Towards an Approach for Efficiency Evaluation of Enterprise Modeling Methods

by

Banafsheh Khademhosseinieh
This is a Swedish Licentiate’s Thesis

Swedish postgraduate education leads to a Doctor’s degree and/or a Licentiate’s degree. A Doctor’s degree comprises 240 ECTS credits (4 years of full-time studies). A Licentiate’s degree comprises 120 ECTS credits.

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ABSTRACT

Nowadays, there is a belief that organizations should keep improving different aspects of their enterprise to remain competitive in their business segment. For this purpose, it is required to understand the current state of the enterprise, analyze and evaluate it to be able to figure out suitable change measures. To perform such a process in a systematic and structured way, receiving support from powerful tools is inevitable. Enterprise Modeling is a field that can support improvement processes by developing models to show different aspects of an enterprise. An Enterprise Modeling Method is an important support for the Enterprise Modeling. A method is comprised of different conceptual parts: Perspective, Framework, Method Component (which itself contains Procedure, Notation and Concepts), and Cooperation Principles. In an ideal modeling process, both the process and the results are of high quality. One dimension of quality which is in focus in this thesis is efficiency. The issue of efficiency evaluation in Enterprise Modeling still seems to be a rather unexploited research area.

The thesis investigates three aspects of Enterprise Modeling Methods: what is the meaning of efficiency in this context, how can efficiency be evaluated and in what phases of a modeling process could efficiency be evaluated. The contribution of the thesis is an approach for evaluation of efficiency in Enterprise Modeling Methods based also on several case studies. The evaluation approach is constituted by efficiency criteria that should be met by (different parts of) a method. While a subset of these criteria always need to be fulfilled in a congruent way, fulfillment of the rest of the criteria depends on the application case. To help the user in initial evaluation of a method, a structure of driving questions is presented.

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This thesis was performed within infoFLOW-2 project, that was funded by KK-foundation. infoFLOW-2 was a research project with a relatively large number of partners: four industrial partners (SYSteam, C-Business, Proton Finishing, CIL Ljungby), one research institute (Fraunhofer ISST) and one academic partner (Jönköping Tekniska Högskolan: JTH).

Here I would like to thank people, who helped me throughout my research process. I am very much thankful to my main supervisor Kurt Sandkuhl, and my co-supervisors Ulf Seigerroth and Sture Hägglund for their positive attitudes as well as all their worthy comments and guidelines. I am also thankful to participants of infoFLOW-2. Without their cooperation, it was not possible to receive support from this project for the purpose of this thesis.

My especial thanks goes to my family for all their encouragements: to my parents for their patience, when I had to spend most of my time in the office, sitting in front of my computer or being lost under books and papers; to my sister Bahar, that kept motivating me and was supportive all the way, despite living in another continent.

Thank you all,

Banafsheh Khademhosseinieh

March 2013, Jönköping
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1. Introduction

This thesis concentrates on investigating the meaning and implications of efficiency in the context of Enterprise Modeling (EM), as well as how to evaluate efficiency in an EM process. For this purpose, this first chapter presents an introduction to the problem domain and motivation for the pursued problems in section 1.1. This is followed by the list of the relevant publications in section 1.2. Section 1.3 indicates what chapters comprise the thesis.

1.1 Background and Motivation

Today there is a general agreement that organizations continuously need to improve themselves in order to stay competitive (Abdiu et al., 2005). These continuous improvements are usually related to different aspects of an enterprise for instance structural, behavioral and informational (Fox & Gruninger, 1999). In order to obtain sustainable improvements, it is usually argued that it is beneficial to have a clear understanding of the current state and the future state. As Harmon (2010) has put it, improvement is a transition process that entails actions of taking a business from a current state (AS-IS) into an improved state, which is regarded as something better (TO-BE). Going through such an improvement process usually means going through a couple of generic phases such as understanding the current situation, evaluation of the current situation, formulating suitable and relevant change actions, and implementing these actions (Hayes, 2007). Such an improvement process also needs to be performed in a structured and rational way and in order to achieve this we usually rely on and seek guidance in different theories, methods, tools etc. In the context of EM this is usually done through different types of activities supported by modeling methods where different aspects of the enterprise are elucidated through different types of conceptual models (Dietz, 2008), e.g. process models, information demand models, goal models, problem models, competence models etc. EM with its different modeling components can therefore be used as a powerful tool in the transformation process where an enterprise wants to improve (Seigerroth, 2011).

Another motive for enterprises to seek support in EM is that they need to deal with complexity, both within and between enterprises (Carstensen, 2011). “Enterprise Modeling tries to capture into models the knowledge about the objectives, processes, organization, roles,
resources and concepts that are of interest for solving particular problems within an enterprise or a network of collaborating enterprises” (ibid).

In the section above EM has been argued for as a suitable support for improvement processes. Vernadat (2002) has broken this down into more details in a number of motivations for the usefulness of EM:

- “managing system complexity by understanding how the enterprise works,
- capitalization of enterprise knowledge and know-how,
- enterprise engineering and continuous process improvement,
- better management of all types of processes, and enterprise integration”.

In an enterprise, all or just a subset of the listed examples might be helpful. Each item in the list has a generic meaning that can be translated and adapted differently in each application case. In other words, it is the potential applier of EM that has to ensure that it will support the goals of the enterprise.

As touched upon earlier, there are a number of different types of artifacts that can be used as support for EM. Examples of such artifacts are computerized tools, methods, frameworks etc. (Ghidini et al., 2008; Rolstadås & Andersen, 2000; Kaidalova, 2011). One issue in this context is to choose the most suitable support for the specific situation at hand. Methods that are implemented in a computerized tool are usually a powerful support for EM. The main reason for this is that methods by nature provide guidelines and useful instructions for ways of working that is understandable for a broad EM audience (Tissot & Crump, 2006).

