benkler, 2006, p. 3)

However, Benkler (2006) does not problematize the Internet as a concept using these categories¹.

Compared with the sources in Table 8.2 that explicitly discuss coordination, the sources in Table 8.3 that explicitly mention coordination tend to be less clear on the connection between coordination and technology. Sources in the bureaucratic thought style argue that the Internet sometimes is only technology, and those who see the Internet as some form of idea of coordination often argue that it is or should be under the control of multilateral-like constellations, for example by recognizing that the **Internet Corporation for Assigned Names and Numbers (ICANN)** exists and plays a part, but arguing that the Internet should be *governed* by the ITU, or a new **United Nations (UN)**-arm.

Of particular interest is that both the UN and the ITU, in official documents, do not per se define or name the Internet to any greater extent. The UN and the ITU both see, in official documents, the Internet as infrastructure, without any mention of the standardization process leading up to the standards which could become part of the infrastructure². Resolution Adopted by the Human Rights Council on 5 July 2018 (2018) develops the UN view of the Internet (or rather access to the Internet) as a possible means of achieving human rights, and without any explicit intention to control the Internet. This somewhat neutral stance on control over the Internet displayed at the official surface of the UN contrasts with the accounts of processes in the UN. Several of my interviews illustrate that there are political games in UN and ITU settings over the placing of the Internet, or at least the naming part of the Internet, under multilateral control. To sum up, the UN discuss Internet-accesses rather than the composition of the Internet.

I consider Mueller, Mathiason, et al. (2007) as a typical example of a bureaucratic thought style approach to the issue of Internet Governance; the search for a “framework convention”³ for Internet Governance. Mueller, Mathiason, et al. (2007) notes that the **nation-state** based approaches to Internet Governance have failed, i.e., that which is (or was) discussed at the **World**

¹However, Benkler (2006) briefly mentions commons-based Wi-Fi mesh-networks, but does not, for example, discuss whether processes hosted in conjunction with IETF meetings fulfill commons-based peer production criteria.

²For example, one of the few times “Internet Standard” is mentioned in any document available at the ITU webpage is a presentation by the then IETF chair Fred Baker, see <https://www.itu.int/ITU-T/worksem/ip-telecoms/presentations/ipw-7.ppt>. This link does sometimes not work, but since the Wayback Machine works, the following link is also available <https://web.archive.org/web/20160304074017/https://www.itu.int/ITU-T/worksem/ip-telecoms/presentations/ipw-7.ppt>.

³“Framework convention” is used in Mueller, Mathiason, et al. (2007), and seems to as a term mean UN agreement or treaty.

Summit on the Information Society (WSIS) and the Internet Governance Forum (IGF) agreements is not reached. Mueller, Mathiason, et al. (2007) notes that this is due to the *fact* that Internet is non-territorial (Mueller, Mathiason, et al., 2007, use the term *fact*). The text goes on to suggest a formal multi-stakeholderism bureaucratic thought style solution to Internet Governance.

In terms of implementation of technology and standards formulation I find little explicit on what the Internet *is* in a bureaucratic thought style lens. However, in terms of what the Internet *should be* there are more explicit examples. Here I mention two accepted Internet Standards with partial bureaucratic thought style logic compared with two suggested bureaucratic thought style standards: Domain Name System Security Extensions (DNSSEC), BGPsec, Digital Object Numbering Authority (DONA), and “new IP”, which all are products of a partly bureaucratic thought style view of technology.

DNSSEC is a nuanced example of bureaucratic thought style values built into an originally interoperability thought style protocol (i.e., ordinary DNS). DNSSEC adds legitimacy and trust as properties to DNS resolution. With DNSSEC there is the possibility of verifying the correctness of an answer, a value of the bureaucratic thought style rather than the interoperability thought style. The original DNS protocol did not contain any mechanisms for verification or trust, it is through and through best-effort built for interoperability. DNS is designed to be independent of the Internet, while most DNSSEC implementations are dependent on one function of the Internet, the IANA root-zone.

Similarly, BGPsec adds additional dependencies to the Resource Public Key Infrastructure (RPKI) over ordinary BGP, just as DNSSEC adds dependencies to DNS, with one explicit difference: that the trust in DNSSEC is anchored at the IANA-function (*one* function) while the trust in RPKI is anchored at *seven* Regional Internet Registries (RIRs).

As Mueller, Mathiason, et al. (2007) discusses, the Internet is non-territorial, and Digital Object Architecture (DOA) can be seen as one way of solving names of unique identifiers (in essence a DNS-replacement for high-level names) from a nation-state bureaucratic thought style lens, where the DONA foundation is intended to oversee an international and multilaterally mediated “root-zone” (as argued by “ITU Delegate (1)”).

“New IP” is a suggested IP replacement which adds bureaucratic thought style components to the central messaging protocol, such as identity provision and the (possible) inclusion of tools to manage the networks of others. “New IP” is at the time of writing not well specified. See Section 9.3 for further discussion of “new IP”.

In terms of meta-coordination ICANN is an example of an arena where bureaucratic thought style logics are becoming dominant (see Section 7.4). However, this is a change in values present and types of discussions held,

rather than that these changes have led to changes in the architecture of the Internet itself or possibilities of using the Internet.

Table 8.3: Internet descriptions of the bureaucratic thought style
Internet descriptions, a selection from interviews, written sources and informal communication. Dominant by the bureaucratic thought style.

Primarily bureaucratic thought style			
Source	T	C	Quote/Description
"Legislator (1)"	(Δ)	(🏢)	"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. Recognizes that there are technical underpinnings to some coordination, but argues for a change.
Richard Li in Mueller (2020)	(🏢) (\$)	(🏢)	Li argues, in a panel discussion, that the Internet should be the convergent communications network for all digital communications. And that the Internet should work by the same premises as "new IP".
ITU	(🏢) \$	—	Although not formally defined, ITU documents discuss the Internet in terms similar to "Internet protocol-based networks" where the Internet is seen as a strictly technical concept where coordination and regulation are external to the Internet itself.

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Table 8.3: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Dominant by the bureaucratic thought style.

Primarily bureaucratic thought style			
Source	T	C	Quote/Description
UN	( )	( )	Does not define the Internet, or its coordination, seemingly by intent. One means of upholding Article 19 of the Universal Declaration of Human Rights, “to seek, receive and impart information and ideas through any media and regardless of frontiers”, is by access to the Internet, as stated in Resolution Adopted by the Human Rights Council on 5 July 2018 (2018).
DeNardis (2020)	( ) ( )	( ) ( )	Introductory text to Internet Governance, which recognizes the power of implementation of technology in a governance setting through a bureaucratic and market thought styles lens. For example “Governance is not only about governments. It is enacted via technical design, resource coordination, private ordering, and conflicts at control points” (p. 3). Basically presents how implementation of technology is important in the bureaucratic and market thought styles.

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Table 8.3: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Dominant by the bureaucratic thought style.

Primarily bureaucratic thought style			
Source	T	C	Quote/Description
Braman (2020)	(Δ)	(\$)	Argues that concepts bundle over time, and that the Internet Governance construct has to cover all possibilities. And up the Internet as a vertically integrated concept of which the parts cannot necessarily be separated. This complexity of governance of all these different entities and processes “make Internet governance research a problem in metagovernance” (p. 49) rather than a governance problem.
Mansell (2012)	(\$)	—	The Internet is not strictly defined but discussed as a technical phenomenon, which is in need of governance since the current regime favors established strong parties (often market actors but not limited to them). The Internet should be governed similarly as cable-TV and telephony. Implies that currently there is no well-defined coordination and no ideals to follow.

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Table 8.3: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Dominant by the bureaucratic thought style.

Primarily bureaucratic thought style			
Source	T	C	Quote/Description
DeNardis (2012)	Δ ( ) ( )	( ) ( )	“The theoretical starting point of this paper is that arrangements of technical architecture are inherently arrangements of power” (p. 721), and elaborates further on the need of understanding the technology to improve understanding of how the Internet is governed. Discuss actual coordination (or rather governance) and does not explicitly mention the ideals behind the coordination.
Mueller, Mathiason, et al. (2007) on the Internet	( )	-	Suggests a definition of the Internet as being a selection of protocols which are in need of governance. For example; “standardized set of software instructions (known as protocols) for sending data over a network, and a global set of unique addresses so the data can be told where to go” (Mueller, Mathiason, et al., 2007, p. 244). Explicitly separates the Internet and Internet Governance, where the Internet is just networks using IP, TCP and “other protocols required” (p. 244).

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Table 8.3: Internet descriptions, a selection from interviews, written sources and informal communication (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Dominant by the bureaucratic thought style.

Primarily bureaucratic thought style			
Source	T	C	Quote/Description
Mueller, Mathiason, et al. (2007) on Internet Governance			“Thus Internet governance consists of intentional decisions made by the collectivity of the Internet community” (p. 244). Explores the “intentional and legitimate ordering” (p. 245) needed for the Internet, which further includes human conduct and behavior on services on-top-of the Internet.
Lessig (1999) and Lessig and Lessig (2006)			Mentions a shift from what can be interpreted as an interoperability thought style Internet (“NET95”), into an Internet between markets and bureaucracies. And further argues that the Internet should follow the values of what I call the bureaucratic thought style.
Benkler (2006)		(Δ)	Does not discuss the Internet as the object of study, but rather what the Internet can be argued to have led to. Introduces the term “commons-based peer production”, but does not explicitly apply it to the Internet itself or related organizations.
RFC-8280 (ten Oever & Cath, 2017)	(Δ)	(Δ)	Argues that the technical design of the Internet is intertwined with human rights, and that this “has led to a broad recognition that human rights have a role in the development and management of the Internet” (p. 3).

In Table 8.4 I show sources closer to the **market thought style**, in which the Internet often is described as a service, or a technology which can be sold

as a service. These sources show the least nuance of the coordination of the Internet and often, implicitly, black-box the Internet as a service more or less entirely under market forces.

One source of market thought style view of the Internet is **net neutrality** literature, in which the Internet mostly is discussed as a service offered on market principles shaped by regulation, as Choi et al. (2015), Economides and Tåg (2012), and Wu (2003) do. The Internet is discussed as the service of Internet-access.

I have found no empirical academic literature on the business of peering (such as overviews of actual contractual relations between **Autonomous Systems (ASs)**). The closest I have found is D'Ignazio and Giovannetti (2006) and D'Ignazio and Giovannetti (2009) which both try to approximate the effects of peering-policy through **routing**-data (i.e., BGP-data). However, there is a significant literature stream which discusses Internet interconnection, or peering, as a theoretical market decision, for example Clark et al. (2011, 2016) and Faratin et al. (2008). These serve as once piece of the puzzle of what the Internet can be seen as.

Netnod (2019), an interoperability thought style non-academic practitioner oriented Internet-access definition, states that the Internet is problematic in a contractual setting (in particular public procurement), and offers its Internet-access definition as a way of discussing Internet through Internet-access defined by contracts and measurements.

Few sources in my material discuss market considerations of Internet Standards, and they are dominated by the interoperability thought style. There are, however, Requests for Comments which are of considerable market concern. **QUIC** is one such example. **QUIC** is often a bit inaccurately used as **Hypertext Transfer Protocol (HTTP)** version 3 (i.e., HTTP/3). Here I use **QUIC** explicitly as the transport version of **QUIC**, that is as a possible replacement of **TCP** and **User Datagram Protocol (UDP)**.

QUIC not only suggests encryption, **QUIC** enforces it (see Iyengar & Thomson, 2020, for specification). The current implementation of **IPv4** and **IPv6** combined with the at the time of writing current version of **QUIC** results in that everything of importance in a packet on the Internet is encrypted. Only information such as sender, receiver, port number, etc are visible to the network. **QUIC** drastically alters the dynamics of traffic differentiation, as it is no longer possible (if using **QUIC** as transport) to differentiate bit-torrent traffic from **HTTP**-traffic from **VPN**-traffic from **DNS**-traffic. **QUIC** represents market thought style logics for edge-actors (which is where the corresponding authors of Iyengar & Thomson, 2020, are employed). I find no academic literature *at all* mentioning **QUIC** (as the transport protocol) and either “market”, “economics”, or “policy” which discusses the topic of market-/economic-/policy- effects of **QUIC**.

No formal interviewee argued for the Internet as being market-value laden, and as the most used protocols are interoperable and not optimized for dif-

ferent forms of differentiation I do not find this surprising. However, the discussions with edge-actors and **infrastructure and network operators** which did not become formal interviews⁴ indicate two principally different wants of the Internet: (1) edge-actors who favor the interoperable Internet on which it is hard to differentiate traffic, and (2) infrastructure and network operators who argue for standards by which integration of concerns is the norm, where the infrastructure and network operators can negotiate with the edge-actors. My intention was to discuss QUIC with actors whose value-capture models depend on the nature of the transport-protocols of the Internet, but was unable to find any accepting to participate in the study.

Table 8.4: Internet descriptions of the market thought style
Internet descriptions, a selection from literature, interviews and non-academic sources. Set primarily in the market thought style.

Primarily market thought style			
Source	T	C	Quote/Description
Wu (2003)	\$ (Δ)	(\$)	Sees the Internet as a service produced by markets (which are regulated by bureaucracies). For example “Internet Darwinians argue that their innovation theory is embodied in the “end-to-end” design argument, which in essence suggests that networks should be neutral as among applications” (p. 146) illustrates an understanding of the technical underpinnings of the Internet but the arguments in the text are in line with markets.
Economides and Tåg (2012)	\$	(\$) (🏢)	Does not define the Internet, but discusses it like a service controlled and defined by market forces which in turn are defined by regulatory frameworks.

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⁴In the formal interviews with **Internet Service Providers (ISPs)**, “ISP (1)” and “ISP (2)” argued, from a perspective of maintaining networks, that the Internet is not made for business logic at a technical level, and speculate that the Internet might not even exist if it since it might require too much coordination.

Table 8.4: Internet descriptions, a selection from literature, interviews and non-academic sources (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Set primarily in the market thought style.

Primarily market thought style			
Source	T	C	Quote/Description
Choi et al. (2015)	(\$)	\$( )	Does not define the Internet, but discusses it from a business perspective, “the effect of net neutrality regulation in a two-sided market framework in which Internet service providers (ISPs) serve as platforms that connect content providers (CPs) and end consumers” (p. 105). Discusses public policy as that regulated the services offered on the market.
van Eeten and Mueller (2012)	(\$)	( ) (\$)	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” (p. 732). Describes the Internet as a mostly technical issue but also discusses the coordination and ideals behind.
Faratin et al. (2008)	(\$)	\$	“Today, the Internet is built up out of regions, or Autonomous Systems (ASes)” (p. 51), and further discusses the Internet as a rational business network of actors exchanging traffic.

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Table 8.4: Internet descriptions, a selection from literature, interviews and non-academic sources (continued).

Internet descriptions, a selection from literature, interviews and non-academic sources. Set primarily in the market thought style.

Primarily market thought style			
Source	T	C	Quote/Description
*Business side infrastructure and network operators	\$	\$ 🏢	Discussions with sales (B2C and B2B) of ISPs describe and contrast the Internet as a service, which is both directly and indirectly formed by commercial considerations and public policy and regulation. Preliminary interview accepts withdrawn.
*Business side high-tech firms with cloud offering	\$ (Δ)	\$ 🏢	Discussion with business side of high-tech firms where the Internet is recognized as a mostly interoperability thought style phenomenon (originally) where their firms are trying to change the primary coordination to principles fulfilling business logic for edge firms (rather than for infrastructure and network operators). Preliminary interview accepts withdrawn.

(* indicates non-formal source)

In terms of implementation of technology and standards formulation the interoperability thought style offers descriptions of how the Internet works and should work, through for example Requests for Comments. Similarly, interviewees with what I would call an interoperability thought style argue that the coordination of the Internet was designed in the same way, with the logics of interoperability. As argued in Section 7.3, the RFCs themselves follow an interoperable logic in terms of format, size, and legality. Several sources argue that the concept behind, for example, the Requests for Comments is more important than the Requests for Comments themselves.

There are later RFCs, as mentioned at p. 195 and p. 201, which show logics of both bureaucratic and market thought styles, for example DNSSEC (verification of actors in trust chain 🏢) and QUIC (market positioning tool for edge actors \$). There are also protocols and suggestion outside the

IETF which follow bureaucratic thought style logics, for example “new IP” (verification and control embedded 🏢) and the DONA-system (multilateral naming scheme 🏢).

In terms of what the Internet is, academic literature closer to bureaucratic and market thought styles often problematize Internet through Internet-access. This is similar to RFC-8280 (ten Oever & Cath, 2017) which problematizes human rights consequences of protocol design, i.e., a bureaucratic thought style evaluation of Internet-access. There is market thought style literature which discusses the Internet as a network of rational businesses exchanging traffic. However, I have found no such literature which ventures to explain the implementation of technology and standards formulation of the Internet.

In Table 8.5 I present the three main synthesized flavors, the service, the Internet as a concept, and as a network of for-profit actors. The perspectives agree on the technical dimension (i.e., a set of protocols and the way the implementations based on them actually work) but differ in the coordination dimension.

While the thought style represents general ways of thinking and reasoning, the flavors represent actual encountered views of the Internet. The flavors are used as a stepping-stone to the suggested conceptualization of the Internet.

In policy and economics literature, I find the first flavor in Table 8.5 to be most prevalent. In terms of the thought styles, this flavor appears in the bureaucratic and market thought styles, with **integration of concerns** as a common denominator and where the Internet can be described as a service, or an artifact. This flavor does not discuss the constitution or the evolvement of the Internet.

The second flavor is more prevalent in technical literature and RFCs, closer to the interoperability thought style and separation of concerns. It includes also a notion of coordination and not only the protocols themselves in the Internet concept. A majority of the interviewees discussed the Internet along the lines of this flavor.

The third flavor is the least prevalent of the three, and exists in a subset of literature concerning peering and the related transactions of market actors running networks. I encounter this flavor as a modelling exercise in academic literature and not as a flavor among practitioners. The relevant interviewees, i.e., “ISP (1),” “ISP (2),” “IXP (1),” “IXP (2),” and “IXP (3),” say that peering agreements are usually very simple, and few actors differentiate by peering today⁵.

In this text, I suggest a conceptualization more in line with the second flavor (interoperability thought style) including concepts of the first (bureaucratic and market thought styles) and the third (market thought style). Among the three, this is the flavor that most closely considers what the Inter-

⁵However, when I asked I was not allowed to look at any of their peering-agreements.

Table 8.5: Three main Internet flavors

The three main flavors identified in Tables 8.2 to 8.4 summarized and condensed, presented in order of prevalence. Literature concerning Internet Governance, including net neutrality, often discusses the first flavor (Internet as a service). Technical documents, technical literature and interoperability thought style interviewees discuss the Internet as a concept. Economics and policy literature on peering discusses the Internet as a rational business network.

Concept	Δ / /\$	Description
The Internet as a service	\$	The Internet is seen as a service, similar to cable-TV-service (\$) or telephony ( ). The Internet runs <i>on</i> telecommunication's infrastructure. The decision of the user is whether to use the service or not, rather than to participate.
The Internet as an idea of a voluntary and permissive network	Δ	This concept of the Internet comes from interviewees who explicitly stated that the Internet is not a part of telecommunications. The two might share the same infrastructure quite often, but are fundamentally different in terms of coordination.
The Internet as a network of business networks	\$	The Internet as a rational set of for-profit actors who in a market setting have to compete to cooperate to deliver end-to-end service to users (i.e., the access above).

net is, rather than what it serves as (the service flavor) or concentrating the view to the relations of for-profit network actors (the third flavor). In previous chapters, I have pointed at how solutions at the technical levels impact the functioning of the network, and these solutions are developed based on ideals, impacting both the solutions and the processes through which these solutions emerge. Another important reason form my choice relates to the development of the present Internet. Through my research process I found that the Internet as a concept was created as a quite explicit response or reaction to centralized network hierarchies where innovation was possible at the edges without explicit permission from the network.

This could be seen as the military needs for a robust network having first become combined with the notion of the permissionless network allowing change, and that by today that network idea has given rise to an infrastructure

of such importance that market and bureaucratic concerns demand attention to a degree that they have not before.

8.2 A suggested conceptualization

In this section follows the motivations for the individual parts of the conceptualization. The entire conceptualization is as follows:

the Internet is an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through ad-hocratic processes based on ideals of design for interoperability

This conceptualization is based on the four levels used in this thesis: implementation of technology (T), standards formulation (S), coordination of technology (C), and meta-coordination (M). I discuss which thought style logic is dominating and observed shifts per level.

architecture for best-effort digital end-to-end communication
(T, Δ)

At a base implementation level the Internet is the concept of a best-effort architecture for best effort digital end-to-end communication. In practical terms the implementation of technology is a combination of interoperability thought style standards implemented to become market products, for example through network equipment manufacturers.

However, as is mentioned in Honda et al. (2011), Papastergiou et al. (21–2017), and Stenberg (2018), among others, the architecture of the Internet is in practice ossified, less interoperable than specified by the Internet Standards. The most problematic concern with ossification, as these texts mention, is that it is no longer possible to extend existing transport protocols (TCP and UDP) since equipment on the Internet uses data above the Internet layer to make informed quality-of-service decisions (for example `diffserv`, a common way of prioritizing traffic within networks).

According to the protocol specification of IP and the interoperable idea of the Internet, the transport protocols should not matter for Internet infrastructure, but in practice they do since infrastructure and network operators optimize according to choices they make. This results in a clash between the interoperability thought style, decouple transport layer from the Internet infrastructure itself, and the market thought style actions where other values, such as optimizing performance, are more important than the interoperability of the network.

This is illustrated with the “T” in Figure 8.2. The dashed arrow indicates previous shifts in logic captured, and the full arrow in indication of current shift.

set of protocols for best-effort digital end-to-end communication
(S, Δ)

At a standards formulation level the Internet concerns best-effort digital end-to-end communication. That is, innovation is at the edges of the network due to separation of concerns constraints in that the idea of the digital network is best-effort packet delivery, neither more nor less. In engineering terms, all logic, business or otherwise, should be at the edges, outside the Internet as a network proper.