EM and the models that are produced can be used for different purposes. One common purpose is to use them as instruments in a change process to address different aspects such as; improvement in interoperable business processes (Bernus, 2003), ensuring quality of operations and business development (Persson & Stirna, 2001), decision making, communication and learning (Bernus, 2001). Methods and computerized tools are in different ways expected to ensure quality both in the work process and in the results that are produced during the work process (e.g. cf. (Seigerroth, 2011)).

The concept of quality is a broad concept, which can be perceived and interpreted in different ways. In a general sense, quality is understandable by everyone. But if we elaborate briefly on the quality concept then we must acknowledge a variety of meanings. According to (Sallis, 2002) some of the confusion over the meaning of quality arises because it can be used both as an absolute and a relative concept. One way of dealing with this confusion is to boil down the
quality notion into a set of sub-criteria for a specific context, in this thesis the context is Enterprise Modeling Method (EMM).

In a review of the current literature different criteria sets for quality can be identified, for example efficiency (Shah et al., 2011; Ortega et al., 2003; Kim et al., 2006), reliability (Wolfinbarger & Gilly, 2003; Madu & Madu, 2002), understandability (Cox & Dale, 2001; Ortega et al., 2003), performance (Al-Tarawneh, 2012; Yang et al., 2003), durability (Garvin, 1978), etc. The efficiency dimension of EMM seems to be partly neglected in the literature and therefore it is relevant and worthwhile to explore the concept in this study. Efficiency is mostly defined as the ratio between input and output (Priem & Butler, 2001). This is an emphasis on the fact that in carrying out a process the focus is not only on obtaining the intended results but also on the usage of resources. To have an efficient process, it should be possible to complete it by following predefined work procedures without waste of resources or unexpected side effects.

An EM process, which is about applying an EMM to produce enterprise models, is expected to be of high quality where efficiency is an important dimension of quality. Efficiency in application of EMM means that, on the one hand the generated models should be useful as basis for change, and on the other hand that resource have not been wasted but used in a purposeful way. The issue of efficiency is therefore relevant in all stages of an EM process, i.e. from the start of the process until all models are completed and used for their designated and intended purpose.

To elaborate a bit more on the quality dimension we can recognize different scopes of modeling quality that have been addressed by different researchers. These different modeling scopes are for example focusing on quality of modeling languages, modeling processes and models by themselves. A subset of these modeling scopes focus only on defining the quality criteria, while others include suggestions regarding how to evaluate fulfillment of the criteria and even how to improve them (e.g. cf. Maier, 1999; Moody et al., 2002; Moody, 2005; Krogstie et al., 2006; Frank, 2007). Despite considerable efforts dedicated to quality in different aspects and scopes of modeling and the fact that efficiency is an important dimension of quality, no investigation regarding efficiency evaluation of EMM has yet been done. This thesis will focus on quality dimensions of EMM based on the following research questions:

- RQ 1. What is the meaning of efficiency in the context of EMM?
- RQ 2. How can the efficiency of an EMM be evaluated?
• RQ 3. In what phases of an EM process could method efficiency be evaluated?

1.2 Related Publications by the Author
This thesis is authored as a monograph. However, parts of it have been published previously. A list of relevant publications is presented below:


1.3 Thesis Outline
This thesis consists of eight chapters. Chapter 1 (the current chapter), provides a brief motivation for conducting this research. The chapter states the issue of efficiency evaluation in EM as the core of the research and clarifies what research questions should be answered. Chapter 2 elucidates why abductive reasoning was the suitable choice for this work, how design science as a research discipline and how case studies as a research method were applied in investigating the research questions. It is also clarified what research path was followed. All these are presented in order to clarify that the research questions are addressed in a scientifically valid manner. Chapter 3 fulfills different aims. First, it sheds light on the
foundational concepts to the thesis, as it is necessary to have a clear understanding of the core concepts exactly mean. Second, chapter 3 supports the understanding of how the topic of quality evaluation in modeling has been approached. These two chapters provide the required (theoretical) background to the audience for following the rest of the thesis, i.e. the research contributions, the evaluation outcomes, discussions, conclusions and future work. Third, chapter 3 presents conclusions that underline the topic of efficiency evaluation that has not been touched on by other researchers, yet. Chapter 4 contains introductions to the research projects and EM cases that were selected for performing case studies. The EM case studies motivated the research described in this thesis and were used for developing the research results. It is explained what problems in the EM case studies that were identified and how they motivated conducting this research. The research contributions are presented in chapter 5. It first clarifies the phenomenon of efficiency in EM and EMM. Following this, the main part of the contribution, which is an approach for efficiency evaluation of EMMs, is presented. It is also explained how this approach should be used in practice. Chapter 6 presents results from validation of the research contributions, i.e. the efficiency evaluation approach that is proposed in chapter 5. The validation process was conducted using two EM cases (different from those followed in developing the results). Chapter 6 starts by an introduction about EM cases used for validation. This is followed by presenting reflections on the efficiency evaluation approach. To resolve issues identified in the reflections, some refinements, that were found necessary for the developed approach, are presented at the end of the chapter. Chapter 7 entails discussions about different topics: answers to the research questions posed in chapter 1, reflection on the followed research discipline (design science) and some lessons learned while conducting the EM cases. Both (EM) case studies that helped in developing contributions and validation cases contributed in learning these lessons. The thesis ends with chapter 8 that contains conclusions about the research contributions and possibilities for future work.

Figure 1 shows how different chapters are related to each other and how understanding a chapter aids in understanding the rest. Table 1 contains guides relevant to Figure 1 and clarifies how different chapters support each other. The table has two columns. Column “Sign” contains different possible combinations of elements and relationship types that are used in Figure 1. Column “Elucidation about the Sign” contains explanations on the presented signs.
### Table 1: Guide relevant to Figure 1

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<th>Elucidation about the Sign</th>
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<tr>
<td><img src="image" alt="Chapter A" /></td>
<td>Clarifies how Chapter A contributed in providing information/material needed for performing tasks that result in gaining contents of Chapter B.</td>
</tr>
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<tr>
<td><img src="image" alt="Chapter C" /> <img src="image" alt="Chapter D" /></td>
<td>Clarifies how Chapter C aids in understanding Chapter D.</td>
</tr>
<tr>
<td><img src="image" alt="Chapter E" /> <img src="image" alt="Chapter F" /></td>
<td>Clarifies how Chapter E provides complementary support for following Chapter F (Parts of Chapter E were used in developing Chapter F. One aim of authoring Chapter F was developing contents relevant and complementary to Chapter E).</td>
</tr>
</tbody>
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2. Research Method
3. Theoretical Background & Frame of Reference
4. Enterprise Modeling Case Studies
5. Efficiency Evaluation in Enterprise Modeling
6. Empirical Validation of the Efficiency Evaluation Approach
7. Discussion
8. Conclusions & Future Work

Figure 1: Logical relations between the thesis chapters
2. Research Method

In all research, scholars attempt to conduct their work in a systematic and scientifically valid way. The current chapter clarifies how the research in this thesis was conducted. The chapter starts by giving explanations to the research approach, discipline and method followed in this thesis (see section 2.1). In section 2.2 the research path followed for carrying out the research is elaborated schematically.

2.1 The Followed Research Approach, Discipline and Method

To perform scientific work, it is necessary to be aware of different research approaches and research disciplines. In section 2.1.1 a brief introduction is given about inductive, deductive and abductive approaches. Following this, it is explained what approach was followed for the purpose of this thesis. Section 2.1.2 contains an introduction to design science, that is a commonly followed discipline in Information Systems science, and how it is positioned in this research. Section 2.2.3 contains an explanation on the case study method and its application in the thesis.

2.1.1 Abductive Approach

According to the Oxford Dictionaries\(^1\), an approach is “a way of dealing with a situation or problem”. A research approach, or as Elalfi et al. (2009) state, a reasoning style, is “the process of using existing knowledge to draw conclusions, make predictions, or construct explanations. Three methods of reasoning are the deductive, inductive, and abductive approaches. Deductive reasoning starts with the assertion of a general rule and proceeds from there to a guaranteed specific conclusion. Inductive reasoning begins with observations that are specific and limited in scope, and proceeds to a generalized conclusion that is likely, but not certain, in light of accumulated evidence. One could say that inductive reasoning moves from the specific to the general. Abductive reasoning typically begins with an incomplete set of observations and proceeds to the likeliest possible explanation for the set”. Abductive reasoning is defined also as the combination of inductive and deductive reasoning. This means that an approach is developed using deductive reasoning, followed by testing with the use of inductive reasoning (Samuels, 2000). While inductive reasoning supports development of new theories and deductive reasoning supports explaining specific cases based on the

\(^1\) www.oxforddictionaries.com
existing theories, abductive reasoning supports delivering new things (Lindström & Polyakova, 2010). Any of the mentioned research approaches support a different purpose. Researchers should have comprehensive knowledge about the weaknesses and strengths of different approaches as well as the needs and possibilities in the intended research to be able to decide what approach is more suitable.

In conducting the research in this thesis, the abductive approach was followed. This approach was selected based on the goal of the research. According to the above paragraph, inductive approach is suitable for cases where a new theory (or “thing”) is going to be developed and deductive approach supports legitimatizing real life cases with the help of existing theories. In fact, the abductive approach is applicable for cases that entail conditions for both inductive and the deductive reasoning. According to (ibid) that states abductive reasoning helps in developing new things, initial development and evaluation can be covered by the abductive reasoning style. In this thesis the aim was developing a new thing (artifact) for efficiency evaluation of EMMs (presented in chapter 5). The initial results were required to be evaluated (validated). Results of this validation are presented in chapter 6). Accordingly, the abductive approach was found to be a suitable choice for the purpose of this research.

2.1.2 Design Science

The purpose of research is “to advance knowledge and the scientific process” (Dennis & Valacich, 2001). Such advancement can be achieved by answering questions, which results in obtaining new knowledge (Marczyk et al., 2010). This means the contributed results have to be novel (Ghauri, 1995).

In the context of Information System (IS) research, behavioral science and design science are examples of the foundational research paradigms (Hevner et al., 2004). As it is stated in the Oxford Dictionaries\(^2\), discipline is ”a system of rules of conduct”. In comparison to approaches, disciplines provide more concrete and more precise ways for performing works. Behavioral science and design science support addressing two key issues in IS: the central role of the IT artifact in IS research (Weber, 1987; Orlikowski & Iacono, 2001; Benbasat & Zmud, 1999) and addressing the perceived lack of relevance of IS research to the business community (Benbasat & Zmud, 1999). The design science paradigm has its roots in engineering and the sciences of the artificial (Simon, 1996). It is fundamentally a problem-solving paradigm. Design science seeks to create innovations that define the ideas, practices,

\(^2\) [www.oxforddictionaries.com](http://www.oxforddictionaries.com)
technical capabilities and products through which the analysis, design, implementation and use of information systems can be effectively and efficiently accomplished (Denning 1997; Anderson & Donnellan, 2012). “The design-science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts” (ibid). This discipline has been used widely by researchers of IS field and is the result of confluence between people, organizations and technology. Following this research discipline “knowledge and understanding of a problem domain and its solution are achieved in the building and application of the designed artifact” (ibid). Different opinions are given on what an IS artifact is: while Hevner et al. (2004) define IS artifacts as constructs, models, methods and instantiations, van Aken (2004) sees an IS artifact as a social innovation.