Notably the standards formulation of the Internet Standards are considerably closer to the logics of the interoperability thought style than the market thought style, but are moving in the direction of standards which are not only interoperable, but also provide market advantages to a particular set of actors. For example, **DNS over HTTPS (DoH)** and **DNS over TLS (DoT)** put additional requirements on the DNS server operator in a way preferable to larger actors in a market sense. Similarly, protocols such as QUIC⁶ alter both market and network logic, since QUIC makes all traffic essentially opaque. This means that infrastructure and network operators cannot differentiate traffic either for the purpose of price discrimination, or for the purpose of providing AS-internal quality of service⁷.

In terms of bureaucratic thought style influence, standards such as DNSSEC have become widely accepted and balance interoperability with the need for verification in the bureaucratic thought style.

As with the implementation of technology, I argue that the standards formulation (the set of standards used) is still dominated by interoperability thought style values (due to path dependence on previous decisions), even if there is a visible drift towards, in particular, commercial logic, but also towards bureaucratic thought style considerations.

This is illustrated with the “S” in Figure 8.2. The standards common older standards are formulated in an interoperability thought style fashion, while some later standards includes integrated verification and are preferable to certain commercial interests.

effected by its users through adhocratic processes (C, Δ , \$)

At the coordination of technology level the protocols of the Internet are coordinated by adhocratic processes. The actual processes for agreeing on the documents which become standards are not well-defined, in that working groups together formulate documents and implementations which must pass

⁶QUIC as a transport protocol, not as HTTP/3.

⁷At a technical level, anything over QUIC has less visible metadata than **Hypertext Transfer Protocol Secure (HTTPS)** over TCP. As an example, **deep packet inspection** is no longer feasible for differentiating traffic, as all data above transport is properly encrypted by default. See Iyengar and Thomson (2020) for protocol specifications for QUIC.

a certain muster. The process is based on voluntary involvement. Implementation of standards is also voluntary, and the last step in effecting the communication infrastructure. All of this combined works towards the **Least Common Internet**, central to the interoperability thought style. The coordination of technology is based on a notion in the interoperability thought style (coordination is legitimized through actual implementation ex-post and an **Internet-model** approach) and the market thought style (since the motivation for sending people to IETF meetings is often some form of perceived financial return for the actor in the future). Also, the actual adoption or implementation of technology is dependent on commercial considerations, since the vast majority of infrastructure and network operators are for-profit actors.

The logics of the market thought style has been present and visible in the actual coordination for a while. However, as several interviewees note, the resulting standards have until recently been dominated by interoperability thought style logic. In particular QUIC seems to have been a wake-up call to several interviewees of shifting logics⁸.

As an example, if we compare QUIC with TCP, and DoT and DoH with DNS, it is possible to argue that the newer protocols just add security. But, compared to DNSSEC which adds validity to DNS (a bureaucratic thought style concern), DoH and DoT also alter market dynamics in favor of certain actors. Encryption, since it separated layers, is also an interoperability thought style want.

This shift is illustrated with the “C” in Figure 8.2.

based on ideals of design for interoperability (M, Δ ,)

At the meta-coordination level, there are interoperability notions everywhere, and bureaucratic thought style logics are becoming increasingly visible. For example, notions such as human rights (instead of network agnosticism) and DNS-abuse (instead of separation of network and jurisdictions) take considerable space in several arenas, topics whose solutions are implemented in an ex-ante bureaucratic fashion with the intention of preventing DNS and human rights abuses. In the EU the **Revised Directive on Security of Network and Information Systems (NIS-2)** intends to, in the current not-yet-final formulation, implement an audit structure for the DNS system in the EU. At an international level the ITU has suggested treaties for a bureaucratic thought style dominated Internet, and in ITU study groups, “new IP” is discussed as a bureaucratic thought style network protocol which incorporates verification and control in the network itself.

⁸There is a lot which can be said about QUIC, here I have so far focused on the commercial consequences of large edge-actors and infrastructure and network operators, but an all out adoption of QUIC would also change dynamics of local networks, such as in practice bypassing traffic inspection mechanisms of home routers.

I think it is necessary to regulate, or at least use strong policy, to ensure adherence [to **Best Current Practice (BCP)**-38]
("ccTLD (1)")

The above quote illustrate an in most matters interoperability thought style interviewee who now thinks that regulation is necessary to prevent the **distributed denial of service (DDoS)** issues described in BCP-38 (RFC-2827, Ferguson & Senie, 2000), illustrative of a shift towards the bureaucratic thought style.

Note the historical nature of interoperability thought style influence on the present Internet, as there are **country code top-level domains (ccTLDs)** who do not recognize ICANN formally, and protocols such as IP, DNS, TCP and UDP are in use. Ideas such as **future vertical communications network** are quite far from becoming the norm, but they do exist, and illustrate intentions of achieving an international communications network run by other sets of values than the current Internet. If a sufficient number of (important) ASs and other users elect to move in such a direction, a change to the Internet would be effected.

This shift is illustrated with the "M" in Figure 8.2. Note the large arrow, indicating the current quite significant shift towards verification and control, however, it is likely that discontent voices are louder than content voices.

In Figure 8.2 I illustrate the Internet as conceptualized above with the help of the interoperability (**Δ**), bureaucratic (**🏢**) and market (**\$**) thought styles and the levels implementation of technology (T), standards formulation (S), coordination of technology (C), and meta-coordination (M). The green-yellow ellipse illustrate the Internet area of the figure, which illustrate that the levels of coordination are slowly moving out of the traditional Internet area. Figure 8.2 is illustrative and strictly based on what I have encountered and captured, I do not in any way suggest that this is the only way to properly illustrate the values and assumptions at play.

In Figure 8.2 the yellow ellipse surrounding the "🌐" illustrate an Internet-like balance of values. However, I capture a changing or shifting Internet, illustrated by the arrows leaving the yellow sphere. Note that the full arrows are my estimates of the strength and direction current shifts, and the symbols (T, S, C, M) are where I place them currently.

8.3 Thought styles regarding the present Internet

This section contrasts the Internet as described in this chapter with how the thought styles would like the Internet to change in the short term based on the current constitution of the Internet. The order of presentation is inter-

Figure 8.2: The thought styles and the Internet

The figure illustrates the Internet and its proximity to the thought styles, the early provenance of interoperability thought style values and the entry over time of logics relating to value-capture on markets and control by bureaucracies. The interoperability (Δ), bureaucratic (🏢) and market (\$) thought styles are represented by their respective symbols. The 🌐-symbol illustrates the Internet as a combination of the values of implementation of technology, standards formulation, coordination of technology, and meta-coordination. The components of the Internet are further illustrated by their symbols according to implementation of technology (T), standards formulation (S), coordination of technology (C), and meta-coordination (M).

operability, bureaucratic and market thought styles, and the examples are drawn from discussions and interviews.

There are some specific issues which go against the notions of the interoperability thought style. Here are two illustrative examples:

Traffic agnosticism (Δ T) (or practical net neutrality) is not upheld.

Since market forces and bureaucratic ideals everywhere do not align with separation of concerns, not all ecology actors strive to uphold separation of traffic and network, which is problematic for the interoperability thought style. QUIC and net neutrality as regulation offer two ways

of dealing with integration of concerns, QUIC by technically separating layers through encryption, and net neutrality through regulation. However, in the best of worlds the interoperability thought style would like none to be necessary.

According to the bureaucratic thought style there are some important issues with the present functioning of the Internet, for example:

Verification of users (🏠 T). With IP there is no guaranteed connection between technical sender and actual sender of a packet, and thus it is difficult to hold the actual sender accountable. Coupling between network address and user would change this, as for example suggested with “new IP” (see for example Jiang et al., 2019; Li, 2020; Mueller, 2020).

Coordination of technology (🏠 C M). Currently most standards are set on technical grounds rather than the needs of nation states. A change to arenas of the ITU for standards and DONA or some other multilateral organization for handling unique identifiers is preferable in the bureaucratic thought style. If not the creation of standards themselves, then at least naming and **numbering** should be done under multilateral supervision. One such suggestion is, or was⁹, DOA and DONA (see Internet Society, 2016).

In terms of the market thought style, matters are, in general, less problematic. For more detail, I divide adherence to the market thought style into two subgroups: those who are infrastructure and network operators, and those who sell services at the edges of the Internet¹⁰.

Traffic value capture (\$ T). For infrastructure and network operators the current situation is good since TCP over IP etc allows differentiation in a technical sense. It is possible to look at general IP-traffic and with a bit of intelligence, sometimes called *deep packet inspection*, figure out enough meta-data about the packets to differentiate services over the Internet (**diffserv** is one such common method). For for-profits at the edges the case is more problematic, since their negotiating position would be better in a norm where it is technically impossible to differentiate traffic (for example with QUIC, see Iyengar and Thomson, 2020; Stenberg, 2018 again).

⁹DOA and DONA received a lot of attention a couple of years ago, but seem to have died out since. Most interviewees mentioned one or the other unprompted in 2017–2018, while no interviewees mentioned either in 2020, unless explicitly asked. When asked, they stated that DONA and DOA were past concerns for them.

¹⁰There is a potential third group as well, those who are not at all, even implicitly, affected by the Internet, although that is a vanishing set of actors today.

Coordination of technology (\$ C). Currently most Internet Standards are set and suggested by for-profits (see Weyrauch and Winzen, 2020), so it is the correct world order (in the market thought style), even if sometimes the wrong firms set the standards. Smaller actors might argue that there is a problem with the world order, which is common in market settings where larger actors set the rules of engagement.

8.4 Chapter summary

I suggest that the **Internet** can be seen as *an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhoc processes based on ideals of design for interoperability*. This involves four dimensions of the Internet, two technical and two **coordination**. The technical dimensions are not subject to much disagreement (a digital end-to-end communications network of some kind according to some technical principles) but the coordination dimensions are contested. Some literature views the Internet as only technical, while I suggest that its coordination principles are intrinsic to its existence. In the suggested conceptualization, protocols such as **IPv4** and **IPv6** are products of the Internet’s coordination rather than the protocols being the Internet itself (as “the Internet is [only] a collection of protocols” approach suggests).

This Internet conceptualization is captured in Figure 8.2, which is an illustrative, rather than analytical, figure. Digital networks in the yellow-green ellipse in this figure are Internet-like according to the description suggested. Figure 8.2 illustrates that the Internet is slowly moving out of the “safe best-effort network”-end of the **interoperability thought style**, into being influenced more by **bureaucratic** and **market thought styles** ideals. Some argue that this is quite bad, mostly members of the interoperability thought style, while others see it as a natural evolution as the Internet matures.

By bringing in coordination dimensions it becomes clear that regulatory enforcement of a different structure than bottom-up processes causes clashes. One view in interviews is that these clashes are going to intentionally change the coordination mechanisms of the Internet (and therefore the Internet), another that they are happening because the **national regulatory authorities** and other governmental or state groups lack domain specific knowledge of the technical nature of the Internet.

In terms of shifts, the coordination of the Internet (**coordination of technology** and **meta-coordination**) is shifting towards a more integrative view of digital networks, where both market logic and bureaucratic ideals play a more central role. The Internet architecture itself is also undergoing shifts, from best-effort and interoperability, to protocols with multiple dependencies. For example, **BGPsec** requires the **Resource Public Key Infrastructure (RPKI)** infrastructure anchored at the **Regional Internet Registries (RIRs)**. **Domain**

Name System Security Extensions (DNSSEC) is dependent on predelegated trust for a set of keys managed by the Internet Assigned Numbers Authority (IANA)-function, etc. These are additional dependencies which need to be coordinated.

The last section of the chapter provides examples of concerns regarding the present Internet from each of the three thought styles.

9

Internet social resilience

Control over ICANN does not imply control over the Internet

— Interviewee

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.

This chapter is written in the light of the Internet-conceptualization in the previous chapter:

an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhocratic processes based on ideals of design for interoperability

This chapter, particularly, looks at the structures of the Internet Engineering Task Force (IETF), the Internet Corporation for Assigned Names and Numbers (ICANN) and the International Telecommunications Union (ITU) from a lens of social resilience, that is how it would be possible to change the Internet with social means.

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 et al. (2013), Cohen et al. (2000), Rohrer et al. (2014), Sterbenz et al. (2013), Wu et al. (2007), and Yuan et al. (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 chapter 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 through 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 (see Section 4.6 for overview). I also went through bylaws and statutes. In addition to that, I used interviews as a sensitizing tool to guide further exploration of which mechanisms and organizations are important for Internet function.

There are two main goals of disruption in the Internet case: disabling the Internet, and controlling part of the Internet (for example for political or economic reasons).

Even though similar in character, “can the Internet be controlled” vs “can the Internet be disrupted” are different. 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, for example 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 structure does not imply control over the Internet due to the autonomy of the **Autonomous System (AS)** and other network operators (in line with the **interoperability thought style** and compatible with the **market thought style**). As an example, the formal multi-stakeholder structure of 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 complicated; 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 conceptualized in this thesis. The first would, for example, 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 (as I further argue in Chapter 10, the **bureaucratic thought style** naturally would point to a different digital network than the Internet). This would be a “bottom-up” push towards increased

regulation for safety and security¹. The second is international pressure, primarily from the **United Nations (UN)** and 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 described in Section 9.3).

The idea in the epigraph, that control over **Internet Corporation for Assigned Names and Numbers (ICANN)** does not imply control over the Internet, was brought up by several interviewees when questioned what a potential non-Internet-friendly actor could do if they controlled ICANN / IETF / the **Internet Society (ISOC)** / etc.

The chapter is organized as follows: first three sections, each on one of the spheres of Chapter 7. After that a reflection on the **infrastructure and network operators** and their influence. This is followed by an overview of the influence of technical errors. After that comes a discussion on the Internet as a service conundrum and a summary of the chapter.

9.1 The ICANN-sphere

ICANN is the formal administrative seat of the IANA-function, which coordinates the unique identifiers of the Internet, such as domain-names (naming), **Internet Protocol (IP)**-addressess (and **Autonomous System Numbers (ASNs)**, numbering) and protocol specifications necessary for naming and numbering.

ICANN has since they changed their bylaws in 2016 incorporated a multi-stakeholder approach in their governance model (ICANN, 2016a), with the **Empowered Community** as an oversight organization for some of ICANN's functions (ICANN, 2017c). The Empowered Community's powers include but are not limited to recalling the board, selling ICANN assets and rewriting the ICANN bylaws. The Empowered Community is described as a way for ICANN's **Supporting Organizations** and **Advisory Committees** to organize as a separate organization under California law (ICANN, 2017c), but the Empowered Community does not represent two of the Advisory Committees: the **Root Server System Advisory Committee (RSSAC)** and the **Security and Stability Advisory Committee (SSAC)** (see ICANN, 2017c). In essence the Empowered Community acts as a common chapter meeting, i.e., appointing and holding the board accountable.

The interviews raised the issue that the Empowered Community structure was quite empty early on (2016-2017) and later on appointees were selected to important positions (2020-2021) and the Empowered Community structure could be considered filled. "ccTLD (1)" and "ccTLD (3)" explicitly lament that this structure not only has appointees with an interest in the Internet, but also people who sit on positions in the Empowered Community as part

¹It is possible to argue that the current formulation of the **Revised Directive on Security of Network and Information Systems (NIS-2)** directive is such a sign. What the final formulation will be is still uncertain, as the directive will not be finalized before the defense of this thesis.

of their employment (as is argued by “Advisory Committee (1)”); “Advisory Committee (2)” but not as explicitly).

“Advisory Committee (1),” “Advisory Committee (2),” “ccTLD (1),” and “ccTLD (3)” also raised the issue that this at the beginning quite empty structure led to some people being higher up in the structure than they have (technical) knowledge for and argue that this is likely to lead to that processes become more important (🏢) than the interoperable idea of keeping the amount of decisions at minimum (Δ).

In an administrative sense, the Empowered Community has five members, or *Decisional Participants*: the **Address Supporting Organization (ASO)**, the **Country Code Names Supporting Organization (ccNSO)**, the **Generic Names Supporting Organization (GNSO)**, the **At-Large Advisory Committee (ALAC)** and the **Governmental Advisory Committee (GAC)** (see bylaws ICANN, 2019). These five organizations together constitute the Empowered Community with one vote each. These constituents in turn might have regional constituents who in turn might have national (or similarly geographically divided) constituents. Here follows an overview of each constituent, see Table 9.1 for an in detail view.

In practice the *Decisional Participants* acts through the *Empowered Community Administration*, an administrative body with one representative per Empowered Community member.

The Country Code Names Supporting Organization (ccNSO) has an elected board by all of its ccTLD constituents. Each individual ccTLD might be a firm, a foundation, a non-profit or a state agency. Not all ccTLDs are members (see Section 7.4).

The Address Supporting Organization (ASO) has a hybrid board where each **Regional Internet Registry (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 means the RIPE Community with its 16 000 members allows for a drawn out process if there is considerable disagreement. The other Regional Internet Registries (APNIC, LACNIC, AFRINIC and ARIN) have similar situations, where AFRINIC stands out and requires voters to be physically present at a meeting². In general, all of these constellations mentioned in this chapter do not distinguish between types or modes of presence.

The Generic Names Supporting Organization (GNSO) in turn has a hybrid board with 21 members, divided into two houses, one house for

²See <https://www.afrinic.net/en/community/elections/nro-aso-election?start=1> for eligible AFRINIC voters.

Table 9.1: Summary of Empowered Community structure
Overview of the Empowered Community structure. Numbers from ICANN bylaws.

Org	Board	Constituents/members	Comments
ICANN	hybrid	The Empowered Community in practice	The Supporting Organizations have dedicated positions on the board and the Advisory Committees have liaisons. The Nominating Committee nominates and the Empowered Community designates board members.
ccNSO	elected	All interested ccTLDs	ccTLDs appoint all board members. ccNSO elects one Nominating Committee member.
ASO	elected	All five Regional Internet Registries	Each RIR elects three ASO board members, two by the chapter meeting and one by the board. ASO and NRO are the same organization. The Regional Internet Registries each have thousands of members, bringing the total number of constituents of ASO into the tens of thousands. ASO elects one member to the Nominating Committee.
GNSO	hybrid	Registrars, registries, ISPs, Internet Exchange Points, other businesses, non-profit interest groups, etc	Complex board with 21 members divided into two houses. The houses represent contracted parties (registries and registrars) and non-contracted parties (businesses and non-profit stakeholders), who formally are further divided into Constituencies which each appoint one member to the Nominating Committee (seven in total).
ALAC	hybrid	Regional at-large organizations	The ICANN nominating committee appoints five (5) out of ten (10) board members. Each of the five (5) regional at-large organizations appoints two (2) board members. ALAC appoints five members to the Nominating Committee.
GAC	elected	Governments, multinational governmental organizations and treaty organizations	Board is elected from pool of GAC members. Appoints a non-voting member to the Nominating Committee.
Nominating Committee	hybrid	—	Consists of 15 voting members, five (5) from ALAC, seven (7) from GNSO, one from ccNSO, one from ASO and one from IETF.
Empowered Community	hybrid	ccNSO, ASO, GNSO, ALAC and GAC	All constituents (“Decisional Participant”) have equal weight in Empowered Community governance matters.

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).

The At-Large Advisory Committee (ALAC) has a similar regional structure as ASO, divided into five regions who all through different processes appoint two members each and the ICANN **Nominating Committee** appointing five members.

The Governmental Advisory Committee (GAC) consists of national governments, multinational governmental organizations and treaty organizations who elect the board of the GAC. A majority of GAC members are **nation-states**.

The board of ICANN consists of sixteen (16) voting directors and four (4) non-voting liaisons (ICANN, 2019). The **Empowered Community** elects all voting directors. GAC, RSSAC, SSAC, and the IETF have one liaison seat each.

Since the board of ICANN can be overridden by the Empowered Community in terms of IANA actions, both the ICANN board and the Empowered Community need to be under control of a party for that party to be able to force through a certain IANA policy. And even if there would be power in the coordination function, i.e., controlling the IANA-function through the ICANN board and the Empowered Community, 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, **top-level domain (TLD)**-names and to some extent protocol specifications.

In practice, the **root-zone** is operated by twelve different operators, who could just ignore any new updates coming from IANA until they, the root-zone operators, coordinate around a new IANA-replacement-function. This scenario was explained by “Root-Zone Operator (1)” and “Root-Zone Operator (2)” (two separate operators) when I asked what I could do if I had control over the IANA-function. However, it should be noted that **Domain Name System Security Extensions (DNSSEC)** involves more work than just the root-zone-operators reorganizing around a new root-zone, as public keys also have to be distributed to all DNSSEC-speaking resolvers for the trust mechanisms of DNSSEC to work. There are millions of resolvers around.

Indicative of the amount of people involved in key aspects of the maintaining the Internet, the IANA Root KSK Ceremony (where the root-zone is re-signed, an important part of maintaining DNSSEC) is always livestreamed, and the last two ceremonies (41 and 41) during the COVID-pandemic where watched live by around 40 (!) people on the public IANA livestream. I

was chatting with “Cryptographic Officer (1)” at the time, who indicated that there were around 20 more people, the Cryptographic Officers and some IANA-internal people, participating in a private call as well. This is indicative of the small number of people involved in core Internet functions. Similarly, there are also root-zone operators with tens of employees.

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, on the one hand, it is possible to create havoc by wresting control of the IANA-function by taking over the ICANN-board, the Empowered Community and the Nominating Committee, 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.

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 (1)”)

In short, controlling the IANA-function through the Empowered Community structure is possible but cumbersome, and ultimately controlling the IANA-function will not give long-lasting control over the Internet nor disrupt it. It is also not clear what would constitute mission evolution (new board with new ideas) or mission disruption (board takeover).

9.2 The ISOC-sphere

The **Internet Society (ISOC)** sphere develops and formulates standards that help coordinate the **Internet**, such as **Internet Protocol (IP)**, **Transmission Control Protocol (TCP)**, **User Datagram Protocol (UDP)**, and **Hypertext Transfer Protocol (HTTP)**. In the ISOC-sphere the most important actor is the **Internet Engineering Task Force (IETF)**, according to the overview in Chapter 7. Of particular importance is **Public Interest Registry (PIR)** which, essentially, funds the entire ISOC-sphere.

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 **Internet Research Task Force (IRTF)**, and the IETF is to a large extent funded through ISOC (from PIR).