Design science is comprised of two main set of activities, which are construction and evaluation (Cole et al., 2005). Different authors, each providing a different level of details, present models and frameworks to demonstrate how an artifact is developed by following design research. While Owen (1998) presents a simple general model, other researchers’ contributions such as Takeda et al.’s (1990) design cycle, Stempfle and Badke-Schaub’s (2002) generic step model, McKay’s (2005) ideal process, Hevner et al.’s (2004) IS research framework and the design research cycle by vom Brocke and Buddendick(2006) are more detailed. Although different authors have followed different styles for representing their proposed model, all emphasize that design science is an iterative process. They clarify that design science-based research is done by carrying out development/design and justification/evaluation cycles iteratively. This supports improving an artifact’s maturity to a satisfactory state. In this chapter and for clarifying how design science was followed, the terms “evaluate” and “validate” are used alternatively to refer to “justify/evaluate” activity.

Hevner et al. (2004) propose seven guidelines to support design research-based research. The left part of Table 2 contains a summary of this proposition. Detailed description, on what each guideline is about, can be found in the main literature, i.e. (Hevner et al., 2004). The right part is a summary of how design science was applied in performing the research described in this thesis. This was performed following the design science discipline, since the aim was to develop an artifact aiding in efficiency evaluation of EMMs. The intended artifact is manifested as an approach built of efficiency criteria for each EMM part and driving questions that support starting an efficiency evaluation process (see chapter 5 and chapter 6).

In the following, we explain how Hevner et al.’s (2004) guidelines about design science were pursued in this thesis.
Table 2: Design science research guidelines and their coverage in the thesis

<table>
<thead>
<tr>
<th>Design Science Research Guidelines (Hevner et al., 2004)</th>
<th>Coverage of Design Science in the Thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guideline 1: Design as an Artifact</td>
<td>Following design science in this research resulted in producing an artifact in the form of an approach for evaluating fulfillment of efficiency criteria in EMMs.</td>
</tr>
<tr>
<td>Guideline 2: Problem Relevance</td>
<td>The developed artifact (approach) is helpful in addressing the unattended problem of efficiency evaluation in EM. Relevance of the artifact to EM and consequently IS, makes a technology-based solution.</td>
</tr>
<tr>
<td>Guideline 3: Design Evaluation</td>
<td>The developed artifact (approach) was evaluated using case study method to find out what shortcomings it had (and even suggest solutions).</td>
</tr>
<tr>
<td>Guideline 4: Research Contributions</td>
<td>The thesis aim at presenting a novel design artifact (approach) applicable for efficiency evaluation of EMMs. The developed artifact was later on evaluated to suggest possibilities for improvement; this demonstrates its viability.</td>
</tr>
<tr>
<td>Guideline 5: Research Rigor</td>
<td>Development and evaluation of the intended artifact was carried out using case study method, which is widely used in IS research.</td>
</tr>
<tr>
<td>Guideline 6: Design as a Search Process</td>
<td>The search process contributed in an iterative process of developing and evaluating the intended artifact (approach). The artifact is adjustable to the environment, i.e. the state of the enterprise and its goal.</td>
</tr>
<tr>
<td>Guideline 7: Communication of Research</td>
<td>The contributed artifact is packaged as an approach for efficiency evaluation of EMMs on an overall level. This approach is usable by different users, those who perform the evaluation and those who are managers.</td>
</tr>
</tbody>
</table>

**Guideline 1: Design as an Artifact:** According to Hevner et al. (2004) “the result of design science research in IS is by definition, a purposeful IT artifact created to address an important organizational problem. It must be described effectively, enabling its implementation and application in an appropriate domain”. This research is done with the purpose of developing
an artifact supporting the evaluation of efficiency in EM and more specifically an EMM application process. The topic of efficiency is a notable problem, as discussed in section 3.1.3. It has however not yet been addressed in EM (see section 3.3). The developed artifact in this thesis is an approach that helps in evaluating efficiency of EMMs, presented in chapter 5. This approach is documented as criteria clarifying how each part of an EMM (see Figure 5) should be together with a list of suggested driving questions.

Another aspect of an IT artifact is that interdependency and coequality with people and the organization they are being used in (Hevner et al., 2004) is taken into account in the design and development of the mentioned artifact. The efficiency evaluation approach is designed in a way that supports evaluating EMMs based on a set of suggested criteria. These criteria are proposed to drive the efficiency evaluation process. Following the efficiency evaluation approach, members of the EM team can unify their understanding about the notion of efficiency in EM. In short, application of the developed artifact provides the basis for reaching efficiency as an objective of using (IT) artifacts (Denning, 1997; Tsichritzis, 1998).

Guideline 2; Problem Relevance: “The objective of research in information systems is to acquire knowledge and understanding that enable the development and implementation of technology-based solutions to heretofore unsolved and important business problems … Design science approaches this goal through the construction of innovative artifacts aimed at changing the phenomena that occur” (Hevner et al., 2004). As stated above, the important problem of efficiency evaluation in EM has been left unattended and unsolved. This was a motive for conducting the research with the purpose of taking this into account and investigating it. The conducted research was done with the aim of addressing the identified problem that gave even additional findings. Attainment of extra findings was controlled and did not lead in deviating from the right path. A solution is the result of eliminating or reducing a problem (Simon, 1996) or the difference between the goal and the current state (Hevner et al., 2004). Assuming that the relevant problem in this research was inefficiency in an EM process (that is not addressed yet) and the goal was unveiling it, the developed artifact (an approach for evaluating efficiency) is the relevant solution for fulfilling this need. In addition to this, EM helps in development of IS (Brinkkemper et al., 1999). Thus, a solution that is developed in EM, supports IS field and consequently is technology-based. According to this, the developed artifact can be considered as a technology-based solution.