PIR is the registry for dot-org. From the [Internet Assigned Numbers Authority \(IANA\)](#)-function view they are the administrative contact, and Afiliis the technical contact. Afiliis is also the operator of the dot-org name servers. Such technical and administrative info is publicly available through the [WHOIS](#) system by doing a `ns` query for `org`. (note the dot).

The IETF structure

In comparison to ICANN, the IETF has a loose multi-stakeholder structure, and functions or boards included in the IETF structure include ISOC (the formal organization), the IETF (a subgroup of ISOC), IESG (in general terms, the board of IETF³), IAB (appoints IESG) and IRTF (the research arm of ISOC). See Table 9.2 for overview.

The IETF LLC, the administrative organization created in 2018, also has a board, the IETF Administration LLC Board of Directors. This board consists of three Nominating Committee appointees, one IESG appointee, and one ISOC appointee. According to interviewees the IETF LLC and board is not concerned with the standard setting process. However, as can be seen from meeting minutes⁴, IETF LLC is slowly growing in scope and personnel.

The main product of the IETF, from an external perspective, is the RFC-stream, that is RFCs published and available. The RFCs 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, 1981b) describes the original [IPv4](#) standard.

Actual standard-suggesting work is done in [working groups](#), who formally are organized in *areas* under the IETF. Each area focus on a set of topics, such as [routing](#), or real-time protocols⁵. The working groups, which belong to an area, suggest RFCs, and if they are intended to be standards they are sent to the IESG for approval and publication⁶. Formally the working groups have chairpersons, but these only have formal roles.

[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 (1)”)

³The IETF does not have a formal board per se and the IESG is not designated as such, but the IESG fulfills the duties of a board in any other organization.

⁴See <https://www.ietf.org/about/groups/llc-board/minutes/> for all meeting minutes.

⁵*Real-time* refers to delay-sensitive implementations, such as voice and video.

⁶Remember that not all RFCs are intended to be standards. See Chapter 7 for more detail.

Table 9.2: Summary of ISOC and IETF
An overview of ISOC and IETF structures. Summary from organizational documents and [Requests for Comments \(RFCs\)](#).

Org	Board	Constituents/members	Comments
IETF	(IESG)	Everyone interested and present	IETF is the open standards organization connected to the RFC series and administratively housed under ISOC. Standards work is usually done in working groups under the IETF.
IETF LLC	IETF Board of Directors	Appointees from the Nominating Committee, the IESG and ISOC	Administrative organizationa and home of the IETF.
IESG	hybrid	IETF chair and area directors	IESG is one of the boards of the IETF, and is practically responsible for the day-to-day operation of the IETF including managing the standards track (i.e., RFCs).
IAB	hybrid	IETF chair and elected members	The IAB oversees IETF operations (such as the Internet standards process) and the IESG. Board selected by the IETF nominations committee.
ISOC	hybrid	Mostly firms (such as Cisco, ComCast, Ericsson and Juniper) but also other organizations (such as ICANN and RIPE NCC)	ISOC is a formal non-profit, and has legal organizational status, which IETF, IESG, IRTF and IAB do not. The ISOC board (“ISOC Board of Trustees”) is elected by the chapters, the IETF and ISOC members.
Nominating Committee	elected	—	The IETF Nominating Committee is elected through a semi-randomized process (RFC-3797, Eastlake 3rd, 2004). The Nominating Committee nominates candidates for IESG (confirmed by IAB), IAB (confirmed by the ISOC board) and IAOC (confirmed by IESG).

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, let us look at 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. Controlling only a working group (by, for example, sending a lot of people to a meeting) has no decisive influence in the Internet standards process as a whole. In particular later interviewees describe that some firms are indeed sending more and more representatives over the years, where opinions differ on if there is actual takeovers taking place in the working groups. In discussion with practitioners several have mentioned that there is a significant shift in standard setting participation in working groups, where standards such as **DNS over HTTPS (DoH)**, **DNS over TLS (DoT)**, **QUIC** as transport, and QUIC as HTTP version 3 are mentioned most often as having been guided through the process a bit quicker than normal.

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.

I have no indications, in interviews or otherwise, that the composition of the IESG or the IAB has shifted similarly as indicated with working group participation.

The selection of the IETF Nominating Committee contains randomization which is not allowed to be seeded⁷ on anything under the influence of the IETF, as described:

The random sources must not include anything that any reasonable person would believe to be under the control or influence of the IETF or its components, such as IETF meeting attendance statistics, numbers of documents issued, or the like.

(RFC-3797, Eastlake 3rd, 2004, p. 3)

The randomization is used to select a number of individuals from a selection of volunteers which have passed an administrative eligibility process.

⁷In a technical sense, computers cannot roll a die, so all digitized randomization processes are based on a seed, such as the time of day, last mouse input, background brightness, etc. RFC-3797 (Eastlake 3rd, 2004) argues that such a seed must be based on something out of the IETFs control to ensure a fair process.

By controlling the Nominating Committee 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, due to fewer formal organizations involved. As the IETF has no formal membership it is possible for the one which shows up with the most people to get their will through in the IETF-setting. However, 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, p. 3)

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. As with the IANA-function, controlling the RFC-stream does not imply control over the Internet. While the IANA-function can be argued to cause quite a bit of hassle in terms of coordinating around a new actor, all RFCs are publicly available and can be copied, literally in seconds⁸.

9.3 The UN-sphere

In Chapter 7 I covered both the **United Nations (UN)** and the **International Telecommunications Union (ITU)** as part of the UN-sphere. Here I focus on the ITU as ITU comes up in discussions and interviews much more often than the UN. In particular, I focus on how **International Telecommunications Regulations (ITRs)** and the **future vertical communications network**-concept can alter or change that which we consider to be the **Internet**.

ITU-structure

The ITU, a membership organization with nation states as members, is set up multilaterally where treaties are agreed on, to be later signed or ratified by its members. Compared to the **Internet Engineering Task Force (IETF)** the ITU uses an ex-ante process. The ITU decides on what will happen or what

⁸`rsync -avz --delete ftp.rfc-editor.org::rfcs-text-only rfcs` will download all RFCs into a folder called `rfc`. This includes all **Internet Standards** and all documents which coordinate the processes of the IETF.

should be implemented, while the IETF takes decisions on what has already been implemented (or is under implementation).

Compared to the **Internet Corporation for Assigned Names and Numbers (ICANN)** and IETF, the ITU is more formal, and gains legitimacy through its members, which are **nation-states**. Larger firms play a role in the sectors (i.e., **ITU Radiocommunications (ITU-R)**, **ITU Telecommunications Standards Sector (ITU-T)** and **ITU Telecommunications Development Sector (ITU-D)**) but not at the ITU Plenipotentiary meetings (i.e., the chapter meetings). From a social resilience perspective the ITU Plenipotentiary meetings are of interest since that is where politics takes place and treaty meetings are called.

ITU plenipotentiaries and treaty meetings

In November 2018 there was an almost business-as-usual ITU Plenipotentiary, where some interesting things were expected to be discussed, such as the **Digital Object Architecture (DOA)/Digital Object Numbering Authority (DONA)** issue and a potential upcoming ITR treaty meeting (like the **World Conference on International Telecommunications (WCIT)** or the **World Administrative Telegraphy and Telephone Conference (WATTC)**).

The difference between an ITR treaty meeting and an ITU Plenipotentiary is that an ITU Plenipotentiary has to take place every fourth year as a chapter meeting with all members (i.e., nation-states), while a treaty meeting is only called for when new treaties are needed. The two last treaty meetings are Melbourne in 1988 (**WATTC**) and Dubai in 2012 (**WCIT**), where Dubai was unique in that not all members signed the treaties.

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.
(“ITU Delegate (1)”)

I did two interviews on the ITU Plenipotentiary in 2018 specifically. One was surprisingly short with a senior representative from the Internet-sphere, who essentially said “whatever they would have decided, it would not have mattered [...] they have tried before, and it did not work then”. The other was a longer interview and discussion with a delegate to the ITU Plenipotentiary (who had also been at **WCIT** 2012, cited as “ITU Delegate (1)”). Both are firmly leaning towards the **interoperability thought style**. None of the **Internet Service Providers (ISPs)** or telecommunications firms I contacted wanted to discuss ITU Plenipotentiary with me, and some did not know of the ITU Plenipotentiary, indicating that these matters are not as important as they

Table 9.3: Summary of ITU-organization
An overview of the ITU organization including sectors and their main organizational units.

Org	Board/bureau	Constituents/members	Comments
ITU	(ITU Council)	Nation states (practically all)	Multilateral organization, connected to the UN since 1949 which handles all ICT related issues of the UN.
ITU Council		Nation state representatives	The governing board of the ITU between ITU Plenipotentiary meetings. Elected by the ITU Plenipotentiary.
General Secretariat			The executive planning arm between ITU Plenipotentiaries. Arranges ITU conferences and meetings, and maintains liaison relations.
ITU-R	Radiocommunications Bureau	As ITU	Focuses on radiocommunications. Its executive arm, the Radiocommunications bureau, is elected by the ITU Plenipotentiary.
ITU-T	Telecommunication Standardization Bureau	As ITU	Focuses on standardization. Its executive arm, the Telecommunication Standardization Bureau, is elected by the ITU Plenipotentiary.
ITU-D	Telecommunication Development Bureau	As ITU	Focuses on the developing world, its executive arm, the Telecommunication Development Bureau, is elected by the ITU Plenipotentiary.
Radio Regulations Board		12 board members	Board consisting of 12 members of the ITU-R elected by the ITU Plenipotentiary who are not elected to serve the interests of their respective nation states, but rather as custodians of radio processes, such as spectrum allocations.

might seem to an Internet researcher. They appear to be considerably more important to the Internet **epistemic community**, presumably so since the ITR meetings potentially disrupt the balance of the **Internet Coordination** ecology.

Prior to the meeting, “ITU Delegate (1)” expected three issues of special importance to the Internet to be brought up at ITU Plenipotentiary 2018. According to this interviewee it is not that easy to find the interesting topics in the agendas before the meetings, since most revolutionary issues are intentionally sent in too late, so they do not have to pass the long mustering processes in all delegations, and rather become “on the spot” issues where you follow your “block”.

The three issues were:

- Potential need for a new **International Telecommunications Regulation (ITR)** treaty meeting
- New **technologies**, such as **artificial intelligence (AI)** and **blockchains**
- **Digital Object Architecture (DOA)**

A new treaty meeting was important to “ITU Delegate (1)” since the last ITR-meeting went in a direction against the Internet as a bottom-up interoperable phenomenon. It was considered necessary (by the ITU Plenipotentiary meeting) that there should be a new treaty meeting in the future and one could be announced in the next four years. However, since that meeting, the expert group on International Telecommunications Regulations, the EG-ITRs, has not concluded to actually call a meeting (or more formally, bring the issue up to a vote in a plenary session). There are some meeting minutes of the EG-International Telecommunications Regulations available publicly, such as EG-ITRs (2019, 2020, 2021), which indicate that Western states, in general, are against calling for a new ITR ITU meeting, but I have not found any records of an actual vote.

The delegate considered the issue of new technologies important since it concerns how the ITU should face developing technologies. It could possibly also change the ITU purpose or mandate to ensure future relevance. As argued by “ITU Delegate (1)”, ITU was relevant when the telegraph and telephone were new, but missed the opportunity for taking a similar role for the Internet, so the ITU now tries to proactively take responsibility for potential future big issues. On the topic of new and emerging technologies, nothing changed, i.e., the ITU mandate did not change.

DOA/DONA was important as a competing **naming** system to the **Domain Name System (DNS)**. This is discussed in Chapter 10 and in more detail where I contrast an optimal digital network in the **bureaucratic thought style** sense versus the Internet we have today. Surprising, to me, as I had been following discussions leading up to the meeting, DOA/DONA did not specifically get added to the acts of the ITU Plenipotentiary. The epistemic community

striving to keep the Internet as a bottom-up-phenomenon wanted IETF and ICANN added formally to the acts of the ITU Plenipotentiary as organizations to interact with, while others wanted DOA/DONA added, and in the end nothing got added. Adding IETF and ICANN would entail that the ITU should consider the opinions of ICANN and IETF on matters which concern the Internet. Since neither organization is part of the main text of the acts (but they are in the footnotes, see ITU, 2018), in a bureaucratic thought style sense the ITU does not have to liaise or communicate with either IETF or ICANN.

The delegate further explained that the working group for those particular documents could not agree on a final form in terms of which organizations to explicitly mention, which meant that none were suggested to the plenary session. The formulation work at ITU Plenipotentiary meetings takes place in working groups, and these working groups suggest formulations and documents which the plenary session later votes on. Specifically Resolution 101 (“Internet Protocol-based networks”) and Resolution 102 (“ITU’s role with regard to international public policy issues pertaining to the Internet and the management of Internet resources, including domain names and addresses”), final version is available as ITU (2018), were of importance to “ITU Delegate (1)”, and according to the delegate also to the rest of the Internet epistemic community.

However, if the plenary session had brought it up to a vote, the proponents of DOA/DONA are likely to have been in the majority according to “ITU Delegate (1)”. This ITU Plenipotentiary case then illustrates failed bureaucratic thought style logic since the presumed will of the majority was not followed.

Regarding social resilience, the ITU Plenipotentiary can call for ITR-meetings which can suggest International Telecommunications Regulations, treaties which have to be ratified by nation-states themselves before they come into effect. This is not a powerful way to force change. As illustrated in Section 7.5, the *WCIT* 2012 International Telecommunications Regulations have only been ratified by a few nation-states. “ITU Delegate (1)” reasons that when it became clear that the USA and Western Europe were not going to ratify the treaty, many nation-states who had voted for it reasoned that it was not worth the effort to ratify.

New IP and the handle-system

Seen from the interoperability thought style **Internet Protocols (IPs)** (including **IPv4** and **IPv6**) are exquisite, they do one thing (address one-off packets) really well. If transmission control is needed, such as resending dropped packets, it is possible to use **Transmission Control Protocol (TCP)** on top of IP. This is all in line with **separation of concerns**, and the network is vertically separated. Similarly, the naming system of the Internet, DNS, also only does one thing.

There is another way, which used to be the common way, to build networks. That is to vertically integrate them, so that one actor controls the entire stack in one area of the network. This follows the norms of **integration of concerns** technically. Examples include traditional telephony and the telegraph.

A current more bureaucratic thought style vertical example is future vertical communications network, of which “**new IP**” can be seen as a member, where the network itself is concerned with the traffic on top of it (see, for example, Jiang et al., 2019; Lehman, 2020; Li, 2020; Mueller, 2020 etc). “new IP” is not particularly well specified, which is by intention according to “ITU Delegate (1)”, so that negotiations can take place, and it is not possible to technically evaluate the merits of “new IP” yet.

“ITU Delegate (1)” and “RIR (1)” argue that there is an intent behind “new IP” to upset the current IP-based world order in digital communications, by offering a yet-not-well-defined protocol which offers functionality which is not present in IP, such as shut-off switches and identity provision at a network level⁹.

Where IP follows interoperability thought style logics, “new IP” follows bureaucratic thought style logics primarily, while not breaking with **market thought style** logics. The “new IP” documents are not explicit, but interviewees and interactions with practitioners indicate that the general understanding is that “new IP”-addresses would be delegated through ITU-sanctioned entities.

In the context of naming or handling unique identifiers the last decade has seen an on-and-off focus on DONA and DOA, commonly called the handle-system. DONA is a Swizz foundation legitimized by the ITU as a root for the DOA-system. DONA and DOA concerns the naming of the resources. DOA in itself is not that well-known, however, one of the authorities in the system, **Digital Object Identifier (DOI)**, is quite well-known in academic circles. In technical terms, DOI (or its identifier 10) is much like a **top-level domain (TLD)** in the DNS system.

As an example, 10.1000/182 (the identifier for the DOI handbook) refers to an object within the DOI-“top-domain” (the 10 at the start) of the DOA system, and the object (10.1000/182) has the prefix 10.1000 and the suffix 182. DOIs are most often used in combination with the DNS-system and the **web**, for example prepending a DOI-identifier with <https://doi.org/>, as in <https://doi.org/10.1000/182>, creates a link which can be resolved by a web browser which will take the user to the relevant resource. In technical terms, the web browser uses (through the operating system or on its own) the DNS system to resolve **doi.org**, and then the web browser sends a request to the

⁹Since neither future vertical communications network nor “new IP” is that well-defined, some documents discuss shut-off controls, others discuss identity provision, and so on. Some documentation use future vertical communications network as a new term for “new IP”, and some documentation use future vertical communications network as the broader concept which “new IP” is part of.

host `doi.org` with the request path `10.1000/182` which `doi.org` resolves. Thus, such a link (<https://doi.org/10.1000/182>) is dependent on both DNS and the DOI part of the DOA system¹⁰.

Future vertical communications network, “new IP” and DOA are conceptually a different blend of the values of the interoperability, bureaucratic and market *thought styles* than the current Internet protocols, and conceptual weight is rather put on meaning in the bureaucratic and market thought styles at the expense of separation of concerns. This can be seen as a different form of Internet disruption, one which might lead to an Internet, or a digital communications network with another name, which could be socially disrupted through potential coups at an ITU-level. This since both “new IP” and DOA invest significantly more power in a central authority than IP and DNS.

9.4 Technical error

Here I cover two kinds of technical error, errors caused by software and error caused by humans. With technical error I refer to issues which might affect the technical core of the Internet, such as naming or *numbering*. This section does not cover how the Internet might be used to cause error in other contexts, as, for example, Apostolaki et al. (2018) and Apostolaki et al. (2017) do with the example of using the Internet to disrupt *bitcoin*.

Error caused by software

Most of the root servers use *BIND* (see Wikipedia Contributors, 2017), an open source DNS software for DNS servers. It would be problematic if that software no longer could be trusted. BIND is currently developed by the *Internet Systems Consortium* through an open source process (see description in ISC, 2017), and this process is considered secure enough by many (for example “[the process] is good enough” (“Cryptographic Officer (1)”).

In a pragmatic view, a fault in BIND would allow for issues if not noticed, for example someone could introduce a problem when resolving, for example, websites of (opposing) political parties and rendering sites unreachable through disrupting the name-resolution process. In that sense faults in BIND propagate to the real world. But such a fault if important would soon be noticed and addressed by someone.

With *Domain Name System Security Extensions (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 *Request*

¹⁰The `doi.org` domain only seems to resolve DOI identifiers (i.e., `10.something/something`) and not all identifiers in the DOA address space.

for Comments (RFC)-4033, Arends et al., 2005a, RFC-4034, Arends et al., 2005c, RFC-4035, Arends et al., 2005b, and following updates). 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 (for example, by flipping a random bit, clients would not see the answers as authentic).

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 the Internet Systems Consortium acts as a gate-keeper for the process. Anyone could contribute to BIND, and if it passes the gate-keeping processes of the Internet Systems Consortium the changes would be added to the next version of BIND. I would assume that most DNS-operators, such as the root-zone-operators, do some internal tests before updating production environment. However, it is possible to imagine that a very specifically compromised BIND, one which for example only flips a bit of the DNSSEC response of a host of one political party, could cause quite a ruckus in a local setting until resolved.

Error caused by humans

In an interview 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 no influence on the stability of the Internet, but the potential vulnerability of registry operation to human error was not something the Internet literature prepared me for.

Although human error will not cause long-term 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 (1)")

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 9.1 (pseudo-format). This would work splendidly since they are FQDN in BIND (i.e. with trailing dot), but b in Figure 9.1 would not, because b in Figure 9.1 would be interpreted as c in Figure 9.1 due to lack of trailing dot and BIND would add “.com.” (your domain) to all non-FQDN to turn them into an FQDN.

Figure 9.1: Comparison of zone-file contents
Illustration of zone-file contents in a psuedo-BIND-format to illustrate potential differences and issues caused by miniscule errors.

(a) Correct zone file, including trailing dot	(b) Faulty zone file, missing trailing dot	(c) Expanded zone file, missing dot
aaa.com. [...]	aaa.com [...]	aaa.com.com. [...]
abc.com. [...]	abc.com [...]	abc.com.com. [...]
[...]	[...]	[...]

In essence, a missing dot could break the Internet, or the technically correct version, break the DNS-system if introduced to the root-zone or any other domain if introduced in their zone-files.

Denial of Service

On the technical and market level issues, such as Internet-of-Things (IoT) and Best Current Practice (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). In for example IoT dependent smart cities and smart societies, a lack of Internet-function would prevent essential services from working.

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 the value creation versus value capture argument. 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? A contrary opinion I found on BCP-38 can be illustrated with the following quote:

I think it is necessary to regulate, or at least use strong policy, to ensure adherence [to BCP-38] (“ccTLD (1)”)

Note that “ccTLD (1)” is in essentially every other aspect averse to regulation and state level interference in Internet-level matters, but for the particular case of BCP-38 argues that regulation might be needed. The reason for this is that 20 years have passed since the publishing of BCP-38, but due to widespread non-implementation there is still a considerable threat from

distributed denial of service (DDoS). This is an illustration of a practical compromise between thought styles.

9.5 Chapter summary

In its simplest form, i.e., as a means of end to end digital communication, the Internet is quite resilient.

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 Internet Corporation for Assigned Names and Numbers (ICANN) have changed from being just containing coordinating in its mission (see ICANN, 2016b) and later dropped the explicitness for coordination and rather focus on ensuring a stable Internet function and collaboration with other entities (see ICANN, 2016a). Note that if the Internet, is considered to be the possibility of end-to-end communication using standards agreed upon by the users, it stops being the Internet as soon as it is regulated rather than coordinated.

The reason for the Internet's basic resilience to manipulation is that coordination is based on mutual acknowledgments, i.e., that power in some sense only exists if recognized, by those who that power is to affect. No central authority exists, and if malicious actors appear, they can be ignored if their maliciousness is recognized (that is, instead of a judicial system which punishes bad actors on behalf of the governed, the informed populace should rather just ignore the bad actors).

Neither BIND nor other Internet infrastructure-essential software, although reasonably resilient, should be considered non-problematic since it might be possible to manipulate the software to serve someone's purposes. However, because of the number of independent actors engaged in maintaining and using the software, I find it unlikely that it, through error or manipulation could cause major, lasting disruption or alterations to the character of the Internet.

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. Mission disruption is possible by external pressure since the intrinsic values can change over time, but the present processes for affecting the Internet via the ITU make notable changes difficult to achieve.

10 Packet neutrality by the thought styles

Net neutrality is the concept of whether the user is in charge or not

— Interviewee

This chapter concerns the topic of **net neutrality** from the three **thought styles**; the **interoperability thought style** (from which net neutrality is a necessary consequence of good design), the **bureaucratic thought style** (from which net neutrality could be a good design, if, for example, equal access is a concern), and the **market thought style** (where actors who are **infrastructure and network operators** can view net neutrality as negative because it and breaks value capture and differentiation opportunities, while actors at the **edges** may appreciate net neutrality for neutralizing the risk of such differentiation-based operator value capture).

Compared with contemporary literature (for example Bartels, 2018; Choi et al., 2015; Choi and Kim, 2010; Economides and Hermalin, 2012) this chapter has a novel approach to net neutrality and frames it not as primarily an economic issue, but rather as view a from the perspectives introduced in this thesis that depending on perspective have economic or other concerns as the foreground.

By doing this I discuss and challenge notions behind net neutrality. For example, I show that net neutrality is reasonably not only framed as an economic issue (for example Choi et al., 2015; Choi and Kim, 2010; Economides and Hermalin, 2012; Economides and Tåg, 2012), nor is it only reasonably

framed as only an **implementation of technology** issue (for example Garrett et al., 2018; Li et al., 2017). Just as I argue that the **Internet** is complex and should be viewed from (at least) three thought styles, so should net neutrality.

This chapter suggests to view net neutrality as:

*traffic perceived as de facto treated according to agreed standards
absent potential technical harm to networks or their users*

Using this description, net neutrality can be seen as the political side of the notion that the edge should be in control. A lack of net neutrality would imply that the users are 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, for example, business or political reasons. 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 to not have net neutrality even under net neutrality-specific regulation.

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. By this description, throttling of traffic in such a way it does not cause a noticeable downgrade in resolution or quality is not an issue, or shaping of traffic without real-time requirements, such as background up- and downloads. *Agreed standards* refers to the common understanding, set through some process, where users have agreed on how a standard should work.

The last part of the description, *absent potential technical harm to networks or their users*, refers to the exceptions to the rule where traffic can be modified or dropped. This to catch, for example, **distributed denial of service (DDoS)** which can be noticed by the large amounts of traffic, while not including harm from packet contents, from for example cyberattacks, which would require network operators to inspect all traffic.

The rest of the chapter includes, first, an introduction to concepts used. This is followed an overview for non-specialists of net neutrality at an individual level. Then I go through one **website** in detail to illustrate empirically how the Internet *de facto* is used, followed by a large set of websites in less depth. This is followed by a discussion based on empirical data provided in this chapter, as well as literature and interviews. The chapter ends with a short summary of what net neutrality can be seen as from the interoperability, bureaucratic and market thought styles.

This chapter suggests that the important issue is not net neutrality vs net non-neutrality in the regulatory sense, and instead suggests that regulation is a problem to net neutrality given the current coordination of the Internet.

The epigraph is from an interviewee who argued that net neutrality is more than just a regulatory issue, but also fundamentally a question of whether the edge-user or the network itself is in control. This conflict returns throughout this chapter, where the interoperability thought style argues that the edge-user should be in control due to an interoperable design of the network, the bureaucratic thought style that the proper net neutrality stance depends on the policy on the issue, and for the actors of the market thought style the stance depends on who they are.

10.1 A practical problematization of net neutrality

Recently in what can be seen as a step against practical net neutrality, the USA 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 United States regulation. There are texts, such as Coldeway (2017) and Electronic Frontier Foundation (2017), which argue that this reclassification does not make sense. I will in this chapter illustrate the empirical nature of website Internet use.

An example of a current net neutrality implementation in the USA is the following, where the treatment of traffic becomes dependent on who the user is:

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 other private Internet users, through home and mobile Internet providers, rather than on firms or other organizations interacting with each other, rather than with consumers. The legislation is thus not user agnostic (which is against the notions of the interoperability thought style). However, the potential difference between inter-company and company-resident or resident-resident traffic implied in this legislation is difficult to implement. There are suggested protocol suites, such as **future vertical communications network**, in which such a differentiation between commercial and private traffic is possible. However, there is no simple way to distinguish the type of traffic contained in an **Internet Protocol (IP)**-packet, and even less simple with protocols such as **QUIC**.

10.2 Net neutrality in practice

Section 5.3 presented net neutrality literature to help illustrate differences between thought styles. This section introduces net neutrality from a technical

perspective, aimed at non-specialists. This serves to present net neutrality as an issue with practical consequences, rather than to just discuss net neutrality in theory.

In most Western countries net neutrality is the norm, and my experience from asking people is that many have not considered an Internet without net neutrality, but from time to time the concept has been challenged. In the EU net neutrality is guarded by regulation (by EU directives and implementation guidelines, see BEREC, 2020 and often in national law, as in Sweden). In the USA net neutrality has never been in federal law, but net neutrality has been under the supervision of the **Federal Communications Commission**, who from early 2015 until late 2017 had rules with regard to net neutrality and there is some state legislation protecting net neutrality.

As a practical example of consequences of net neutrality, according to Seward (2014, a journalistic article), who hints at being an inside source, and corroborated by other sources such as Morran (2014), Comcast started to slow down, or shape, Netflix's traffic in 2013 into the Comcast network. Netflix in turn up- and downgrades video quality to properly match actual throughput, with the effect that the shaped traffic resulted in lower quality. In March 2014 Netflix signed a deal to pay Comcast for not slowing down traffic (see Morran, 2014; Seward, 2014), which makes perfect sense in the market thought style.

Netflix supposedly have similar arrangements in place with Time Warner Company, AT&T and Verizon. This means Netflix pays the network operator to not intentionally slow down their traffic, which is supported by Seward (2014) and Erickson (2014), both journalistic texts. These commercial agreements run counter to the interoperability thought style where the network should be interoperable and not differentiate traffic.

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 **Internet Service Providers (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 USA at a federal level but enforced in several states based on state law.

Net neutrality violations are said to affect one in five Internet users in Europe (Berec & European Commission, 2012; Karr, 2017), and in particular common for services such as VoIP, P2P and gaming. Karr (2017), in a journalistic overview, presents a comprehensive list of mostly USA-centered net neutrality violations, and proposes that the same behavior could be considered normal in a Western context. Molavi Kakhki et al. (2015), an academic text, backs up Karr (2017) for all the services measured in Molavi Kakhki et al. (2015). According to Flach et al. (2016) around 7 % of Internet connections are affected by policies negatively affecting traffic. Technical literature, in general, seems to discuss different forms of differentiation and practices

behind them (for example Garrett et al., 2018) or how to avoid classification or differentiation of traffic (such as Li et al., 2017).

My personal experience is that violations of net neutrality occur much more frequently on cellular connections than for wired access. As an example, I often unscientifically experiment with YouTube on a computer and a cellphone with a hotspot during travels (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 10.1. In the table “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 (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 a website in full to my computer. My cellphone contract does not specify any clause regulating different throughput for different services, either at home or abroad. “Throughput” is relative, either as expected or lower than expected, and measured as the raw data throughput on my computer.

Table 10.1: Net neutrality and cellular throughput

Evidence from personal experimentation with hotspots and tunneling during travels. Selection of illustrative results. Illustrative of net neutrality infringements which technically can be illegal, but not illegitimate since the behavior in most cases does not affect the user. See Table 4.1 for distinction between illegitimate and illegal.

Connection	Service	Throughput
Cellular	website	As expected
Cellular	YouTube	Lower than expected
Wired	website	As expected
Wired	YouTube	As expected
Cellular + VPN	website	As expected
Cellular + VPN	YouTube	As expected

The table shows that 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 throughput depending on application, i.e., YouTube gets throttled. If I enable a VPN-client, the YouTube stream is not throttled anymore, presumably since the ISP can no longer distinguish the traffic. 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.

Technically I test with running a wireguard-tunnel to my personal server which sits on a high throughput connection in Sweden. The worst infringement I have measured was while sitting on an ICE-train in semi-rural Germany using cellular, where enabling my tunnel increased my YouTube throughput by a factor of 15 (!).

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, and possible ways to avoid them.

Congestion can be expected to be a larger problem for cellular traffic than for wired. Differentiating between traffic based on practices that can be expected to not impair the experience of those subjected to throughput decrease can allow an ISP to provide more users with an acceptable experience when total throughput becomes a bottleneck. 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 (and from the ISP's perspective it is impossible to distinguish if I am watching on my phone or on a computer using my phone as a hotspot). 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 infringement¹.

These examples are of last-mile throttling or blocking. Technically it is possible to throttle or congest traffic in transit as well, i.e., between networks of the Internet when transferring data over long distances.

As an example of long distance throttling; a couple of years ago when I was working as a software engineer, I needed some data transferred to my laptop when I was travelling in the USA. The data needed was roughly 30 GiB in size and stored at our server location in Sweden. Fetching the data directly (with either SFTP or HTTPS) gave me throughput 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) data to Google-drive from the server, and then downloading it from Google-drive to my laptop in the USA. By doing this I averaged upwards of 1 Gbit/s upload to Google's servers, and a download of closer to 100 Mbit/s at the hotel (presumably limited by the hotel Wi-Fi and Internet access). Ergo I could by using the parallel (transit) network of Google transfer my data 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. This type of congestion remains untouched in non-technical literature². This is also part of the reason organizations

¹The 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 10.1.

²I find literature on the modelled economics of interconnection, but as noted in Chapter 8 I have found no literature with empirical backing of actual agreements and differentiation in place for transit networks.

transfer large amounts of data with services such as the AWS Snowmobile³, which literally is a large truck full of drives, since transferring data over the Internet is too time-consuming for large amounts of data.

Never underestimate the bandwidth of a station wagon full of tapes
hurtling down the highway. Tanenbaum, 1996, p. 83

Previous examples have been centered around throttling throughput, in practice often limiting quality for video-streams, but there are other ways to infringe on net neutrality, such as blocking traffic entirely, delaying traffic or setting data caps, which I will discuss further.

As an example, Tesla cars currently regularly communicate with central servers to both upload and download significant amounts of data (such as diagnostic data and firmware). Tesla cars were 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). This means that their business model is based on a working Internet connection without caps. With a repeal of net neutrality, ISPs might charge differently for packets to and from different destinations, and set traffic-specific data caps, such business models would be hampered. In the Tesla 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.

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. Surprisingly, even high level managers for firms selling cloud services lack good answers. Cloud service providers are dependent on that reaching the cloud (somebody else's computer), is not more complicated than reaching an in-house server in your own firm, as it probably would be if agreements were needed to reach the cloud provider.

Internet-of-Things (IoT) is yet an example of where present expectations regarding the future could be affected by the presence or absence of net neutrality. Not all IoT devices are dependent on high throughput and low latency, but still add significant value to the owners or users, value which network operators might be inclined to capture part of in a net non-neutrality world.

10.3 One website in detail

This section goes through one website in detail to provide an overview of how the Internet is used in practice. In particular by a website. This example illustrates the large set of actors involved in a task such as providing a website experience to a user, actors who are mostly for-profit and would be affected by different net neutrality regimes.

³See <https://aws.amazon.com/snowmobile>

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 Figures 10.1 to 10.4. I have developed the engine used to draw the graphs over the years, so the later graphs are significantly richer in detail than the older graphs. The later graphs are also vector based, so they can be “zoomed into” in a PDF-reader. The method is described in Chapter 2, Section 2.8.

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. I focus on two types of visits, one with a default browser with no filtering or other blocking, and a setup where I filter requests by means of common ad-blocking tools.

The results are shown in Table 10.2. 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 traversed over three times as many networks (**Autonomous Systems (ASs)**) as the filtering setup (lines three and four).

The table illustrates two sets of runs, one in 2018 and one in 2020. In those two years the front page more than doubled in size (13 MB to 30 MB), but decreased on hosts used, presumably due to a smaller number of actors paying for front-page ads. Similarly, when loading two articles the 2020 visit is 60 MB, and the 2018 visit 38 MB. Comparably the filtering visits are quite similar between 2018 and 2020. Note, however, that the 2020 visit is using the year 2020 version of the filtering tools, which are likely to have become better over the years.

Browsing the front page and two articles in 2018 and 2020 is illustrated in Figures 10.1 to 10.4. As can be seen, a vast array of hosts and networks are used when browsing without intentional blocking and filtering on the client side. In this particular case around 24 hosts are necessary for loading the “core”-page in 2018, and around 8 in 2020.

Figures 10.1 to 10.4 use the same coloring schema: a yellow node represents the starting host (the computer running the script), 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 (lines) between ASs (red nodes) represent some kind of IXP, 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 when looking at the graphs.

Table 10.2: Front-page and articles of news site

Varying front page reading two articles with and without filtering for www.dn.se. Manual webpage interaction.

Year	Pages	Filtering	MB	Hosts	ASs
2018	front page		13	140	53
2020	front page		30	103	50
2018	front page	AGP	5.6	24	21
2020	front page	AGP	3.5	8	6
2018	front page and two articles		38	189	67
2020	front page and two articles		60	184	56
2018	front page and two articles	AGP	9.5	29	19
2020	front page and two articles	AGP	9.6	21	6
Adblock, Ghostery, Pi-hole					

In Tables 10.3 to 10.5 I list all ASs 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 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 instead 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

Figure 10.1: News site, unfiltered, 2018

Graph for an unfiltered visit to a news agency, www.dn.se, including reading two articles in 2018. Note that light-blue circles represent individual hosts and the blue clouds are large collections of these hosts. None of the big clouds are under control of the news agency, they all belong to the ad-ecology to some extent. The red circles are ASs. The yellow circle represent the client (the computer running the script). The “Ads”-labels represent manually identified collections of hosts which serve ads. Manual webpage interaction.

of highways and longer connections. Both CDNs and players in the ad ecology try to be as close to the highways as possible.

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 participat-

Figure 10.2: News site, unfiltered, 2020

Graph for an *unfiltered* visit to a news agency, www.dn.se, including reading two articles in 2020. Circles represent entities of the network, and the diamonds are classification labels. Blue blobs represent individual hosts and the blue clouds are large collections of these hosts. None of the big clouds are under control of the news agency, they all belong to the ad-ecology to some extent. The light blue circles represent hosts which were not possible to trace fully. Orange and red-toned circles represent ASs. Includes registered country (green diamonds), as per [ISO-3166-1](#), and a human-readable name of some ASs (purple diamond). Uses an updated graph-engine compared to the graphs from 2018. Vector based image which can be zoomed into. Manual webpage interaction.

Figure 10.3: News site, filtered, 2018

Graph for a *filtered* (i.e., ad-blocking and aggressive **Domain Name System (DNS)**-blocking) visit to a news agency, www.dn.se, including reading two articles in 2018. Blue blobs represent individual hosts and the blue clouds are large collections of these hosts. None of the big clouds are under control of the news agency, they all belong to the ad-ecology to some extent. The red nodes represent ASs. The edges represent connections between ASs, which often is an **Internet Exchange Point (IXP)**. Note that compared to Figure 10.1 much fewer hosts and networks are used, since ad providers are blocked. Manual webpage interaction.

ing in the ad bidding process, but rather just contain the ads themselves and serve them when needed.

Also, as previously mentioned, playing a large role selecting resources for the website to show are real time bidding actors⁴ which broadly can be categorized as an automated (i.e., algorithm and data driven) aggregated buy side and an automated aggregated sell side. When a user visits an ad sponsored website the user sends meta-data (such as IP-address, location (Rich neighborhood? Poor neighborhood? Country? Ice-hockey-interested suburb?), resolution, cookies among others⁵) and then the sell side with the help of that meta-information holds an auction through a trading platform where

⁴See previous argumentation and for example Stange and Funk (2014) and Yuan et al. (2013) for a more detailed overview of these actors and processes.

⁵The interested reader might want to have a look at <https://panopticlick.eff.org>, a service which shows identifiable information in browsers.

Figure 10.4: News site, filtered, 2020

Graph for a *filtered* (i.e., ad-blocking and aggressive DNS-blocking) visit to a news agency, www.dn.se, in 2020. Circles represent entities of the network, and the diamonds are classification labels. Blue circles represent individual hosts. The light blue circles represent hosts which were not possible to trace fully. Orange and red-toned circles represent ASes. Includes registered country (green diamonds), as per ISO-3166-1, and a human-readable name of some ASs (purple diamond). Uses an updated graph-engine compared to the graphs from 2018. A vector based image which can be zoomed into. Note that compared to Figure 10.2 much fewer hosts and networks are used, since ad providers are blocked. Manual webpage interaction.

Table 10.3: Autonomous Systems visited, transit
ASs (transit and unknowns) visited to properly display www.dn.se. ASs involved as transit networks, that is propagating packets rather than containing servers which contain parts of the website.

Transit	
ASN	AS owner
174	COGENT-174, USA
1299	TELIANET Telia Carrier, SE
1653	SUNET, SE
2603	NORDUNET, NO
2843	LIUNET, SE
3356	LEVEL3 — Level 3 Parent, LLC, USA
5588	GTSCE GTS Central Europe, CZ
12552	IPO-EU, SE

the winner is the buy side ad-owner or ad-aggregator willing to pay the most to show the user the ad. There is an entirely automated ecology surrounding online advertisements.

All of Tables 10.3 and 10.4 and Figure 10.1 are based on the unfiltered version of the website. Table 10.4 contains 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 10.3 and Table 10.4 for a better table fit, as some AS-names are quite technical in their nature.

A visit to www.dn.se requires data from networks owned by Facebook, Twitter, Microsoft, Akamai, Amazon and Google, to name a few. The differences between Figures 10.1 and 10.3 is the result of the use of an ad-blocker, which drastically lowers the amount of needed hosts (as shown in Table 10.2).

Figures 10.1 to 10.4 are not meant to be analytically useful, but rather are meant to serve as illustrations of the amount of different networks and hosts contacted for the simple task of opening a webpage on a client computer. Visiting a website is by all accounts a bit more complicated than most 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

Table 10.4: Autonomous Systems visited, CDNs

All the **Content Delivery Networks (CDNs)** visited to properly display **dn.se**. These ASs are commonly known as Content Delivery Networks, and can roughly be considered data repositories.

ASN	AS owner
8523	BASEFARM-SE-ASN, SE
12516	WEBORAMA, FR
13335	CLOUDFLARENET, USA
14061	DIGITALOCEAN-ASN, LLC, USA
15133	EDGECAST - MCI, USA
15830	TELECITY-LON, GB
16245	NGDC, DK
16276	OVH, FR
16625	AKAMAI-AS, Inc., USA
20940	AKAMAI-ASN1, USA
24940	HETZNER-AS, DE
24961	MYLOC-AS, DE
27357	RACKSPACE, USA
29791	VOXEL-DOT-NET, USA
29990	ASN-APPNEXUS - AppNexus, Inc, USA
30633	LEASEWEB-USA-WDC-01, USA
35220	SPOTX-AMS, NL
42622	DCSTO-AS, SE
42695	CNHAB, SE
43948	GLESYS-AS, SE
48173	UNBELIEVABLE-AS, DE
53340	FIBERHUB - VegasNAP, LLC, USA
54104	AS-STACKPATH - netDNA, USA
54113	FASTLY - Fastly, USA
56396	TURN, GB
57367	ECO-ATMAN-PL ECO-ATMAN-, PL
60068	CDN77, GB
197541	VIDEOPLAZA-AS, SE
197595	OBENETWORK, SE
201979	TAPAD-AM1, NL

Table 10.5: Autonomous Systems visited, ad-ecology
AS:es (ads and similar) visited to properly display www.dn.se. These ASs seem to contain components of the ad-bidding and -selling ecology. While the Content Delivery Networks contains content, these ASs seem to contain the logics which decide which content to show to each specific user and visit.

Ads and tracking	
ASN	AS owner
8068	Microsoft Corporation, USA
8075	Microsoft Corporation, USA
13414	TWITTER - Twitter Inc., USA
14618	AMAZON-AES - Amazon.com, Inc., USA
15169	GOOGLE - Google LLC, USA
16509	AMAZON-02 - Amazon.com, Inc., USA
18568	BIDTELLECT - Bidtellect Inc., USA
25751	VALUECLICK - Conversant, Inc., USA
26667	RUBICONPROJECT, USA
30419	MEDIAMATH-INC - MediaMath Inc, USA
32934	FACEBOOK - Facebook, Inc., USA
33419	TRIBAL-FUSION, USA
34010	YAHOO-IRD, GB
44788	ASN-CRITEO-EUROPE, FR
62713	AS-PUBMATIC - PubMatic, Inc., USA
198622	ADFORM, DK

became infected back in 2017 (see Goodin, 2017) with a JavaScript snippet that used the visiting computer’s 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 interoperability thought style solution of users (or even ISPs) using software to block malicious hosts and content, and the bureaucratic thought style 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 DNS names 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 website, but the Internet does not decide what to show in a specific website. The website itself decides what to show, and can in turn outsource components to other services, such as ad-services. This is in line with the “Title II Common Carrier”-definition of the Communications Act.

(11) Common Carrier

The term “common carrier” or “carrier” means any person engaged as a common carrier for hire, in interstate or foreign communication by wire or radio or interstate or foreign radio transmission of energy
Communications Act, § 153 — Definitions

However, the Communications Act does not mention ISPs directly, or AS-operators for that matter, which means that the Federal Communications Commission can designate which classification ISPs belong to. The Information Service definition is much wider, and its provisions does not regulate or limit in the same sense as the Common Carrier provisions.

(24) Information Service

The term “information service” means the offering of a capability for generating, acquiring, storing, transforming, processing, retrieving, utilizing, or making available information via telecommunications
Communications Act, § 153 — Definitions

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](https://www.google.com)). I have not shown that all Internet services are as distributed as news websites, but rather illustrated the complexity of how the Internet is de facto used by the web.

10.4 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 to demonstrate that [dn.se](https://www.dn.se) is not unique among news websites, and that complexity is not specific to news websites.