Guideline 3; Design Evaluation: A design artifact should be evaluated in terms of quality, utility and efficacy using well-executed methods. This should be done respecting requirements that are established by the business environment (Hevner et al., 2004). The
designed artifact in this research, i.e. approach for efficiency evaluation of EMMs had shortcomings and inconsistencies, same as any other new developed product. This imposed the need for performing design evaluation. The principle and underlying criterion for evaluating the intended artifact was the extent to which it is usable for evaluating efficiency of an EMM. The design evaluation method pursued in this research was case studies. For this purpose, two EM cases were selected to carry out the design evaluation (see chapter 6). In this way, feedback on strengths and weaknesses of the artifact were gained and were used for writing reflections on the approach (presented in section 6.2) and suggesting refinements (see section 6.3) for the artifact.

**Guideline 4; Research Contributions:** Expectation from design research is gaining a novel contribution that can be categorized into at least one of the areas of the design artifact, design construction knowledge (i.e., foundations) and design evaluation knowledge (i.e., methodologies) (Hevner et al., 2004). According to this, the focus of the thesis was on developing an artifact (a design artifact) for evaluating efficiency of EMMs. Use of this novel artifact results in reaching conclusions about whether an EMM supports efficiency and if not, what the shortcomings are. The developed artifact was evaluated in terms of representational fidelity and implementability, as it is emphasized in (ibid). According to the evaluation (validation) results, the developed artifact is relevant and contributing to EM. It demonstrates that the artifact was developed in environments where EMMs were followed. This is evidence showing the artifact is applicable and implementable in the business environment, which makes it a clear contribution. It is clear in the sense that it is explicit what can be supported using it (efficiency evaluation of EMMs) and how it can be done (by checking whether the defined criteria are fulfilled). The contribution is verifiable, too. The proof for this claim is chapter 6, which entails results of evaluating (validating) the artifact. This shows the proposed artifact can be verified with the use of case studies.

**Guideline 5; Research Rigor:** As Hevner et al. (2004) mention, following rigorous construction and evaluation processes is necessary in a design science-based research. This was satisfied in this thesis, too. The research started with a literature review. Following this, the artifact development was done. This entailed construction and evaluation. In the literature review, a massive number of different sources about EM, EMM, quality evaluation in IS as well as modeling were reviewed to identify the state of the art. Following this, two EM cases from two different projects were selected as case studies (see chapter 4). These cases provided motives for conducting this thesis. The same cases were used for developing the intended artifact (presented in chapter 5). This was done by taking the state of the art and the method
notion (see Figure 5) into account. The developed artifact had to be evaluated to find out whether it was capable of covering the specified needs. Evaluation was done using two other EM cases. In short, both development and evaluation were done using case studies. Following the confirmed research method, whilst not hesitating to embrace spontaneous changes in the path, helped in pursuing a concrete but flexible approach.

**Guideline 6; Design as a Search Process:** Being iterative is the nature of design science and makes it “essentially a search process to discover an effective solution to a problem”, which is in fact seeking for a satisfactory solution (ibid). This fact was considered and met in writing this thesis. As stated, the current research was performed with the purpose of developing an artifact. The process was however not completed in a single round. It was done iteratively and resulted in a gradual but controlled development process. The reason for following an iterative work process was the nature of a search process, which requires an ongoing process until reaching a satisfactory state. In conducting this research, reviewing the two EM case studies iteratively was the key means to search for the intended results. Not only the development process, but the evaluation process was done iteratively. To do evaluation, the artifact was checked several times against EM cases, that were selected specifically for this purpose to ensure gaining a rich evaluation result.

Due to the iterative nature of design science and the search process, the research results were gained gradually and along the way. The search process supported learning new things, especially about the relevant study field, i.e. EM, and the relevant EMMs, namely EKD (Bubenko et al., 1998) and IDA (Lundqvist, 2011). Besides these, the search process required shifting between results development (and evaluation) and the relevant EM cases. In each iteration, the cases were reviewed to extract relevant data and apply them in the development (or evaluation) process.

**Guideline 7; Communication of Research:** The presentation of design science research in this thesis is a way that details necessary for the audience are provided. This thesis is packaging an approach (artifact) supportive to efficiency evaluation of EMMs. The contribution is manifested in the form of efficiency criteria for different EMM parts plus suggestions for driving questions that aid in evaluating fulfillment of the defined criteria. According to (Hevner et al., 2004), a technology-oriented and management oriented audience need sufficient detail to enable construction and determine resource allocation of artifacts, respectively. The contribution of the thesis is usable by people who are directly responsible for performing efficiency evaluation as well as managerial people. The need for this contribution is motivated in detail in “Theoretical Background & Frame of Reference”
(chapter 3) and “EM Case Studies” (chapter 4). The significance of EM is motivated by elaborating its support for business improvement. It is also explained how receiving support from EM requires applying a relevant EMM and this application process has to result in gaining the expected results, while resources must be used in a worthwhile way. Evaluation (and improvement) of efficiency however has not been addressed yet by other researchers. Thus, a management audience needs to take this contribution into account. After accepting this need, the potential applier of the artifact (approach for efficiency evaluation of EMMs) can refer to the presented details to realize how to conduct the efficiency evaluation process. The contribution is presented as efficiency criteria for various EMM parts. This presentation is done on an overall level, which makes the contribution comprehensible by different ranges of audience, varying from technology-oriented (here: those who are going to perform an efficiency evaluation) to management oriented (here: those who manage and observe the process). Each person may review the defined criteria to interpret and tailor them according to her/his needs. After referring to the presentation of the developed artifact, while being aware of the state of the art, the audience can understand the artifact’s novelty as well.