For website selection, I used the Alexa website ranking for the ten thousand most popular hosts, ran the scripts which provide the images in Section 10.3 and Tables 10.6 to 10.8 for all of these hosts. I looked at the results, cleaned it from duplicates (example: I merged [google.com](https://www.google.com), [google.jp](https://www.google.jp),

google.se, google.dk etc into google.com which are all Google), and then in the interest of reducing the number of hosts manageable number, made a selection for the tables in this section.

In the end, I had the websites presented in Table 10.6 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. Amazon and DealExtreme (dx.com) were kept as examples of online stores, Twitch as an example of a streaming site and Reddit because of its popularity as an Internet forum. I kept LiveJasmin (livejasmin.com) as an example of pornographic content. I also kept Wikipedia as an example of a webpage run by a non-profit.

Both Table 10.6 and Table 10.7 contain data collected by visiting several websites over a period of a week. The first column in Table 10.6 and Table 10.7 is the host, 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, ASs, are the number of ASs we need to visit to fully load the page, an approximation of the number of network owners involved to load the page fully⁶. In the fifth and final column, ASs 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.

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.

The point of these tables it to show that looking at the Internet as a content provider delivering a service to a content consumer over one discrete pipe or “a series of tubes” is quite a simplification. The complexity of regulating the whole becomes greater. The current net neutrality 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 10.2, 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 10.6 and Table 10.7 then? As can be seen in the tables, those websites affected the most by DNS-based ad-blocking are news sites, which have a greater reliance on ad revenues. 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 the interoperability thought style, 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,

⁶Important to note that this refers to infrastructure operators rather than server operators.

Table 10.6: Set of websites, unfiltered

Data for hosts queried and resources used *without* filtering. Average values rounded to integer. Columns represent **H**ypertext **T**ransfer **P**rotocol (**HTTP**)-requests made, hosts queries, ASs with resources visited, and ASs r includes those ASs which were only used for transit. Automated browser control.

<i>News</i>	Requests	Hosts	ASs	ASs r
nytimes.com	512	113	28	33
washingtonpost.com	74	5	4	9
theguardian.com	273	71	20	27
thesun.co.uk	497	157	47	59
svd.se	228	60	19	25
dn.se	516	140	43	53
spiegel.de	381	69	16	23
sueddeutsche.de	143	42	16	26
tribunnews.com	586	130	39	52
<i>Search / Social</i>	Requests	Hosts	ASs	ASs r
google.com	17	6	1	5
yahoo.com	337	62	29	41
reddit.com	203	62	20	30
facebook.com	40	2	1	5
<i>Retail</i>	Requests	Hosts	ASs	ASs r
amazon.com	329	36	13	19
amazon.de	323	33	12	17
dx.com	252	27	7	12
<i>Other</i>	Requests	Hosts	ASs	ASs r
twitch.tv	177	40	8	14
livejasmin.com	58	19	4	9
wikipedia.org	8	2	1	3

Table 10.7: Set of websites, filtered

Data for hosts queried and resources used *with* filtering. Same hosts as Table 10.6 but with filtering. Note the drop in numbers. Average values rounded to integer. Columns represent HTTP-requests made, hosts queries, ASs with resources visited, and ASs r includes those ASs which were only used for transit. Automated browser control.

<i>News</i>	Requests	Hosts	ASs	ASs r
nytimes.com	269	63	19	20
washingtonpost.com	71	4	3	5
theguardian.com	163	28	8	11
thesun.co.uk	160	47	16	22
svd.se	174	39	12	16
dn.se	157	51	20	26
spiegel.de	177	28	8	11
sueddeutsche.de	95	25	12	18
tribunnews.com	151	27	9	16
<i>Search / Social</i>	Requests	Hosts	ASs	ASs r
google.com	17	6	1	2
yahoo.com	193	31	15	23
reddit.com	89	22	6	11
facebook.com	41	2	1	4
<i>Retail</i>	Requests	Hosts	ASs	ASs r
amazon.com	334	16	4	9
amazon.de	289	9	3	7
dx.com	236	19	5	8
<i>Other</i>	Requests	Hosts	ASs	ASs r
twitch.tv	158	30	6	10
livejasmin.com	42	13	2	4
wikipedia.org	8	2	1	2

even though that might entail problem for ad-financed websites. The natural solution for such websites is to block ad-blocking users. In the market thought style this behavior is a bit more contentious, as this would be similar to programmatically skipping the ads on a cable-TV show.

In terms of hosts and requests Washington Post (washingtonpost.com) stands out, where the unfiltered visit on average contact less than 5 % of the hosts than a comparable visit to New York Times (nytimes.com).

Search and social are according to expectations, where the sign-in page of Facebook (facebook.com) and the start-page of Google search (google.com) are resource light as they do not use many other resources. Comparably, Yahoo (yahoo.com) and Reddit (reddit.com), which are partly ad-financed, use a significantly higher number of hosts and networks. Google search, Facebook and Wikipedia stood out since they had all their resources in one network (AS).

The retail sites surprised me; I expected them to be quite resource heavy (many requests) but to have all resources within an AS or two. This indicates that even more specialized sites, such as Amazon, use the interoperable nature of the Internet.

Twitch (twitch.com, a streaming site) and LiveJasmin (livejasmin.com, an adult streaming site) show different use of networks, mostly due to the fact that LiveJasmin is behind a paywall.

Table 10.8 shows the total number of unique hosts and ASs used for visiting the page during a week. The reason this is different from Table 10.6 is that many websites 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 visitors' browsing history through the use of cookies.

This is the reason that TribunNews (tribunnews.com) visits around 130 hosts and 40 networks per visit, but in total sent me to closer to 400 different hosts over several visits. The differences in visited hosts and ASs in Tables 10.6 and 10.8 is larger for ad-financed websites. Both TribunNews and The Sun stood out in the ten thousand first entries of the Alexa-ranking with their large number of hosts and networks needed.

Table 10.8 illustrates that out of all visited webpages, only the sign-in page of Facebook, the search page of Google, and the front page of Wikipedia can accurately be described as a content provider and content producer relationship. Figure 10.5 is an illustration of all hosts and networks visited after browsing the first hundred websites of the Alexa ranking. The figure contains 2045 hosts and a couple of hundred ASs. If read in a PDF-reader it is possible to zoom into the figure and read the labels⁷.

⁷The image is also available at <https://github.com/flindeberg/internet-tools/tree/master/resources> along with some more illustrative graphs.

Table 10.8: Set of websites, complete data-set

The complete sets of hosts in Table 10.6 and Table 10.7 visited in total. The unique set of hosts and ASs. Columns represent HTTP-requests made (N/A), hosts queries, ASs with resources visited, and ASs r includes those ASs which were only used for transit.

<i>News</i>	Requests	Hosts	ASs	ASs r
nytimes.com	N/A	155	44	56
washingtonpost.com	N/A	32	6	12
theguardian.com	N/A	205	38	50
thesun.co.uk	N/A	360	79	97
svd.se	N/A	103	27	37
dn.se	N/A	295	68	89
spiegel.de	N/A	179	36	50
sueddeutsche.de	N/A	48	19	30
tribunnews.com	N/A	394	70	90
<i>Search / Social</i>	Requests	Hosts	ASs	ASs r
google.com	N/A	8	1	5
yahoo.com	N/A	177	56	75
reddit.com	N/A	157	47	61
facebook.com	N/A	3	1	5
<i>Retail</i>	Requests	Hosts	ASs	ASs r
amazon.com	N/A	37	14	20
amazon.de	N/A	35	13	18
dx.com	N/A	122	9	21
<i>Other</i>	Requests	Hosts	ASs	ASs r
twitch.tv	N/A	58	11	18
livejasmin.com	N/A	21	4	9
wikipedia.org	N/A	2	1	3

Figure 10.5: Alexa ranking, top 100, unfiltered, 2021

Graph for an *unfiltered* visit to the Alexa-ranking top hundred domains. Circles represent entities of the network, and the diamonds are classification labels. Blue blobs represent individual hosts and the blue clouds are large collections of these hosts. The light blue circles represent hosts which were not possible to trace fully. Orange and red-toned circles represent ASs. Includes registered country (green diamonds), as per ISO-3166-1, and a human-readable name of some ASs (purple diamond). Vector based image which can be zoomed into. Automated webpage interaction.

More than half the hosts in the figure are present in ASs registered in either the USA or China. The owners of the most used ASs are Google, Cloudflare, Amazon, and Quantil Networks (subsidiary of Wangsu Science & Technology, a Chinese firm). Lehr et al. (2019) and Stocker et al. (2020) argue for a centralization of content to a small amount of large CDNs, which is visible in the figure. Many of the hosts with advertisements serve ads to multiple websites in Figure 10.5, this explains why the host-to-website ratio is 20:1 in the figure, while it is 100:1 or so in Tables 10.6 to 10.8.

10.5 Four zones in more detail

The previous sections focused on actual websites and their Internet use. This section goes over a set of zone-files in detail to provide a different perspective on the borderless and dynamic nature of the Internet. There are, in essence, four publicly available zone-files representing **country code top-level domains (ccTLDs)**: the dot-ch, dot-ee, dot-nu and dot-se zones.

Most **top-level domains (TLDs)** only allow access to their contents through individual queries, that is you might ask the top domain operators “What is the IP for cisco.com” but not “Give me all dot-com-addresses”. You might, though, ask “Give me all the dot-se-addresses”⁸ since the policy of the **Swedish Internet Foundation** is to provide the zone-file.

According to “DNS-Expert (1)” the primary reason that most top-level domains have not made their zones open is that most top-level domains do not differentiate between registered (i.e., someone owning a domain) and delegated domains (i.e., technically present in the zone-file). This means that it is not possible to defensively register a domain, for example an upcoming trademark, without the registration being visible in the zone-file. To solve this the se- and nu-zones allow registrations which are not delegated, i.e., registrations which are not visible in the zone-file. I assume the ch- and ee-zone administrators have a similar solution in place.

The se-zone file, which is delegated to the Swedish Internet Foundation, contains around 9 million records in total. Each registered domain has several DNS-records, and there are around 1.5 million unique domains in the se-zone.

Every one of these domains has at least one authoritative name server (one name server can technically serve many domains). These authoritative name servers in turn resolve to around 160 000 unique IP addresses spread over around 4500 ASs registered in 96 regions (as specified by ISO 3166-1). Table 10.9 illustrates similar data for four zones.

All in all, the se-zone, the ccTLD for the Swedish country code, is dependent on Internet infrastructure registered in 96 regions (most of them countries) to work as intended, which illustrates the nation state agnostic nature of the Internet. Not only are domains delegated by ccTLDs agnostic of countries represented by their ISO-3166-1s as envisioned by the logics of the interoperability thought style, they are also so in practice.

Compared to larger zones such as dot-com or dot-org, the se-zone is quite small. There are around 150 million dot-com domains⁹.

There is a program for zone-files, Centralized Zone Data Service (CZDS), run by the **Internet Corporation for Assigned Names and Numbers (ICANN)**,

⁸For example `dig @zonedata.iis.se se AXFR` would request the entire se-zone, practically by asking the host `zonedata.iis.se` for an AXFR (complete, and not incremental, zone-transfer) of the se-zone.

⁹The exact number is usually reported by Verisign, the registry for dot-com, at https://www.verisign.com/en_US/channel-resources/domain-registry-products/zone-file/index.xhtml.

Table 10.9: Overview of four zone-files

Data from the publicly available ch-, ee-, nu- and se-zones. Illustrates that a country code connected zone (i.e., a ccTLD) not necessarily is limited to servers and infrastructure in the country representing that country code.

Zone	Domains	Auth NSs	ASs	CCs	Top AS country codes
ch.	2 222 501	45 279	4175	95	CH, DE, US, FR, NL
ee.	137 033	28 162	2005	73	EE, US, NL, FI, DE
nu.	252 309	61 454	2386	78	SE, US, NL, DK, DE
se.	1 493 434	162 229	4531	96	SE, US, DK, DE, NO
Σ	4 105 277	234 394	6670	112	SE, CH, US, DE, DK
root	1499	3483	423	161	US, GB, IE, CN, DE

Country codes as specified in ISO 3166-1. Domains show unique domains. Auth NSs for authoritative name servers identified by unique IP. ASs for autonomous systems. CCs for country codes. Top country codes are the five most common registration country codes for the originating autonomous systems for the prefixes of the authoritative name servers. “root” refers to the root-zone, of which the top-level domains are domains. Σ refers to the sum of the unique components of the zones. Code for generating rows for the table available at <https://github.com/flindeberg/internet-tools> in the `zoneyoga` folder.

through which “any interested party” can request access to a zone-file. The general lament by interviewees is that the CZDS is a good enough initiative on paper, but does not work in practice as it is quite cumbersome compared to an AXFR initiated zone-transfer which can easily be repeated to provide the currently relevant zone-file (of course with the limitation that a certain amount of technical knowledge is required). An AXFR-request, such as `dig @zonedata.iis.se se AXFR`, outputs a zone-file in a technically good format¹⁰ which can be used directly as input to another process, i.e., an interoperability thought style way of interacting with *technology*.

The root-zone itself contains around 1500 domains, so-called top-level domains. In a technical sense there is not that much difference between the root-zone and any other zone. The last row in Table 10.9 is the root-zone. The ISO-3166-1 code “ie” is for Ireland, where many international tech firms have their European headquarters. The CCs column illustrates that there are top-level domains with authoritative name servers in *prefixes* announced by ASs registered in 161 regions as defined by ISO-3166-1. This means there are dot-ch, -ee, -nu, and -se domains in 70% of the regions where there are top-level domains registered.

¹⁰The tool `dig` defaults to *BIND*-formatted zones, but can be told to output JSON as well, which is useful for data-mining purposes as JSON potentially handles different character sets and whitespace better.

The main point of this section is to illustrate that ccTLDs, even if they by their ISO-3166-1 are connected to a geographical area, their delegations by and large are not. For example, if a domain name ends with `.se` there is no guarantee that the host, or website, is in Sweden, or is even Swedish.

10.6 Internet-routing

This section discusses **routing** in the context of net neutrality, and net non-neutrality, in an effort to widen the discussion from the last-mile context.

Routing is a conflict laden construct by the interoperability and bureaucratic thought styles. 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 (which makes perfect sense by the interoperability thought style), as recent **Border Gateway Protocol (BGP)**-hacking incidents show.

Note the previous illustrations of the complexity of the routed Internet, for example Figure 8.1, and the table noting the complexity, Table 3.5. Figures 10.1 to 10.4 note the large amount of networks used to properly display a webpage.

Demchak and Yuval (2018) shows a significant misuse of BGP-configurations to route large amounts of packets through state controlled infrastructure, presumably to gather intelligence. In the bureaucratic thought style this makes sense. 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 large-scale 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. [grammar and punctuation corrected]
(Demchak & Yuval, 2018, p. 3)

As a technical note, all (public) BGP-announcements, that is when ASs tell their neighboring ASs which ASs can be reached through them, are in one way or another recorded, publicly, and can be access both in user-friendly

ways¹¹ or as raw data¹². China Telecom (as described in Demchak and 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 it might be impossible to prove nefarious intent. I use such publically available routing data to draw the technical representation of the Internet (see Figure 1.1, Section 2.8 and similar).

Demchak and Yuval (2018) goes on further and argues that BGP-hijacking is common for certain industries, such as banking, where traffic routinely gets routed the “wrong” way to allow an attacker to look at traffic. Stories similar to the events in Demchak and Yuval (2018) are surprisingly common, 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 of similar issues going on which never see the light of day, and possibly never will, due to lack of incentives for doing so¹³. For example, the Rostelecom case (see Noction, 2018; 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, even if the traffic is encrypted.

In an interoperability thought style sense, the solution to BGP-hijacking is to improve the protocol to prevent hijacking without additional dependencies. This in practice has meant that Internet Service Providers treat BGP announcements differently depending on source, since some ASs are known to be less trustworthy. The current approach taken with BGPsec, which is as distributed as BGP but not as interoperable, since BGPsec relies on Resource Public Key Infrastructure (RPKI) for trust. And thereby leans towards the bureaucratic thought style in that additional dependencies are not view as something to be avoided and BGPsec provides for a bureaucratic thought style want, verification.

In a bureaucratic thought style sense, BGP-hijacking should never have been an issue, and delivery should also preferably be guaranteed at the traffic level, so that prior to actually sending a packet it would have been possible to decide which route it is going to take. The current IP and routing standards do not allow for selection of a specific path, so the actual path is known (by

¹¹For example <https://stat.ripe.net/widget/routing-history>

¹²For example <ftp://archive.routeviews.org> or <http://data.ris.ripe.net/rrc00/>

¹³As 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 the project failed due to some participants using information provided in the meetings for political gain. This should be taken with a grain of salt, since I have not been able to formally verify the existence of such a project, but it plays well with the larger narrative of experts wanting to communicate but lack the place to do so without possible political repercussions.

the omnipresent entity; the packet itself carries no such information) only after the packet has been received, not before it is sent.

In terms of net non-neutrality there is no support in BGP for differentiated routing, for example to send different types of packets different routes, and there is no support for booking a route or similar. Both BGP and BGPsec can propagate routes, and it would be technically possible to add additional flags to routes, for example “voice and video”, however that would require coordination to ensure that all involved actors use the flags similarly. “ISP (1),” “IXP (2),” and “IXP (3)” all argue that the simplicity of BGP (and all other protocols) is what made them work for thousands of networks.

10.7 Discussion

This section ties together literature, empirical data and thought styles on the topic of net neutrality given the view of Internet in Chapter 8. The section starts widely, and narrows down to net neutrality in the context of the Internet as *an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhocratic processes based on ideals of design for interoperability*.

Revisiting assumptions of net neutrality literature

This section recapitulates some assumptions in net neutrality literature identified in Section 5.3 that appear problematic in light of the structure of Internet traffic that I have demonstrated in this chapter. As mentioned in Section 5.3, academic net neutrality literature outside the technical domain in general can be said to assume:

1. Network owner and ISP are the same.
2. Congestion happens in last mile.
3. Services have one producer and one consumer.

Item 1: as previously noted, this seems a typical approach in a bureaucratic thought style or market thought style way of designing vertically integrated digital communications networks. Note that this is the vertical integration suggested in Huber (1987) as a consequence of market forces. In contrast, the interoperability thought style rather support the view of the ISP as a wholesaler of services on someone else’s infrastructure, where service provider and infrastructure operator by could likely be different actors.

Item 2: 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 Huber (1987)

notes, net non-neutrality activity is to be expected at the edges of the market and the network if regulation is dysfunctional.

For antitrust purposes, in any event, the story is fairly simple. Without regulatory oversight, the RBOCs, like the many other phone companies already involved in information services, surely could work some anticompetitive mischief at the edges of the market. Given their miles of network they will always be positioned to take an extra, undeserved inch here and there. Close, continuing regulatory vigilance is therefore in order.

(Huber, 1987, p. 1.30)

However, congestion can happen anywhere and is not limited to the last-mile, or the edge of the Internet. Models which aim to explain net non-neutrality regimes need to take height for congestion in all parts of the network.

Item 3: that services have *one* producer and *one* consumer, is also a problematic assumption. As shown in Figures 10.1 to 10.4 and Tables 10.2 to 10.5 resources from up to forty or more networks are needed just to browse a website. 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.

These three items will be important in the coming discussion of net neutrality in light of the thought styles.

Internets and splinternets

In terms of the interoperability and bureaucratic thought styles, splinternets are an illustrative example of the conflicts at hand of when different values clash. Net neutrality regulation is one way of through policy affecting network behavior, in terms of packet neutrality; the splinternet-concepts goes further and discusses networks almost completely under national or regional control.

Splinternets concern how the Internet should be vertically or horizontally segregated. Vertical integration within jurisdictions makes bureaucratic thought style sense, but directly breaks vertical separation since the notion of the Internet model is that the lower layers should not in any way concern themselves with, or be dependent upon the implementations of the higher layers, such as jurisdictions.

The concept of “splinternets” was popularized in Lundblad (2002), and plays on the notion of not “one Internet” but rather many internets in some sense splintered off from the Internet. 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)

Practical 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 (and today they also have their own root-zones ready to go if needed). Russia started blocking IP-ranges affiliated with Google and Amazon in an attempt to block Telegram¹⁴ who used their cloud computing resources. At the opposite end of the spectrum, from the policies of China and Russia, is ICANN who promotes “one Internet” in the sense of one coordinating mechanism for naming and numbering (i.e., the Internet Assigned Numbers Authority (IANA) function).

Also, supposedly (encountered during discussions, and publicly reported online in McCarthy, 2017), in the works is a BRIC-root-zone¹⁵, with the explicit purpose of securing a working Internet if the (supposedly) USA controlled IANA function decides that the BRIC countries to not get to play ball anymore. The endeavor rests on the bureaucratic thought style. 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).

Splinternets make sense from the bureaucratic thought style, since according to this thought style jurisdictions should matter even at a traffic level. From the interoperability thought style the problem is two-fold: first, the problem of networks where the infrastructure itself is aware of jurisdictional specifications, second, potential incompatibilities between the splinternets hinder interoperability. These potential incompatibilities are brought up by some interviewees in terms of net neutrality as well, “Advisory Committee (1)” argues the notion that regulation should not dictate network behavior in too much detail, and that regulation for net neutrality needs to be well formulated to avoid going too far towards, for example, splinternet like situations.

Article 15 and Article 17

Both Articles 15 and 17 are upcoming directives in EU legislation and are commonly dubbed “the link tax” (Article 15) and “the meme ban” (or “upload filter”, Article 17) which go against net neutrality. Both are part of a *directive*, which has to be implemented by member states. Comparably, **General Data Protection Regulation (GDPR)** is EU-level *regulation*, which does not have

¹⁴An end-to-end-encrypted messaging service.

¹⁵BRIC here referring to Brazil, Russia, India, and China.

to be implemented by members state to be valid. An article by The Verge summarizes the intention of Article 15 and 17 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)¹⁶:

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 **separation of concerns** 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.

This is interesting in an EU context since EU are for net neutrality (see for example BEREC texts BEREC, 2020; Berec, 2017) while the EU proposes directives against net neutrality, in particular Article 17. This is in line with the literature noting that net neutrality is not that well-defined.

¹⁶Vint Cerf (“legendary Internet pioneer”) and Tim Berners-Lee (“father of the web”) are among the signatories. However, weight should be put on ideas rather than people, and it should not matter who is behind it (even though it clearly does).

Pricing a non-neutral Internet

I consider texts such as Choi et al. (2015) and Economides and Hermalin (2012) abstracted too far, and ad real-time bidding implementations might prove a fruitful exercise in what a price-differentiated Internet could look like as they are fully automated and each transaction is too small to warrant human interaction in the pricing process.

In an Internet-context, Rupp (2000) provides a model for pricing an “Integrated Service Internet”, where pricing arrangements between networks can go beyond just best-effort to allow for quality aware interconnections, such as latency, to foster a more efficient Internet, from the market thought style. As with ad-ecologies, Rupp (2000) argues for an auction-like solution where it is possible to bid for different service levels.

For example, in such a regime, if a car owner wants to update the car firmware, the car manufacturer would enter into temporal peering agreements which ensure delivery of new firmware to the customer. That is, the servers at the car manufacturer 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 the manufacturer 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 or large swaths of horizontal or vertical monopolies). As can be seen on the FCC broadband map, FCC (2020), large parts of the rural USA lack ISP competition for high speed Internet-access, and veritable monopolies are common¹⁷.

Stange and Funk (2014), Wang and Yuan (2015), and Yuan et al. (2013) provide overviews of real-time bidding for advertisements, and they illustrate complex ecologies with low margins and high throughput of deals. For example, thousands of ad-views measure in single USD, the margins per transaction are significantly too low to allow for human operators. Online advertising is an automated split-second decision-making system based on numerous exchanges.

In general, the mentioned literature treats 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 from a market or policy angle. This can be compared with a more general net neutrality approach in which, for example, transit operators start charging differently (i.e., Atlantic-cable oper-

¹⁷According to FCC (2020) 26 % of rural population in the USA do not have any access to fixed 25 Mbit/s or above, and 45 % of the rural population have access to fixed 25 Mbit/s or above from *one* provider. 3.3 % of the rural population have access to 25 Mbit/s or above from 3 or more providers.

actors refusing or throttling certain services) in a more technically 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 areas between these often for-profit networks, such as transit actors could be considered as functioning markets and therefore do not warrant further investigation in a market-imperfection net neutrality-lens.

Another assumption or non-mentioned characteristic is network owner compared with 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 or similar to allow for vertical separation rather than integration).

In the interoperability thought style, 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 fibers or cables should not also sell different kinds of services to consumers or businesses (according to the values of the interoperability thought style).

Also, in the interoperability thought style, congestion can happen anywhere, and is an integral part of routing. Most 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 (technical) Internet.

Technology and net neutrality

The prior section discussed net neutrality as a policy problem, that is something likely to start in a bureaucratic thought style train of thought to regulation entities governed by market thought style incentives. This section spends a couple of paragraphs to discuss net neutrality from the interoperability thought style.

As previously argued, practical net neutrality is a consequence of good implementation of technology design in the interoperability thought style, since layers are separated and separated concerns explicitly implies that the network is neutral with regard to packets (i.e., traffic) on the network itself. Net neutrality can be argued to be coordinated by principles of the interoperability thought style, but it is not enforced. One can argue that the separation of concerns built into the normal **Transmission Control Protocol (TCP)**-stack is based on the notion that the actors are not evil and they adhere to the interoperability thought style; that is they would never intentionally break separation of concerns principles.

In reality not all actors act in the interest of the interoperability thought style, and there are voices raised which suggest that implementation of technology should enforce separation of concerns, which also would enforce net

neutrality. One such example is QUIC (draft available as Iyengar and Thomson, 2020)¹⁸, a transport layer protocol (i.e., similar to TCP and **User Datagram Protocol (UDP)** above the IP layer), which enforces encryption (as discussed in Chapter 8 at p. 201). When QUIC is used, layers below transport, such as IP (**IPv4** and **IPv6**), frame relay protocols, Ethernet, the infrastructure and network operators, etc, cannot understand the transport layer and above (since it is encrypted). This precludes discriminating between packets based on their content. Separation of concerns becomes enforced through encryption since integration and creation of dependencies becomes impossible (in all practical terms today), ensuring practical net neutrality.

In practical terms though, QUIC requires a bit more reflection (a good overview can be found in Stenberg, 2018). QUIC is primarily sponsored and developed by Google, a company operating in the market thought style¹⁹, and one that undoubtedly has something to gain by universal acceptance of QUIC. This something is market position; if infrastructure and network operators (including ISPs) cannot differentiate traffic and potentially capture more value based on traffic type, the infrastructure and network operators' market position grows weaker in relation to the market position of edge companies. This is in line with technology “as a platform for market shaping and innovation” in Kaartemo and Nyström (2021).

Therefore, it is possible to see QUIC as a play on practical net neutrality in value capture terms for infrastructure and network operators which improves the market position for edge actors. QUIC supports notions of the interoperability thought style (enforcing separation of concerns, the most important concern in Gamma et al., 1996) and relates to the market thought style concern with value capture (by improving the market position of a set of actors relative to).

10.8 Net neutrality by the thought styles

The Internet is coordinated through an explicit bottom-up process, mainly through the organizations IETF and ICANN and the forums they provide. Neither ICANN nor IETF have a history of getting involved in political debates but rather try to behave as neutral executors of a multi-stakeholder

¹⁸At the time of writing QUIC is a draft, and does not yet have an **Request for Comments (RFC)**-number, even though QUIC is in use by Google. This is likely to have changed at the publication and defense of this thesis. See <https://datatracker.ietf.org/wg/quic/> for current document status of the QUIC **working group**.

¹⁹In the framing of this thesis, Google is beyond doubt a firm in the market thought style. Google might use principles from the interoperability thought style to design products, but is governed by market thought style principles. For example, Google would not decommission itself if it sees itself as controversial to technical development. In comparison, several interviewees adhering to principles of the interoperability thought style argue that the **Internet Engineering Task Force (IETF)** and ICANN should decommission themselves when they become detrimental to change and the Internet's architecture.

process, with ICANN focusing on coordination and maintenance issues while IETF focuses on technical issues, although the distinction sometimes is hard to make (see argument in Chapter 7).

Not everyone agrees directly that the state of affairs described in the previous paragraph is desirable, in particular not policy literature. And as described in Chapters 7 to 9, the majority in **United Nations (UN)** and the **International Telecommunications Union (ITU)** would prefer a nation-state-based multilateral approach to **Internet Coordination** (i.e., **Internet Governance**) rather than the current model (based on the outcomes of **World Conference on International Telecommunications (WCIT)** 2012).

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.

Figure 10.6 maps initiatives in the previous sections of this chapter with the thought styles. The figure illustrates splinternets, EU-regulated net neutrality (similar to Title II common carrier), (Title I) information services, the web by Sections 10.3 and 10.4, QUIC, and Article 17.

Splinternets as a concept belongs close to the logic of the bureaucratic thought style, where local internets are **nation-state**-level concerns under direct state control (see argumentation and description in Lundblad, 2002). EU-level net neutrality regulation balances values of the interoperability and bureaucratic thought styles in terms of formulation, but as regulation has bureaucratic coordination effects.

The American Title I information services (*Non-NN* in the figure) approach lies closer to market thought style logic and further from interoperability thought style logic regarding **integration of concerns**. This is what Lessig and Lessig (2006) argues against, market based communications networks. Note the different positions of IPv6 and Non-NN in the figure, where IPv6 can be said to represent another non-market based form of networks.

The position of “the web”, as captured in Sections 10.3 and 10.4, illustrates that the web uses an interoperable Internet to connect entities in a business network. (Sections 10.3 and 10.4 describe the sets of actors involved in presenting a website to an end-user. See Figure 10.5 for a broad illustration of actors involved in browsing a hundred webpages without further interaction.)

I also include QUIC (as discussed in Section 8.1) to illustrate the different sets of values present in the suggested protocol. QUIC is far from the bureaucratic thought style values, since most forms of audit and control over networks based on traffic content becomes virtually impossible, even at smaller scale such as corporate firewalls. As shown in Figure 10.6, QUIC and regulated net neutrality are similar in terms of interoperability and integration, both lead to more technical interoperability than both a net non-neutral regime or nation-state controlled splinternet scenario, but through different means and for different purposes.

Figure 10.6: Perspectives on net neutrality

Illustrates the net neutrality typology by the thought styles in figure format. Aims to map blends of thought styles to practical net neutrality. The yellow ellipse plots the Internet-like area as identified in Chapter 8. Illustrates QUIC, EU-level like regulated net neutrality (Regulated NN), Title I information service (Non-NN), the web as described in Sections 10.3 and 10.4, Article 17, and splinternets per the thought style. Also contains IPv6 as an example of an interoperable protocol.

Article 17 illustrates a scenario where interoperability and separation of concerns is dropped in favor of preventing distribution of copyrighted and illegal material (bureaucratic and market thought styles concerns).

The original Internet values, as described, for example, by [Request for Comments \(RFC\)-2026](#) (Bradner, 1996) and RFC-6722 (Hoffman, 2012, “the Tao of the IETF”), are best envisioned in the left to top left area, where markets set rules of engagements based on technically meaningful standards 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 in a interoperability thought style sense.

Net neutrality is usually used in the bureaucratic and market thought styles. 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, 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., implemented by edge servers and clients). Thus, the argument of Handley (2009) 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 mostly quiet on the subject, and as an example the CEO of ICANN stated that the repeal of net neutrality in the USA would not impact ICANN’s work (see reporting in Saez, 2017) rather than engaging in discussion of the coordination of the Internet and its connection to net neutrality. Another interesting detail is that the ICANNWiki-entry on net neutrality has not been updated since 2016 (see ICANNWiki, 2016b).

It is worth reiterating that both ICANN and the IETF are not representational in the sense of being formed by individuals elected to represent the different parties of the Internet (as for example countries elect representatives to represent them in the UN), but rather as the forum where actual coordination happens. And as previously noted, Internet-lobbyists in other parts of society are few and far between (see Chapter 7).

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 Figure 10.6 I suggest a parsimonious model for illustrating the different versions of a digital communications network given the values behind the design of the network.

It should not be forgotten that the Internet in a technical sense is *best-effort*; 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.

10.9 Chapter summary

There is reason to care for net neutrality and Internet Coordination. Without de facto net neutrality several of the assumptions behind the Internet fall, and then it is up to the infrastructure and network operators to decide what the Internet is. Today most of the Western Internet is de facto net neutral, or packet neutral, with some forces pushing towards **Internet Standards** 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 USA) under a market Internet regime.

In general terms, the academic net neutrality debate has changed the last years, and gone from discussing the Internet in a USA context as either a common carrier (requiring regulatory and in some sense enforced net neutrality due to common good and utility argument) or information service (requiring no regulation regarding net neutrality at either service or infrastructure layer, since the Internet is entertainment rather than a need or utility) to a richer debate about what net neutrality is and how and why it could be maintained or relinquished, more in line with this chapter.

From a technical standpoint, there are no considerable issues with a net neutrality repeal; the network would still function, but as illustrated by my web examples (Figures 10.1 to 10.4 and Tables 10.6 and 10.8) the Internet is complicated, and discriminatory routing even more so. 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 thousand, price negotiation would quickly become costly and a turn in the direction of automation and/or aggregated brokerage is probable.

Also, as shown in Figures 10.1 to 10.4 and Tables 10.2 to 10.8, today there is a wide ecology of actors who create value together in network-like constellations. As previously argued, issues such as net neutrality are problematic in a regulatory sense, since state regulation fits neither the coordination of the Internet nor 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 the light of this thesis.

As is illustrated in Figure 10.6, I suggest a thought-style-based mapping of digital communications networks. Close to the interoperability thought style side (at the left), network design and interoperability values lead to net neutrality by default. Moving towards the market or bureaucratic thought styles, net neutrality could be sought or not, depending on the objectives of the actors. Historically, in a Western context, the Internet has been largely de facto net neutral as the end-to-end principle has been upheld for most intents and purposes. This means that the network itself did not add or capture value beyond that involved in content neutral propagation of traffic.

Identified forces push towards the right-hand side of the logics illustrated Figure 10.6, an increased role of regulation in deciding what the Internet, or digital communications network, is. Particularly ambiguous are organizations such as the EU, which on the one hand move for net neutrality through regulation, but also pass regulation which goes against net neutrality, such as Article 15 and 17. Both Article 15 and 17 require layers to care about each other, an integration of concerns, which goes against the notion of net neutrality as traffic agnosticism.

My probing suggests that many organizations are not prepared for that the Internet might change into something which no longer can be black-boxed. This even includes organizations whose core business relies 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, in line with the claim in Handley (2009) that the Internet has never been completely neutral. 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 use an Internet that works predictably without pre-existing contracts pertaining to the particular task it is used for. 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, and not only an economic or policy issue, but rather an important norm concerning how the world in future should look at digital communication; can the service provider treat traffic at its own discretion or should norms, ethics or even regulation affect traffic operators and protect edge-users? This may fundamentally influence society. Low-quality Netflix- or YouTube-streams might not cause permanent harm, but what if network operators blocked sources with different political views?

Should the Internet be considered a utility, like water or electricity, and be regulated similarly? (🏠) Or should the Internet be treated as a service offered on a market? (\$) Or should the Internet be treated as a platform for society, similar to money? (Δ)

Depending on the answers to the questions above, net neutrality takes different shapes and forms. Given that which is captured in Chapters 7 to 9 the Internet gives rise to the notion that *traffic perceived as de facto treated according to agreed standards absent potential technical harm to networks or their users* is a meaningful way to conceptualize net neutrality. Net neutrality is then ultimately not only an issue of how infrastructure and network operators can capture value, but also the notion of what the end-users can do with the Internet and how the Internet and the Internet's use can develop over time.

11 Conclusions

The Internet is the first thing that humanity has built that humanity doesn't understand, the largest experiment in anarchy that we have ever had.

— Eric Schmidt

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 12, goes beyond the questions themselves and suggest further avenues for research.

Research Question I

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

I identify three prevalent and sometimes **incommensurable** perspectives on the **Internet**; the **interoperability** (**Δ**), **bureaucratic** (**🏢**) and **market** (**💰**) **thought styles**. These thought styles disagree both on what the Internet *should be*, and to a lesser extent on what the Internet *is*.

The **bureaucratic** and **market** thought styles conflict is a well known conflict, and is often described as the conflict between markets and bureaucracies (see, for example, Benkler, 2002, 2006; Lessig, 1999; Ouchi, 1979; Ouchi, 1980; Weber et al., 1991). In this setting the **interoperability thought style** is the novel addition in a **coordination** lens. The interoperability thought style adds

values and nuances behind design for change, regardless of it being **technology** or coordination. Descriptions of phenomena from multiple perspectives is not novel, for example Fleck (1935/1979) and Kuhn (1962) argue that all science is set within paradigms or thought styles, where assumptions and social processes also guide and decide that which is considered to be theory and fact. In the telecommunications and Internet arena, Cowhey (1990) is a description of the international telecommunications regime shift from nation state considerations to market logic driven by **epistemic communities** as the trendsetter of a thought style. Texts such as DeNardis et al. (2020), Lehr et al. (2019), van Eeten and Mueller (2012), and Zittrain (2008) go in similar directions, describing the interdisciplinary nature of the Internet and the need for different perspectives or lenses.

The interoperability thought style, as identified, is based on values of technology change over time. In this context being able to handle rapid development in technology and changing uses is of paramount importance. This is achieved through concepts such as **separation of concerns** and interoperability where it is important to avoid dependencies between different components and modules.

Documents such as **Requests for Comments (RFCs)** (in particular the **Internet Standards**) and software engineering best-practices (for example Gamma et al., 1996; Kim et al., 2013; Martin et al., 2003) are good sources for the core values of the interoperability thought style. For example, in an interoperability thought style lens it is of utmost importance that the network (i.e., the Internet) is independent of the traffic on the network. Therefore, practical **net neutrality** is a necessary consequence of good design. But, net neutrality through regulation would be wrong in an interoperability thought style sense, since then there would be a dependency between legal setting and network implementations, which is also an unnecessary dependency in an interoperability thought style sense.

The **bureaucratic thought style**, as identified, represents the reasons and **raison d'être**s for planning, control and audit. It is assumed that society should be organized through rules, agreed processes and ex ante agreements. As a consequence of control and audit, **integration of concerns** is preferred over separation of concerns.

The values of the bureaucratic thought style can be found in documents such as **International Telecommunications Union (ITU)** meeting minutes (for example ITU, 2018) and vertically integrated standards such as **future vertical communications network** (for example as described in Li, 2020) for matters concerning digital communications. Also, the bylaws of **Internet Corporation for Assigned Names and Numbers (ICANN)**, for example ICANN (2019), illustrate the impact of logics from the bureaucratic thought style for the Internet. For example, in the bureaucratic thought style, if net neutrality is wanted it should be coordinated through enforceable policy and regulation, not through voluntary standards or any other non-enforceable method. LEK

(2003, the Swedish electronic communications directive) is one example of net neutrality, or **Internet Coordination**, through regulation.

The **market thought style**, as identified, represents the market forces and actors and their wants and needs, such as the primary want value capture. From this perspective standards are market products or market positioning tools, and it is assumed that all actors try to capture as much value as possible. Compared to the interoperability and bureaucratic thought styles, whose opinions are rather even throughout the thought styles, the actual market thought style opinion depend on the identity of the actor. For example, in the context of net neutrality it is possible to identify two main categories of actors with different views on the topic. The first, **infrastructure and network operators**, actors who participate in the network itself and gain revenue from some form of packet transmission fees, and second, **edge** actors which are not part of the network itself, such as cloud-firms and content providers.

A large edge actor would prefer net neutrality since that would prevent infrastructure and network operators to capture value based on traffic prioritization or discrimination. It is likely that net neutrality regulation would imply that smaller edge actors subsidize larger edge actors (cf. arguments in Choi and Kim, 2010; Economides and Tåg, 2012; Hubert, 2017). In contrast, for-profit infrastructure and network operators stand to gain, in a market thought style sense, if they can capture value freely, without net neutrality, and also preferably bundle services, such as content and content delivery, to shape the market to their advantage.

These thought styles and levels are similar in several ways to other groupings, perspectives or lenses of the Internet or actors of the Internet. For example, Lehr et al. (2019), Lessig (1999), van Eeten and Mueller (2012), and Zittrain (2008), each provide a different take on the Internet. The primary nuance added in this thesis is the explicit addition and conceptualization of the interoperability thought style, that is a way of explaining the values built into, and still present in, protocols such as **IPv4**, **IPv6**, **Transmission Control Protocol (TCP)**, **Domain Name System (DNS)**, etc, and loose organizations without actual ownership of standards such as the **Internet Engineering Task Force (IETF)**.

The thought styles lead to different implementations of technology, and different views of standards and models; should models predate implementations and be prescriptive (🏢 and 💰), or should models and standards come after the (working) implementation and be descriptive (Δ)? Or a nuanced mix of the two?

These thought styles together shape what the Internet is today and will be in the future. It is therefore important to identify where the thought styles conflict and where they are consonant or compatible. As illustrated in Figure 11.1, even if separation of concerns values in the interoperability thought style was the originating context of the Internet, there are forces, both in terms of international governance in multilateral contexts and mul-

Figure 11.1: The thought styles and the Internet
The figure illustrates the Internet and its proximity to the thought styles. The early provenance of interoperability thought style values and the over time entry of logics relating to value-capture on markets and control by bureaucracies. The interoperability (Δ), bureaucratic (🏢) and market (\$) thought styles are represented by their respective symbols. The 🌐-symbol illustrates the Internet as a combination of the values of **implementation of technology**, **standards formulation**, **coordination of technology**, and **meta-coordination**.

tistakeholder standard setting arenas, who push for a more integrated and controlled Internet. Such wishes can be rooted both in the logics of the bureaucratic thought style where control is necessary, for example, either as a measure to ensure democratic welfare, or as a means of totalitarian control of the Internet's use; and in the logics of the market thought style where some additional control is necessary to erect barriers of entry and use technology as a market positioning or shaping tool.

Figure 11.1 illustrates logics of the thought styles dominating what the Internet actually is, where the original values of the interoperability thought style over time have become muddled with other ideas of what a digital network is or should be.

Research Question II

How is the Internet, as conceptualized here, coordinated?

The **Internet**, in practice, is coordinated through three distinct but separate collections of processes, here described as the **Internet Standards** process, **coordination** of unique identifiers, and the *actual implementation* of **technology** by **infrastructure and network operators**. These are illustrated in Figure 11.2.

The Internet Standards process is based on informal multi-stakeholderism through the **Internet Engineering Task Force (IETF)**. Participation in IETF is voluntary and contributions to standards are (supposed to be) valued on their quality according to 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 direct participation of involved **epistemic communities**.

The design of the process shows signs of engineering and **separation of concerns** values; the processes for Internet Standards themselves are designed similarly as a system expected to be facing change should be designed. The notion is that interdependence should be avoided, 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. Consequently, 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.

Recent Internet Standards show clearer market positioning or shaping intent than earlier Internet Standards and **Requests for Comments (RFCs)** which were closer to “good standards for the general case” rather than “good standards for a particular organization”.

Unique identifiers, i.e., **Internet Protocol (IP)** addresses, **Autonomous System Numbers (ASNs)**, prefixes, and domain names, are coordinated by technical policy through a compared to the IETF, formal multi-stakeholder process at the **Internet Corporation for Assigned Names and Numbers (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** over time putting greater emphasis on formal contracts, rights, and duties of **country code top-level domains (ccTLDs)** vs ICANN, connections between national territory and domicile of ccTLDs, etc, in line with governmental practices and national considerations.

The third process, central to the coordination of the Internet, is the implementation, including operation, by the infrastructure and network operators of the infrastructure the Internet practically runs on. Most infrastructure and

Figure 11.2: Central concepts in the **Internet Coordination** ecology
These are required for the **Least Common Internet**, i.e., that which ultimately is coordinated in Internet Coordination arenas and that which constitutes minimum of coordination required for the practical and technical Internet.

network operators are organized in for-profit constellations, which leads the decisions on of Internet Standards to be based on a **market thought style**.

Two of the arenas for these central processes of the Internet, IETF and ICANN, were created as coordination arenas for actual needs at their respective inceptions, the need for coordination of **standards formulation**, and the need for coordination of unique identifiers. They were not the result of organizations looking for (additional) purposes. This is an indication of an organizational design grounded in the **interoperability thought style**, which also allows the functions to move to other organizational settings if need be.