2.1.3 Case Studies

Case study is the most followed research method in qualitative research of Information Systems (Darke, et al., 1998). Yin (1994) defines a case study as “an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident”. A case study can be used in both quantitative and qualitative research approaches (ibid) and also within positivist and interpretivist traditions (Cavaye, 1996; Doolin, 1996). It encompasses various data collection techniques such as interview, observation, questionnaire, data and text analysis (Yin, 1994). This research method is applicable for fulfilling various aims such as providing descriptions about phenomena, developing theories and testing theories (Cavaye, 1996). Case studies support any of these needs by providing a basis for bringing research questions up on the table, data collection and analysis, and presentation of the obtained results.

Case studies is similar to field studies in the sense that both support examining phenomena in their natural context. They are different in the sense that in case studies, the researcher has less prior knowledge about constructs and variables (Benbasat et al., 1987; Cavaye, 1996). Case studies can also be compared with experimental studies, where both need several studies for gaining comprehension about a particular phenomenon. Nonetheless, their difference is that case study does not support studying any relation between cause and effect. In other
words, manipulation of variables is not possible in this research method (Cavaye, 1996; Lee, 1989).

For this thesis work, the design science discipline was followed and case study for developing results and evaluating them. According to (Remenyi & Money, 2004), case studies support providing a multi-dimensional view of a situation. This feature of case studies made the process of the current research more flexible. Using this method, the author had the possibility of interpreting moments, expressions and actions in the EM case studies (presented in chapter 4) and validation cases (presented in 6.1) in different ways. As Perry et al. (2004) mention, when a case study is seen as a research method, it should help in defining research questions as well as collecting and analyzing data to answer the research questions. According to section 2.2 (and Figure 2), EM case studies helped in defining research questions and developing results (presented in chapter 5). Also, validating the research results was done using case studies, which are called validation cases. In short, case study provided a flexible means for performing this research.

2.2 Schematic Overview of the Followed Research Path

In this section it is elaborated in schematic form what phases were performed to complete the research. Challenges in writing this chapter was grouping different tasks into activities and give each activity a relevant name. It might be required to investigate the traversed path from either high or low level of details. On a high level, the research can be divided into two phases of Background Formulation of Research Questions and Contribution Evolvement. In the lower level, each phase is comprised of a series of activities. An overview of the followed research path as well as its phases and activities is presented in Figure 2. In this section, each research phase is elaborated. This is done by explaining activities within each phase in sections 2.2.1 and 2.2.2. Figure 2 shows a schematic and straight forward working path. In reality, deviation from the decided path was inevitable and happened now and then. The reason for this was that at some points in time it was necessary to repeat a prior activity. In other words, the figure is not presented to show the exact time frame, rather it is dedicated to the logical structure of the research path.

As explained in section 2.1.2, this thesis work was done by following the design science discipline, an abductive approach and the case study method. To decide what research discipline, approach and method should be followed, literature relevant to research methods
were reviewed. This is however not shown in the figure. In fact, this elaboration is about how the research process was done after selection of discipline, approach and method.

Figure 2: Schematic overview of the followed research path

2.2.1 Background Formulation of Research Questions

Similar to other dissertations, in this work it was required to find out what is already done and what research gap(s) that exists in the research field. To shed more light on this phase and its details, we break it into a series of activities: Literature Review, Case Observation i and Problem Identification and Formulation of RQs.

**Literature Review**: This activity is the starting point in any research work and requires spending considerable amount of effort and time. It was started by reviewing the Initial Description of the PhD position that was suggested by the PhD supervisors and reviewing the Existing Literature. The Existing Literature included different types of scientific publications, such as technical reports, dissertations and papers. Literature Review aided mainly in identifying the State of the Art in EM, and did shed light on what had been developed in
different parts of the EM research field, especially contributions regarding quality (and efficiency) evaluation. Therefore, various topics in EM were reviewed. The review process was continuous.

**Case Observation i:** Besides reviewing literature and working on identifying the *State of the Art*, the author reviewed *Case Material i* coming from the EM case studies (see chapter 4). The focus of this activity was on reviewing the obtained experiences, trying to identify the implicit knowledge and transform it into explicit knowledge. The output of the activity was called *Empirical Data i*, which was the motive for pursuing the research. This activity itself can be broken down into two sub-activities: *Case Selection* and *Empirical Data Collection* (for simplicity the sub-activities are not shown in Figure 2).

- **Case Selection:** In an empirical study, the aim is to go through one or several cases to assess them from a specific viewpoint. For this purpose, the author started selecting suitable cases and deciding about how to observe and assess them. The set of target cases entailed an EM session from the infoFLOW-2 research project and one project group from the EM course, Spring 2012, at Jönköping University (in the remainder of this chapter: EM Course), explained in sections 4.2 and 4.3.

- **Empirical Data Collection:** After selecting the target case for empirical data collection started. An EM session involves different people cooperating with each other. There might be cases where all members of a modeling team focus on the same task. In such a state the observer is able to follow the work process conveniently. In an EM session team members can be divided into groups and each group works on a fragment of the current task. In such a situation, following all groups at the same time becomes a problem. To solve this issue the decision became to record video from the modeling sessions and focus on them as *Case Material i*. Besides this, notes that were made during the modeling sessions were considered for review and data collection. This facilitated the work in different ways. Through this, it became possible to assess parallel work divisions and not missing them. Moreover, the recordings could be reviewed several times, any time after finishing the EM sessions. This lessened the risk of missing details and made it possible to review the findings iteratively.