In terms of the **Internet Assigned Numbers Authority (IANA)**-function, ICANN is replaceable as facilitator for coordination, rather than necessarily being the coordinator, and the IANA-function could be housed elsewhere under different conditions. The most important resource of the IANA-function, the **root-zone-file**, is open and could be copied by anyone who wanted to maintain a new root-zone. Technical standards such as **Domain Name System Security Extensions (DNSSEC)** put additional requirements on a potential new root-zone maintainer, but it is technically possible to coordinate a new IANA maintainer.

The IETF coordinates publication of RFCs written by its members, including but not limited to Internet Standards and **Best Current Practices (BCPs)**.

The Internet Standards are not enforced or policed, only published. All the RFCs are openly published and could be copied, literally in seconds, which can allow for a competitor forum to try to take over the role of facilitator of coordination for Internet Standards should members want to go elsewhere.

The landscape for international governance of the Internet is changing; there is pressure from the **International Telecommunications Union (ITU)** to put an IANA-like function under the ITU (see the similar thoughts in DeNardis and Raymond, 2013). This could leave the technology dimension of the Internet intact, but change the coordination dimension into, for example, a top-down non-Internet structure. Such a change of coordination would unavoidably change the technology aspects, as coordination and technology are intertwined, and could provide a different kind of network (or collaboration of networks). This form of integrative control or governance is a **layer violation** in the interoperability thought style; where coordination, and not only technology, should be separated as much as possible.

The external policy and regulation pressures have changed the way ICANN is organized to a more formalized structure with the **Empowered Community** and subgroups. This change has not been without conflict, and currently there is a visible schism between the interoperability and **bureaucratic thought styles** in terms of what ICANN should be. Interoperability holds that it should return to its root as the IANA-function, while according to the bureaucratic thought style it should grow into a proper governor and policy-maker with legitimacy.

Research Question III

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

This thesis captures the **Internet** as a combined phenomenon of **technology** and **coordination**. The Internet as a concept can meaningfully be divided into four levels; **implementation of technology** (T), **standards formulation** (S), **coordination of technology** (C), and **meta-coordination** (M).

These levels can, together with the **thought styles** presented in this thesis in RQ I, describe the Internet conceptually. This conceptualization is based on what I call the **Least Common Internet**, as it illustrates the least amount of coordination needed for a (large) set of networks to exchange traffic without discrimination with interoperability.

I argue that the Internet can be conceptualized as:

an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through adhocratic processes based on ideals of design for interoperability

This conceptualization is descriptive, rather than prescriptive, and aims to describe what the Internet is. This Internet concept can further be divided into the levels as mentioned above. The levels are used to illustrate the shift in logics at different levels of **Internet Coordination**.

architecture for best-effort digital end-to-end communication
(T, Δ)

At a base implementation level the Internet is the concept of a best-effort architecture for best effort digital end-to-end communication. This current actual implementation is illustrated in Figure 11.3 as a massively interconnected and interoperable set of networks. There are current changes ongoing, for example **BGPsec** which aims to strike a balance between interoperability and **integration of concerns** by verifying **Border Gateway Protocol (BGP)** announcing actors.

However, the current **Internet Standards** are still, even if changing, mostly **interoperability thought style** induced.

set of protocols for best-effort digital end-to-end communication
(S, Δ)

The coordination of technology (C) follows a mix of interoperability (Δ) and **market** (\$) thought styles, where interoperability thought style logics used to lead and **market thought style** values have increased over time. For example, market positioning effects are present in **Requests for Comments (RFCs)** to a greater extent than before.

effected by its users through adhoc processes (C, Δ , \$)

Market forces play a larger role since large for-profit actors shape the coordination more than before. Captured in this dissertation is a blend of interoperability and market thought styles coordinating the Internet. However, large parts of the market thought style values are hidden, often publicly motivated by interoperability thought style logics. As mentioned, **QUIC** is one such example, where the suggested standard is arguably interoperability thought style leaning in that QUIC separates traffic content and network through encryption (see Iyengar and Thomson, 2020; Stenberg, 2018), but hidden in the technical details is that the logics of value capture of traffic changes completely, as traffic by design is forced opaque, preventing all forms of **deep packet inspection**, and thus also preventing filtering and prioritizing based on content.

based on ideals of design for interoperability (M, Δ ,)

Figure 11.3: An illustration of the Internet in 2020

Illustrated as a BGP-typology which contains a total of more than a million **Autonomous Systems (ASs)** and prefixes. Central well-connected networks and prefixes are dark blue, and turn green towards white for the lesser connected prefixes and AS. The image is flat and is not correlated to the geography of the Earth.

Currently, the coordination of the Internet has an increase of market thought style logics, whereas the future of the Internet could be expected to be shaped increasingly along a **bureaucratic thought style** as that thought style makes inroads in the meta-coordination, the values and ideals shaping and directing the coordination. This is illustrated both by the increase of bureaucratic logic at arenas such as the **Internet Corporation for Assigned Names and Numbers (ICANN)**, and also by that a large group of the members of the **United Nations (UN)** and the **International Telecommunications Union (ITU)** are vying for a more central role in both **governance** and coordination of standards (such as with “**new IP**” and proposed **future vertical**

communications network) and for unique names and identifiers, such as with Digital Object Numbering Authority (DONA).

The Internet has a long history of distributed voluntary bottom-up governance where empirical evidence and function has led 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 intentional, and explicitly uses different structures than those for nation-state based multilateral agreements, as is common in the international telecommunications regime.

The central concepts of the Internet are included in the Least Common Internet, 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). This has implications for where encountered problems should be discussed and solved, and this conceptualization explicitly includes coordination, and the values behind the technology.

The suggested conceptualization has a number of consequences. First, the Internet is not a function of any single or a set of protocols, but rather the other way around. For example, the Internet Protocol (IP), the Domain Name System (DNS), BGP, etc are all dependent on the idea that is the Internet based in a certain view of looking at the world. There could still be an Internet, even if IP, 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, as I find the values of coordination of the Internet central to its conceptualization. I consider the yellow ellipse in Figure 11.1 to be a possible illustration of where this thesis would consider a digital network including its coordination to be the Internet. Moving beyond that into the green, the red, or the blue, it would no longer be the Internet.

12 Implications and further research

*Should we trust the Americans more than the Chinese?
Doubtfully [...] Don't trust anyone*

— 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.

12.1 Framing coordination and technology issues

This thesis notes that literature and practice in general seem to separate **technology** and **coordination** “vertically” (if assuming that coordination is above technology, and that **thought styles** are horizontally separated). In comparison, this thesis suggests that it is more meaningful to view technology and coordination as integrated and rather look at the conflicts and compatibilities of thought styles.

I illustrate this in Table 12.1. The black bars illustrate an approach, looking at technology and coordination as separate, where conflict is modelled as between technology and coordination. The colored vertical bars represent the thought styles as used in this thesis.

As an illustrative example based on Table 12.1, should a conflict between the data points (observation, standards formulation, implementation, etc)

Table 12.1: Comparison of thought styles
Illustrates coordination and technology issues. This thesis suggests that comparison between thought styles are more descriptive and useful in practical and academic contexts rather than descriptions of inherent technology and coordination conflicts.

	Thought style A	Thought style B	Thought style C
Coordination			Data point
Technology	Data point		

be described as a conflict between technology and coordination or is it more prudent to describe it as a conflict between the thought style the coordination is set in and the thought style the technology is set in. This thesis argues that the thought style conflict is likely to explain the conflict in a more satisfactory manner than a description of a conflict between technology and coordination.

As an example, digital sovereignty. I have encountered two flavors of, or two ways to achieve a status which might be labeled “digitally sovereign”. One is the **interoperability thought style** notion of digital sovereignty through nation state agnosticism of both technology and coordination. The other is the **bureaucratic thought style** or **integration of concerns** view of explicit connection between nation state level, or other federal or union level, essential services and processes visible to, and perhaps set by, the public powers.

12.2 Longitudinal studies

Both the website-tracer¹ and the Large Graph Layout engine (LGL)² can be used to draw changes over time.

In the case of the LGL-engine (the engine which draws the large flat illustrations of the **Internet**), the Opte-project adopted some of my changes and are using them to release footage and videos of the Internet over time³. This might provide a nuanced picture of how the Internet evolves over time with respect to its routing, at a technical level, and can be used to illustrate specific moments in time when large **Border Gateway Protocol (BGP)** changes hap-

¹<https://github.com/flindeberg/internet-tools>

²<https://github.com/flindeberg/LGL>

³See <https://www.opte.org/the-internet>

pened. For example, it is possible to illustrate larger BGP-hijacks, regimes shutting down the Internet within countries, and so forth.

The website-tracer can be used similarly. For example, a longitudinal study of website traces might very well provide a quite nuanced picture of how websites evolve over time, and therefore serve as a useful indication of actual Internet use. The website-tracer also collects data on networks, resources, and hosts visited. For example, the website-tracer-tool generated the tables in Chapter 10. It is also possible to use the website-tracer to draw graphs based on **HAR files**, which allows interoperability with a large selection of other tools which outputs HAR files.

I hope that these tools will be used by researchers and practitioners to make sense of the Internet. The purpose of these tools is to illustrate the technical nature of the Internet in a way which does not require technical familiarity with the standards of the Internet.

12.3 Future Internet Architecture efforts

There are several efforts for future Internet design, including but not limited to NDN, MobilityFirst, XIA, Nebula, ChoiceNet, Pursuit, and **future vertical communications networks** / “**new IP**”. I will here compare the mentioned suggested future Internet architecture efforts to the current Internet with the help of the thought styles.

NDN (Jacobson et al., 2009), MobilityFirst (Baid & Raychaudhuri, 2012; Baid et al., 2012), and Pursuit (Fotiou et al., 2012) reverse the network problem from being a best-effort concept to a content centered delivery mechanism (through differently named pull-mechanisms, see Sollins and Lehr, 2020 for overview). This makes the network dependent on content type, since the network has to store the content, or at least cache it. This is a different view of technology than one of change and adaptability, and rather use dependent technology. In Figure 12.1 these are bundled as *ICN* (for information centric network, the network design paradigm).

ChoiceNet (Wolf et al., 2014; Wolf et al., 2012) has a **market thought style** twist on the notion of the network, along the lines of the integrated services Internet in Rupp (2000), where use of the network is closely bundled with the network itself. I view this as an example of integration of concerns of network and network use.

Nebula (see Nebula in Galis and Gavras, 2013) aims to offer guarantees for delivery. The goal of Nebula, at a society level, is comparable to the future vertical communications network, which could serve, for example, remote surgery and different forms of identity provisions. The **Internet Engineering Task Force (IETF)** Deterministic Networking **working group**, however, argues that such networks are only technically feasible under single administrative

Figure 12.1: The thought styles on suggested Future Internet Architectures. Illustrates the suggested protocols for the future Internet architecture as preferable by the bureaucratic and market thought styles. The current **IPv6** formulation can be said to be further towards the interoperability thought style than the overall composition of the current Internet. Future Internet architecture protocols based on formulation of the initial publication describing the architecture, i.e., Anand et al. (2011), Baid and Raychaudhuri (2012), Baid et al. (2012), Fotiou et al. (2012), Galis and Gavras (2013), Jacobson et al. (2009), Li (2020), and Wolf et al. (2014), Wolf et al. (2012), have been tentatively placed based on considerably less information and analytical processes than the current Internet and the IPv6 positions. Also note the fading yellow circle indicating that which this thesis captures as Internet-like networks.

control due to the coordination necessary (Deterministic Networking Working Group, 2021).

XIA (Anand et al., 2011) is, by my reckoning, the closest to the current **Internet Protocol (IP)** based architecture. However, XIA adds more functionality to the **routing** layer, in principle flags such as traffic type, which can be used to treat traffic differently. These flags in turn imply a different trust-relationship between the **edge** user and the network operator than the Internet does. For example, the classification flags assume that the user trusts the classification of the network, and that the network trusts the classification

of the user. There is no such technical trust relationship in place today for the current Internet.

“New IP” (see Li, 2020; and argumentation by “new IP” creator Richard Li in Mueller, 2020), technically a part of the larger future vertical communications network, contains elements of increased network control, and what can practically amount to identity controls at a network level.

The mentioned suggested future Internet architectures conflicts with the interoperability thought style, particularly by breaking the traffic-agnosticism covenant and principles of the **Least Common Internet**, and is more compatible with both the bureaucratic and market thought styles where the application (usually) is the **raison d’être** for the network, rather than the network itself being foregrounded. The suggested architectures are a different blend of the values of the interoperability, bureaucratic and market thought styles, but none is an improvement by all perspectives. The changes these technical standards would bring, in comparison with the present Internet, would change both market and regulatory dynamics.

Figure 12.1 is an illustration of these suggested future protocols and architectures, which also includes the Internet (as) and IPv6 (as IPv6), to illustrate the differences and thought style considerations. I argue that they, based on the suggested architectures in the referenced texts, except IPv6, are more useful from certain market perspectives or more helpful for certain nation state purposes as viewed from a bureaucratic thought style than the current Internet. I can only speculate, but I assume that the Future Internet Architecture projects were initiated to handle perceived pitfalls with the current Internet-architecture, and as the current architecture is still rather aligned with the interoperability thought style, it is natural that suggested solutions draw more on other schools of thought.

The above-mentioned architectures could be implemented on top of the Internet. For example, it is possible to build an information centric network which uses the Internet as a packet-propagation infrastructure. It is also possible to argue that current **Content Delivery Networks (CDNs)** are doing just this, using IP anycast or more likely geographically different **Domain Name System (DNS)** resolutions⁴ to direct traffic to the nearest content or information repository.

Compared to the above-mentioned architectures, the by the IETF coordinated protocols **QUIC**, **DNS over HTTPS (DoH)** and **DNS over TLS (DoT)** are geared similarly, that is an increase of bureaucratic and market thought styles based logic which put the Internet closer to right half of the figure.

⁴See, for example BIND9 and GeoDNS / GeoIP, there seems to be two brand names, which offers this feature. Note that **BIND** is open source so even private individuals can set up advanced GeoDNS-services.

12.4 The great generational shift

In this thesis I illustrate and argue that it is not markets or bureaucracies which, in general, have decided what the Internet is or should be. It has rather been a smaller collection of individuals who framed the Internet outside the traditional market and bureaucratic contexts.

A significant part of this core collection of individuals, or **epistemic community** using the terminology of Haas (1992), are now retiring. The first generation of pioneers, those who lead the discussions which culminated in protocols such as IP, DNS, etc, retired around twenty years ago from active positions and have held ceremonial and evangelist positions since. Now the second generation, those who built many of the Internet organizations during the 1990s and administered them, are retiring from active positions. This shift is likely to matter, since the notion of what the Internet was or should be is not that easily conveyed by documents, and the current order is based on the will and ideas of quite a small circle. Those in coming generations who share their ideals may be too few and with an insufficient power base to steer the future development of the Internet. In my interviews and discussions, I encounter, primarily, bureaucratic and market thought styles primed descriptions of where the Internet is going now. Technology design for a market or bureaucratic need is rising in prominence at the expense of the interoperability thought style design for interoperability, best-effort, end-to-end, and to keep coordination at minimum.

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.

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 on the [Internet](#).

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Figures used in thesis.

The majority of figures in this thesis are created by me with the intention of being used in this thesis. See Section 2.8 and Section 2.8 for overview of these tools.

Figure	Comment
Figure 4.1	Used with explicit permission of the Regional ccTLD organizations of CENTR, LACTLD, APTLD, AfTLD (via Lydia Stoddart of CENTR).
Figure 4.2	Used with the explicit permission of its creator, Patrik Fältström.
All other figures	Either created for use in this thesis or part of the creative commons.

Epigraphs used in thesis.

Shows the source and context of the epigraphs, i.e., the introductory quote per chapter, in this thesis.

Quote	Comment
“The principle of constant change is perhaps the only principle of the Internet that should survive indefinitely”	From RFC-1958 (Carpenter, 1996), p. 1.
“So the problem is not so much to see what nobody has yet seen, as to think what nobody has yet thought concerning that which everybody sees.”	Arthur Schopenhauer in Schopenhauer (1851, p. 93), in original German “Daher ist die Aufgabe nicht sowohl zu sehen was noch keiner gesehen hat, als bei Dem was Jeder sieht, zu denken was noch Keiner gedacht hat”.
“To infinity and beyond”	Motto by character Buzz Lightyear in the movie Toy Story.
“með lögum skal land byggja en með ólögum eyða”	Proverb from Njáls saga describing the necessity of laws and order to properly build a society.
“Good companies will meet needs; great companies will create markets”	Philip Kotler cited in Crainer (2002, p. 37)
(continues on next page)	

Epigraphs used in thesis (cont).

Shows the source and context of the epigraphs, i.e., the introductory quote per chapter, in this thesis.

Quote	Comment
“The Internet is not governed, it is coordinated”	Said by interviewee after I used the term governance. Said with the intention of correcting me.
“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.”	Quoted from van Eeten and Mueller (2012, p. 729).
“Maybe we should call it [the Internet] something else to indicate that we are entering a new, different, phase”	Interviewee on the topic that the Internet is changing, and is here referring to the bureaucratization of several previously only technical concerns.
“Control over ICANN does not imply control over the Internet”	Comment made by interviewee on the topic of what ICANN could potentially do.
“Net neutrality is the concept of whether the user is in charge or not”	Interviewee when asked to summarize net neutrality as succinctly as possible.
“The Internet is the first thing that humanity has built that humanity doesn’t understand, the largest experiment in anarchy that we have ever had”	Eric Schmidt at Internet World Trade Show, New York, 18 November 1999
“Should we trust the Americans more than the Chinese? Doubtfully [...] Don’t trust anyone”	Interviewee on who should be trusted in terms of the Internet. The further argument is that it is necessary not to trust the Internet.

Glossary

Address Supporting Organization (ASO) Membership organization for Regional Internet Registries (RIRs), is part of the Internet Corporation for Assigned Names and Numbers (ICANN) Empowered Community.

adhocracy An organizational configuration in Mintzberg (1993) characterized by **mutual adjustment**. Represents an organization without strict hierarchies.

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.

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).

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).

At-Large Advisory Committee (ALAC) Part of the ICANN Empowered Community, represents the at-large community.

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.

Autonomous System Number (ASN) A unique number given to each **AS**, is used for **routing** purposes. An **AS** can announce several prefixes, and a prefix can be announced from several **Autonomous Systems (ASs)**.

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 **Request for Comments (RFC)**-2827, Ferguson & Senie, 2000, for document).

BGPsec **BGP** with trust, similar to **DNS** and **DNSSEC**, see RFC-8205 (Lepinski & Sriram, 2017) for specification. In practice verifies announced AS-paths with cryptographic signatures. Depends on **Resource Public Key Infrastructure (RPKI)** for verification.

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 **Internet Systems Consortium** develops the core functionality of **BIND**, although there are spin-off projects, such as **Bundy**.

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).

blockchain The concept or technology of a distributed digital ledger/-database. Should not be confused with implementations, such as **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.

brand top-level domain (bTLD) A **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).

bureaucratic thought style The bureaucratic perspective focus on the legitimacy actor in charge and possibilities to enact sanctions. Often, in the bureaucratic thought style, the coordination behind actions is just as important as the outcome of the actions.

Classless Inter-Domain Routing (CIDR) A classless method for **routing**, used so describe address blocks. Usually on the format **a.b.c.d/xx**, where **a.b.c.d** is the starting address and **xx** the significant amount of bits. The smaller **xx** is the larger the block is, for example **192.168.1.0/24** is smaller than **192.168.1.0/16**. **IPv4** addresses are usually assigned individually (i.e., /32) while **IPv6** are assigned as blocks (i.e., /48 or /64).

Content Delivery Network (CDN) Wholesaler of Internet content delivery services, in practice **Content Delivery Networks (CDNs)** host most websites.

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.

coordination of technology The notion of coordinating technology. Used in this thesis to describe actual coordination.

Country Code Names Supporting Organization (ccNSO) Membership organization for **country code top-level domains (ccTLDs)** which is part of the ICANN Empowered Community.

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 Norway, Finland and Zimbabwe).

deep packet inspection A process of inspecting the contents of packets. “Deep” refers to a deeper inspection than required to just transmit the packet onwards.

Defense Advanced Research Projects Agency (DARPA) US federal agency tasked with advanced and to some extent speculative research. DARPA funded the research which lead to the early Internet.

Digital Object Architecture (DOA) An architecture for handling unique identifiers for digital object. Also known as the “Handle System”.

Digital Object Identifier (DOI) One of the “top-domains” of the larger **Digital Object Architecture (DOA)** system.

Digital Object Numbering Authority (DONA) A Swizz foundation which acts as the Global Handle Registry for the DOA or handle system.

direct supervision Concept in Mintzberg (1993) to describe a regime were a direct supervisor is in charge of deciding what gets done.

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.

DNS over HTTPS (DoH) DNS over **Hypertext Transfer Protocol Secure (HTTPS)**, a protocol which essentially wraps a DNS-request in a HTTPS-request. HTTPS normally runs over **Transmission Control Protocol (TCP)**.

DNS over TLS (DoT) DNS over **Transport Layer Security (TLS)**, a protocol which essentially wraps a DNS-request in a TLS-tunnel.

DOCSIS The primary protocol used by cable-TV, the earlier versions defined the whole stack and did not allow for custom data (such as **Internet Protocol (IP)**-based traffic), the later version of DOCSIS allow for custom traffic. Important is that DOCSIS allows for one primary network controller and several clients, this means that several connections share the same physical cable.

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.

Domain Name System Security Extensions (DNSSEC) A version of **DNS** which supports cryptographic verification of responses, in essence the ability to verify the validity of the answers. Requires pre-delegated trust to work.

Dynamic Host Configuration Protocol (DHCP) A protocol for configuring stateful hosts, common on IPv4 networks, and is supported but not recommended on IPv6 networks.

edge A technical term to describe the edge of the Internet or more correctly the edge of an AS. A normal Internet user is at the edge of the Internet. There are certain functions which are only meaningful at the edge, such as filtering on source **IP**-address of traffic coming into the network.

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**.

Empowered Community 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**.

epistemic community A group or smaller community, such as a part of 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).