**Problem Identification and Formulation of RQs:** The two above activities were in fact prerequisite to this activity and information material that had been gained as their output were used here. As stated above, during Literature Review a wide range of topics were touched upon that resulted in finding the *State of the Art*, which was reviewed and even revisited iteratively to define the problem precisely. By doing this revision process and considering
Empirical Data i, the research problem was identified and the relevant research questions were defined. This activity as the last activity from Background Formulation of Research Questions phase supported conducting the Contribution Evolvement phase by specifying the Knowledge Gap (Problem & RQs). In the following, the second phase of the research path, i.e. Contribution Evolvement is elaborated.

2.2.2 Contribution Evolvement
After identifying the Knowledge Gap, it was time to contribute in solving it. For this purpose, it was necessary to conduct activities that converge into supporting this phase. These activities in general included collecting relevant data, developing results and making refinements to the results. These are elaborated in more details in the following:

Case Observation ii: An EMM as the relevant tool for receiving support from EM, is usually of interest when it is in use. Finding out what strengths or deficiencies it has, can be clarified during usage. Therefore, it was decided to observe EM cases with the purpose of data collection. The result of this activity was Empirical Data ii, which were required for preparing Results Development. The same EM cases and case material as in Case Observation i were used here, though the approach was different. In this activity, the problems were already known. Having this in mind, focus of the activity was on specifying statements required for Results Development.

Results Development and Results Validation: Results Development and Results Validation support developing an artifact that address the research questions. Due to the close relevance and relation between these two activities, they are explained in the same paragraph. The State of the Art (as an indirect input), the identified Knowledge Gap and Empirical Data ii were used in Results Development for developing Results. This was done iteratively to reach satisfactory Results. As continuation to this, Empirical Data iii (Case Material ii) and Results were used in Results Validation attain Validated Results. This was also carried out iteratively, which required reviewing the relevant inputs for the activity several times. Case Material ii were used directly as an input (Empirical Data iii) to Results Validation. Thus, we do not differentiate them. As the main intention of this research was to contribute to the efficiency of EMMs, the direction of the Results Development and Results Validation activities were towards developing outcomes in relation to establishing understandings about how an efficient EMM should be and how to evaluate its fulfillment. Both activities were done respecting the research questions and with the purpose of addressing them. From one side Results Development and Results Validation helped in answering the research questions and
even modifying them. From the other side, the modified research questions ensured maintaining the right track.

**Making Conclusions & Answering RQs:** As stated above, the research questions had direct effect on the research work, and vice versa. Answers to the research questions were dependent on the *Results* and the *Validated Results*. This activity received *Results* and *Validated Results* to assist in answering the research questions. These answers are helpful in finding out how it is possible to apply this work and what can be supported by it. Besides answering the research questions, this resulted in *Making Conclusions* on the gained attainments.

In both phases mentioned, it was necessary to move back and forth between activities within each phase every now and then. It was even required to move between activities of one phase and activities of the other phase. For example, whilst the *Results Development* and *Results Validation* were under progress, it was needed to review the *State of the Art* or even do extra *Literature Review* to check details of the *Knowledge Gap* and also making decision about the rest of the development. However, for the reason of simplicity, Figure 2 is presented as a straight forward path.
3. Theoretical Background & Frame of Reference

The focus of this thesis is on studying efficiency (as an aspect of quality) in EM. Thus, it is required to gain an understanding about the relevant theoretical background to it, which is addressed in this chapter. This is started by describing the foundational concepts relevant to EM and quality (see section 3.1). Since, efficiency is an aspect of quality and this thesis is written to contribute to the area of EM and efficiency evaluation in EM, section 3.2 clarifies how quality evaluation in EM has been approached by other researchers. The chapter ends with section 3.3 that contains conclusions of the whole chapter and a hint regarding how the presented theoretical background motivated the current research.

3.1 Foundational Concepts

This chapter aids in understanding the relevant and foundational concepts. In section 3.1.1 we explain what EM and enterprise models mean. Following this, clarifications about the method notion and how it supports EM, are given in section 3.1.2. It is lastly elucidated what efficiency as an aspect of quality in the IS research field stands for (see section 3.1.3).

3.1.1 Enterprise Modeling & Enterprise Models

This section intends to elaborate the notion of EM and enterprise models. This aids in unifying the author's and the audience's perception about these notions. Also, clarifying these two meanings is a foundation for the developed tentative research contribution.

3.1.1.1 Enterprise Modeling

EM, Enterprise Architecture (EA) and Business Process Management (BPM) are three areas that have for a long time been part of a tradition where the mission is making improvement in enterprises (Harmon, 2010). According to (Degbelo et al., 2010) “since more than two decades, the contribution of EM to solving problems in organizational development, process improvement or system integration has been acknowledged”. But why EM? “EM, or Business Modeling, has for some years been a central theme in Information Systems (IS) engineering research and a number of different methods for this purpose have been proposed” (Bubenko Jr. et al., 2010). All organizations desire to make progress in their business to remain competitive in their business. Therefore, all organizations need to know how to make such progress. For this purpose, they need to know about the current (AS-IS) situation as well as
the desired (TO-BE) situation. Indeed stakeholders need to gain an understanding about the reality of the enterprise. But the reality is often complicated and confusing, and any insight is rarely achieved without considerable simplification. Modeling is a means that helps in simplifying facts without losing elements that are essential to representation and reasoning. Also, since EM takes time and costs money, the model must be developed with a justifiable purpose in mind. In other words, enterprise models should give the complete and correct description respecting the purpose they are developed for (Christensen et al., 1996).