Federal Communications Commission The FCC is an independent federal agency of the United States. Oversees and is in charge of telecommunications regulation in the United States.

File Transfer Protocol (FTP) Protocol for transferring files. Ostensibly better than **Hypertext Transfer Protocol (HTTP)** at that in a technical sense, but due to standards and common availability HTTP is often used instead in a web-context.

For Your Information (FYI) An **Request for Comments (RFC)** stream aimed at providing informational RFCs. The stream is no longer active.

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 **Fully Qualified Domain Name (FQDN)**, while `www.google` is not. Technically very important to distinguish **Fully Qualified Domain Names (FQDNs)** from other domain names when configuring **Domain Name System (DNS)**.

future vertical communications network Essentially the same concept as “**new IP**”, they are commonly mentioned in the same texts, but are never clearly differentiated. Richard Li in Mueller (2020) frames **future vertical communications network** as the larger concept which “**new IP**” can be seen to be a part or implementation of.

General Data Protection Regulation (GDPR) An EU-level treaty regarding 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”.

Generic Names Supporting Organization (GNSO) Membership organization for gTLDs. Is a part of the Empowered Community.

generic top-level domain (gTLD) Highest level domains in **DNS** used for, in essence, all purposes except those related to **country code top-level domains (ccTLDs)**.

governance The formal top-down component of **coordination** in this thesis, in other **thought collectives** could describe the entirety of something’s governance.

Governmental Advisory Committee (GAC) Part of the ICANN Empowered Community, represents governments.

HAR file A HAR file is a HTTP archive file which contains, normally, a browsing session. Technically it is a JSON-object populated with HTTP-requests and replies.

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.

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).

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.

implementation of technology The notion of implementation **technology**, in essence its physical manifestation. Describes actual technology, not the processes of implementing technology.

incommensurable In Fleck (1935/1979) used to describe the non-matching of different **thought styles** and therefore their inability to agree on what is scientific fact and what is not.

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**.

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 **Internet Exchange Points (IXPs)**, **Internet Service Providers (ISPs)**, fiber owners, fiber operators, municipal communications companies, etc. I use infrastructure *and* network operators to capture all involved actors, as there are difference between infrastructure operators, network operators, and communications operators.

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.

International Telecommunications Regulation (ITR) A regulation intended to govern international telecommunications set at the ITU. There have been two meetings in modern times for setting ITRs, WATTC-88 and WCIT-2012.

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).

Internet The concept of a best-effort bottom-up coordinated digital network, formally defined in this thesis as *an architecture and set of protocols for best-effort digital end-to-end communication effected by its users through*

adhocratic processes based on ideals of design for interoperability. 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 does not guarantee delivery.

Internet Architecture Board (IAB) Committee of the **IETF** who, in general, provides **IESG** oversight and **IESG** confirmation. Previously Internet Activities Board.

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.

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.

Internet Coordination The concept of coordinating the Internet. A preferable term to **Internet Governance** since the Internet can be argued to be coordinated rather than governed.

Internet Corporation for Assigned Names and Numbers (ICANN) Non-profit based in California tasked with overseeing the **IANA**-function. Rewrote their bylaws in 2016. Often implicitly assumed to govern the Internet.

Internet Engineering Steering Group (IESG) In practice the board of the **IETF** and editor of the RFC document stream.

Internet Engineering Task Force (IETF) One of the sub-groups in **ISOC**. Is the *de facto* proposer of **Internet Standards**. Does not enforce in a regulatory sense.

Internet Exchange Point (IXP) Wholesaler of Internet peering services, practically where **Internet Service Providers (ISPs)** exchange traffic.

Internet Experimental Note (IEN) Similar to a RFC in design, the IENs were made by Internet people not involved in the DARPA-project (simplifying a bit). Around the time ARPANET switched to TCP/IP the IEN series was discontinued, and essentially all new IENs became RFCs.

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”. I use **Internet Coordination** in this thesis.

Internet Governance Forum (IGF) Successor to **World Summit on the Information Society (WSIS)** from 2006, an annual **UN** supported forum for policy dialogue on Internet Governance.

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, 1981b) and its amendments for technical details.

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.

Internet Service Provider (ISP) Wholesaler of Internet services. Does not have to own infrastructure. In some jurisdictions it is common to own the entire communications stack, from canalization to service offering, in other jurisdictions other models are more common.

Internet Society (ISOC) Prime member of the technical universe. Administrative seat of the **IETF**.

Internet Standard A standard of the **IETF** RFC standards track, which is formally known as “the Internet Standards track” which constitutes those RFCs known as Internet Standards.

Internet Systems Consortium A public benefit which operates one root server and is in charge of developing **BIND**, the most common **Domain Name System (DNS)** server software.

internetification Used as the act of a non-Internet entity or actor using principles of Internet Coordination to solve problems. For example, **OpenRAN** can be argued to be **internetification** of radio-networks.

Internet-model An ex-post explanation of how the Internet works. In contrast to the **OSI-model**, which is prescriptive, the **Internet-model** aims to capture how the actually Internet works, rather than how it should work.

Internet-of-Things (IoT) The notion of automations using the Internet for communication.

interoperability thought style The interoperability perspective focus on the notion of building for change, often through interoperability. That is, the intrinsic value of preparing for change is more important than any other notion.

IPv4 Version number 4 of **IP**. Most used version today. Standardized in RFC-791 (Postel, 1981b). IPv4 is intended to let other layers offer quality of service.

There are no mechanisms to augment end-to-end data reliability, flow control, sequencing, or other services commonly found in host-to-host protocols. The internet protocol can capitalize on the services of its supporting networks to provide various types and qualities of service.

(RFC-791, Postel, 1981b, p. 1)

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. Described in RFC-1883 (Deering & Hinden, 1995) and standardized in RFC-8200 (Deering & Hinden, 2017).

ISO-3166-1 An ISO-standard representing country codes. The standard includes regions with economic activity, so all entries are not sovereign entities. Examples include many island nations.

IT-artifact A sociomateriality construct to represent technology, in this thesis not to be confused with **information technology (IT)**.

ITU Council The **International Telecommunications Union (ITU)** board for all practical purposes. Consists of roughly 40 members which act as leaders of the ITU between **ITU Plenipotentiarys**.

ITU Plenipotentiary The ITU quad-annual chapter meeting. Convenes every four years and usually handles “business as usual”. Commonly the ITU Plenipotentiary calls for specific extra meetings, for example **International Telecommunications Regulation (ITR)** meetings such as the **World Conference on International Telecommunications (WCIT)**, instead of treating larger issues at the ITU Plenipotentiary.

ITU Radiocommunications (ITU-R) A sector of ITU focused on radio communication, such as radio spectrum.

ITU Telecommunications Development Sector (ITU-D) A sector of ITU which focus on the developing world, and assists where it can.

ITU Telecommunications Standards Sector (ITU-T) A sector of ITU focused on telecommunications standards.

layer violation The notion that one (abstraction) layer in a structure is affecting (abstraction) layers above or below it.

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.

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**.

Makefile The file containing the descriptions for one or several **make**-processes.

market thought style The market perspective takes the values of, for example, a for-profit looking to capture value. In the market perspective the value of technology is set by how much it helps value capture.

Memorandum of Understanding 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.

meta-coordination The notion of coordinating future or upcoming coordination, in essence a meta-level of coordination.

mutual adjustment Concept in Mintzberg (1993) to describe a regime what is done is decided by what can be said to be mutual agreements and consensus.

naming An overview term for handling the unique naming resources of the Internet, such as domain-names handles through **DNS**. Coordinated by the **IANA**-function.

national regulatory authority National authority for regulation of a specific area, in this thesis national regulatory authorities will refer to the telecommunications regulator.

National Security Agency (NSA) A United States governmental 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.

National Telecommunications & Information Administration (NTIA) United States public entity formally residing within the Department of Commerce. **ICANN** previously operated under scrutiny of NTIA.

nation-state Sovereign nation-state. This thesis uses sovereign nation-state as defined by the **United Nations (UN)**, which for all practical purposes are the members of the UN.

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 standards absent potential technical harm to networks or their users*.

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).

“new IP” A suggested replacement for IP suggested in a ITU-T committee. The standard is not (yet) formalized, and the current suggestion is different from IP both in terms of technology and coordination. See Jiang et al. (2019), Lehman (2020), and Li (2020) for the motivations and available material.

Nominating Committee A committee which suggests (and sometimes appoints) board members. Both **ICANN** and **IETF** have their own view of **Nominating Committees**.

Number Resource Organization (NRO) Coordinator entity where the **Regional Internet Registries (RIRs)** are constituents.

numbering A term for the service provided by the **IANA**-function through RIRs in which **IP**-addresses and **Autonomous System Numbers (ASNs)** are distributed and coordinated, i.e., coordination of the unique numbers of the Internet. A requirement for routing.

OpenRAN Stands for *Open Radio Access Networks*, and is a modularized version of building and maintaining radio access networks in manner similar to the Internet-model.

OSI-model An ex-ante model of how networks should be built. It is a prescriptive model of how to build networks, and is a part of the ISO-standards extended family.

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.

prefix A bundle or group of IP-addresses. A prefix, due to its technical constituency, represents an interval of IP-addresses. Example, 192.168.0.1/24 represents all addresses matching 192.168.0.XX, where the /24 that the 24-first bits (out of 32) are significant.

Public Interest Registry (PIR) A registry for public interest domains, controls (among others) dot-org, dot-ngo and dot-ong. Finances **ISOC** to a large extent.

public protection and disaster relief An umbrella term for departments concerned with security, safety and defense. **public protection and disaster relief** radio communications is a heavily debated topic, and there are legislative **public protection and disaster relief** 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.

Public Technical Identifiers (PTI) Administrative and legal entity for the **IANA**-function.

QUIC A protocol aimed at replacing TCP. QUIC, originally an abbreviation for “Quick UDP Internet Connections”, is currently the name of a Google sponsored **User Datagram Protocol (UDP)** and TCP replacement. In practice QUIC is similar to running a smarter TCP on top of UDP, where it is possible for the user to configure the level of transmission control (e.g., fire-and-forget or ensure delivery). Currently, the QUIC draft is at the 31st revision (draft available as Iyengar & Thomson, 2020) and is expected to pass muster for a proper RFC number in the near future (at the defense of this thesis it is likely a RFC on its way to Internet Standard). I have encountered QUIC with two different meanings: (1) QUIC as a transport protocol (as in Iyengar & Thomson, 2020), and (2) as HTTP version 3. Google QUIC was originally an evolution of HTTP over TCP. This thesis discusses the transport protocol as QUIC.

raison d'être Justification for existence, used in this thesis as the core meaning or core justification for existence. There might be different core justifications depending on thought style.

Regional Internet Registry (RIR) An often non-profit entity coordinating IP-address and ASN allocation in a geographic region.

Request for Comments (RFC) The document stream managed by the IETF through the IESG. In an academic perspective RFCs can be seen as manuscript suggestions which have to pass and be approved by an editorial board (the IESG). In essence RFCs define all Internet Standards and processes related to the IETF.

Réseaux IP Européens Network Coordination Centre (RIPE NCC) The operations part of the community group RIPE. RIPE NCC is the registry.

Resource Public Key Infrastructure (RPKI) An implementation of Public Key Infrastructure (PKI) for use with BGPsec in routing. The RPKI system is anchored by the Regional Internet Registries. While Domain Name System Security Extensions (DNSSEC) is anchored in one root-zone maintained by ICANN, RPKI is anchored in the seven Regional Internet Registries.

Revised Directive on Security of Network and Information Systems (NIS-2) Suggested EU-level directive on the security and stability of essential services in the union. At the defense of this thesis the revised directive has been up for comment but not voted on. Note that in EU terminology it is not regulation, but a directive. The difference is that regulation is implemented at EU-level, while directives are implemented at member-level, i.e., nation-state-level.

Root Server System Advisory Committee (RSSAC) Advisory committee of ICANN *not* part of the Empowered Community.

root-zone The technical name for a top zone in the DNS system. The term usually refers to the root-zone managed by the IANA-function, but in a technical sense many root-zones can exist. In practice IANA prepares the root-zone-file which is distributed to root-zone operators who for all intents and purposes answer queries for the root-zone.

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)

Secure Shell (SSH) A layer-based protocol for secure remote communication. Technically separated into two main bodies (SSH-1 and SSH-2, where SSH-1 is obsolete) and four layers (transport, authentication, connection, and resolution (often not used)).

Secure Sockets Layer (SSL) A today outdated cryptographic protocol for communication security. Succeeded by **TLS**.

Security and Stability Advisory Committee (SSAC) Advisory committee of ICANN *not* part of the Empowered Community.

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 from the executive and the judicial power.

Session Initiation Protocol (SIP) Application level protocol primarily for voice communications. Works over both IP and cellular service.

Simple Mail Transfer Protocol (SMTP) A simplistic protocol for sending mail. Is the standard protocol for sending mail, and virtually all mail services except those using Microsoft Exchange use **Simple Mail Transfer Protocol (SMTP)** for sending mail (in one for or another, for example Gmail use modified version of both IMAP and SMTP).

sociomateriality A concept coined in Orlikowski (1992) which aim to describe the duality of 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.

sponsored generic top-level domain (sTLD) A **TLD** sponsored by an organization for a specific purpose, such as dot-coop, dot-xxx and dot-post.

standard In this thesis used as the formulation of technology, and can be constructed both ex-ante and ex-post in relation to the actual implementation of technology.

standardization of outputs Concept in Mintzberg (1993) to describe a regime where outputs are standardized.

standardization of skills Concept in Mintzberg (1993) to describe a regime where training and skills are standardized.

standardization of work process Concept in Mintzberg (1993) to describe a regime where work is standardized by its processes (rather than for example training or specifications of outputs).

standards formulation The notion of formulation of the standards of technology, in essence the plans behind or the descriptions of the actual implementation or the descriptions of implementations.

Supporting Organization Address Supporting Organization (ASO), Country Code Names Supporting Organization (ccNSO) and Generic Names Supporting Organization (GNSO) are the Supporting Organizations of ICANN.

Swedish Internet Foundation 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. Was previously divided into two distinct entities, the foundation (i.e., IIS) and the firm (i.e., NIC-SE), but is today run as one entity. For transparency, the Swedish Internet Foundation also funded the later part of this thesis, therefore the ccTLD for dot-se is mentioned explicitly in the text so that readers can be aware that it is not the opinion of any arbitrary ccTLD (or rather the leadership of), but the express opinion of the organization funding the finalization of this thesis.

Technical Expert Group Group consisting of ICANN-board, Technical Liaison Group and invited participants. Formal task: The Technical Expert Group 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.

Technical Internet Governance A term coined by ICANN which differentiates Internet Governance as policy from Internet Governance as coordination of technology. The terminology is not particularly well-defined.

Technical Liaison Group Group of technical experts tasked with providing technical advice to the ICANN-board.

technology In this thesis I use technology broadly to define the material aspects of the Internet. I discuss two technology components in detail: implementation of technology and standards formulation.

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 as a concept.

thought collective According to Fleck (1935/1979), a collection of thought styles a community of people who exchange ideas or interact with one another and who collectively are bearers of a thought style, a certain body of knowledge and culture and its historical development. Fleck (1935/1979) uses thought collectives to explain scientific communities and the **incommensurable**.

thought style According to Fleck (1935/1979), the style of thought of making sense of reality and everything in it maintained and developed by a thought collective.

top-level domain (TLD) The highest level domains in **DNS**, and are broadly categorized into three types (available in the root-zone); ccTLDs (such as dot-se and dot-de), **generic top-level domains (gTLDs)** (such as dot-com or dot-org) and infrastructure domains (dot-arpa).

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.
(RFC-793, Postel, 1981c, p. 1)

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**.

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.

United Nations (UN) Member-organization for nation states.

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.
(RFC-768, Postel, 1980, p. 1)

See RFC-768 (Postel, 1980) and its amendments for technical details.

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 trucks have to roads, i.e., they are clearly connected but also clearly conceptually different. The web is technically not limited to run over the Internet, but practically is mostly used over the Internet, just as trucks can drive on other surfaces, but mostly drive on road.

WHOIS WHOIS is a service for looking up the administrative and technical contact for unique identifiers, including both names and numbers.

working group **Internet Engineering Task Force (IETF)** unit which works on a particular topic. Working groups are not overly formal and are composed on a best-effort basis.

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.

World Summit on the Information Society (WSIS) Precursor to IGF, a **UN** supported discussion forum.

World Wide Web Consortium (W3C) A non-profit working on web-standards (i.e., explicitly not Internet Standards).

xDSL Technology used to send digital data over telephone line copper. Subscribers have one line per subscriber, so there is no sharing of physical infrastructure as with **DOCSIS**.

Acronyms

AI artificial intelligence

ALAC At-Large Advisory Committee

API Application Programming Interface

AS Autonomous System

ASN Autonomous System Number

ASO Address Supporting Organization

BCP Best Current Practice

BGP Border Gateway Protocol

bTLD brand top-level domain

ccNSO Country Code Names Supporting Organization

ccTLD country code top-level domain

CDN Content Delivery Network

CIDR Classless Inter-Domain Routing

DARPA Defense Advanced Research Projects Agency

DDoS distributed denial of service

DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DNSSEC	Domain Name System Security Extensions
DOA	Digital Object Architecture
DoH	DNS over HTTPS
DOI	Digital Object Identifier
DONA	Digital Object Numbering Authority
DoT	DNS over TLS
EFF	Electronic Frontier Foundation
FQDN	Fully Qualified Domain Name
FTP	File Transfer Protocol
FYI	For Your Information
GAC	Governmental Advisory Committee
GDPR	General Data Protection Regulation
GNSO	Generic Names Supporting Organization
gTLD	generic top-level domain
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IAB	Internet Architecture Board
IANA	Internet Assigned Numbers Authority
IAOC	IETF Administrative Oversight Committee
ICANN	Internet Corporation for Assigned Names and Numbers
ICMP	Internet Control Message Protocol
IEN	Internet Experimental Note
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force

IGF Internet Governance Forum

IoT Internet-of-Things

IP Internet Protocol

IRTF Internet Research Task Force

ISOC Internet Society

ISP Internet Service Provider

IT information technology

ITR International Telecommunications Regulation

ITU International Telecommunications Union

ITU-D ITU Telecommunications Development Sector

ITU-R ITU Radiocommunications

ITU-T ITU Telecommunications Standards Sector

IXP Internet Exchange Point

NAT Network Address Translation

NIS-2 Revised Directive on Security of Network and Information Systems

NRO Number Resource Organization

NSA National Security Agency

NTIA National Telecommunications & Information Administration

PIR Public Interest Registry

PTI Public Technical Identifiers

RFC Request for Comments

RIPE NCC Réseaux IP Européens Network Coordination Centre

RIR Regional Internet Registry

RPKI Resource Public Key Infrastructure

RSSAC Root Server System Advisory Committee

SIP Session Initiation Protocol

SMTP Simple Mail Transfer Protocol

SSAC Security and Stability Advisory Committee

SSH Secure Shell

SSL Secure Sockets Layer

sTLD sponsored generic top-level domain

TCP Transmission Control Protocol

TLD top-level domain

TLS Transport Layer Security

UDP User Datagram Protocol

UN United Nations

W3C World Wide Web Consortium

WATTC World Administrative Telegraphy and Telephone Conference

WCIT World Conference on International Telecommunications

WGIG Working Group on Internet Governance

WSIS World Summit on the Information Society

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DISSERTATIONS FROM THE SWEDISH RESEARCH SCHOOL OF MANAGEMENT AND INFORMATION TECHNOLOGY

Doctoral theses (2003-)

1. **Baraldi, Enrico (2003)**, *When Information Technology Faces Resource Interaction: Using IT Tools to Handle Products at IKEA and Edsbyn*. Department of Business Studies, Uppsala University, Doctoral Thesis No. 105.
2. **Wang, Zhiping (2004)**, *Capacity-Constrained Production-Inventory Systems: Modelling and Analysis in both a Traditional and an E-Business Context*. IDA-EIS, Linköpings universitet och Tekniska Högskolan i Linköping, Dissertation No. 889
3. **Ekman, Peter (2006)**, *Enterprise Systems & Business Relationships: The Utilization of IT in the Business with Customers and Suppliers*. School of Business, Mälardalen University, Doctoral Dissertation No 29.
4. **Lindh, Cecilia (2006)**, *Business Relationships and Integration of Information Technology*. School of Business, Mälardalen University, Doctoral Dissertation No 28.
5. **Frimanson, Lars (2006)**, *Management Accounting and Business Relationships from a Supplier Perspective*. Department of Business Studies, Uppsala University, Doctoral Thesis No. 119.
6. **Johansson, Niklas (2007)**, *Self-Service Recovery*. Information Systems, Faculty of Economic Sciences, Communication and IT, Karlstad University, Dissertation KUS 2006:68.

7. **Sonesson, Olle (2007)**, *Tjänsteutveckling med personal medverkan: En studie av banktjänster*. Företagsekonomi, Fakulteten för ekonomi, kommunikation och IT, Karlstads universitet, Doktorsavhandling, Karlstad University Studies 2007:9.
8. **Maaninen-Olsson, Eva (2007)**, *Projekt i tid och rum: Kunskapsintegrering mellan projektet och dess historiska och organisatoriska kontext*. Företagsekonomiska institutionen, Uppsala universitet, Doctoral Thesis No. 126.
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13. **Myreteg, Gunilla (2007)**, *Förändringens vindar: En studie om aktörsgrupper och konsten att välja och införa ett affärssystem*. Företagsekonomiska institutionen, Uppsala universitet, Doctoral Thesis No. 131.
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17. **Hansson, Magnus (2008)**, *On Closedowns: Towards a Pattern of Explanation to the Closedown Effect*. Örebro University School of Business, Örebro University, Doctoral Thesis No. 1.
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20. **Henningsson, Stefan (2008)**, *Managing Information Systems Integration in Corporate Mergers & Acquisitions*. Institute of Economic Research, Lund Studies in Economics and Management No. 101.
21. **Ahlström, Petter (2008)**, *Strategier och styrsystem för seniorboende-marknaden*. IEI-EIS, Linköping universitetet och Tekniska Högskolan i Linköping, Doktorsavhandling, Nr. 1188.

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