“Professionals in various disciplines feel the need to describe an enterprise according to prescribed rules in order to be able to pursue specific goals through the modeling” (Kassem et al., 2011). EM is a field that has been arisen and developed to support filling this gap. Indeed, according to (Persson & Stirna, 2010), EM is now applicable for a variety of purposes related to organizational development and helps in various ways such as designing or redesigning the business, eliciting requirements for information systems, capturing and reasoning about organizational knowledge. EM helps in visualizing an enterprise from specific viewpoints for the purpose of understanding the enterprise. This understanding is the basis for further activities such as design, evaluation, improvement, etc.

Persson and Stirna (2010) state two reasons for applying EM:

- "Developing the business" this entails developing business vision, strategies, redesigning the way the business operate, developing the supporting information systems, capturing IS requirements, etc.
- "Ensuring the quality of the business" here the focus is on two issues: 1) sharing the knowledge about the business, its vision, the way it operates, and 2) ensuring the acceptance of business decisions through committing the stakeholders to the decisions made”.

To explain this in a more detailed way, one can refer to (Kassem et al., 2011) that expresses the following reasons for using EM:

- Development of information systems: EM is of high importance in IT projects and supporting companies. According to (Shen et al. 2004), EM is an initial and essential task for an IT project and this is carried out at the stage of system analysis and user requirements gathering.
- EM as the backbone element in enterprise integration projects: EM helps in increasing synergy and interoperation among people, systems and applications throughout the enterprise, including integration in manufacturing or Computer
Integrated Manufacturing (CIM) and workflow management dealing with automation of paper and document flows as well as control of business processes (Kosanke & Nell 1997; Vernadat, 2001).

- **Shift from organizing companies in separated departments to process orientation:** Nowadays, there is an intention in companies to shift from organizing companies in the form of departments (silos) to processes. To support this “EM can provide a better understanding of existing processes and help companies in the migration from departmentalized organization to process orientation” (Kassesm et al., 2011).

In order to start a discussion about EM, first we need to have a definition for it. By going through the existing literature, it can be seen that several definitions are presented for the term. Some of these definitions are developed for a specific field, whereas some others are general and can be specialized to a case. Regardless of a definition belonging to any of these two groups, it enumerates some characteristics for EM. By reviewing these definitions, we have extracted the main characteristics presented below. Each item in this list is covered by a subset of the definitions, and not all.

**Enterprise Knowledge Representation:** The aim of EM is capturing the knowledge about an enterprise and representing it in an abstract form. Indeed, the intention of this is helping stakeholders in extracting the knowledge of the domain of discourse under assessment, which is usually a part of an enterprise, and then presenting them in the shape of models. This characteristic has been obviously taken into account in all definitions presented to EM.

**Focal Areas:** “A focal area means that certain aspects are focused in that investigation” (Goldkuhl & Röstlinger, 2003). Capturing and representing the enterprise knowledge can be done from different focal areas, such as business processes, resources and organizational divisions. It is important when working on more than one focal area, the results of modeling processes, i.e. the models are consistent with each other. In other words, modeling from different focal areas, i.e. modeling different facets of the enterprise, each focusing on different constructs and concepts, in a specific domain of discourse should result in models that complement and match each other. (Ngwenyama & Grant, 1993), (Zhao & Fan, 2003) and Nurcan, 2008) are examples of contributions that have mentioned “Focal Area” in their definition of an EM.

**Structure of the Enterprise:** EM supports the stakeholders in developing models to show what the structure of the enterprise is in each focal area. This is done by finding special types
of elements (according to the focal area) in a domain of discourse. Realizing the relation between the specified domain of discourses is another necessary phase, which has to be done as complement to show the structure of the domain of discourse. (Fox & Gruninger, 1998) and (Vernadat, 2002) are examples of contributions that have mentioned “Structure of the Enterprise” in their definition of an EM.

Further Use: An enterprise is always in need of improving its business to be able to compete with the rest of the organizations in the same field. The purpose of EM is helping stakeholders in developing models that will be used for understanding the state of the enterprise. Also, EM helps stakeholders to show the future (desired) state in the form of models. Stakeholders need to gain understanding of these issues on both business and managerial levels. The reason is that they should act towards developing improvement plans. (Frank, 2002), (Vernadat, 2002) and (Delen & Benjamin, 2003) are examples of contributions that have mentioned “Further Use” in their definition of an EM.

From the presented definitions, Vernadat’s (2002) is accepted as the basis for this thesis, since it covers all the marked points:

“enterprise modeling is the art of externalizing enterprise knowledge which adds value to the enterprise or needs to be shared. It consists in making models of the structure, behavior and organization of the enterprise.”

The definition explicitly mentions “structure of enterprise” as well as “enterprise knowledge” representation as features of EM. Bringing the issue of “adding value” to enterprise up on the table can be accepted as a variation of “further use”. After all these, Vernadat has talked about the fact that EM support modeling “structure, behavior and organization” of the enterprise. According to this, the definition has taken the issue of “focal areas” into account, too.

3.1.1.2 Enterprise Models

As EM is about developing enterprise models, we need to have a concrete understanding about what an enterprise model is. For this purpose, we should know what characteristics such a model has. Although at first glance it seems that different authors have presented very different specifications for enterprise models, it is still possible to underline the main characteristics enumerated by various researchers.

- “Enterprise model is used as a semantic unification mechanism, or knowledge-sharing mechanism” (Petrie, 1992).
- It is a symbolic representation (Liles, 1996; Whitman & Huff, 2001) of an organization from a specific focal area.

- Enterprise models show what elements (element types) from the real world in the enterprise exist and the relations (relationship types) between them (Koubarakis & Plexousakis, 2002) from the specified focal area.

- Such a model identifies the basic elements and their decomposition to any necessary degree (ANSI/NEMA, 1994), that should be comprehensive (Taveter & Wagner, 2000) and at the same time simplified and explicit (Gandon, 2001). Making decisions about simplicity and details in an enterprise model depends ultimately on what the stakeholders require (ibid).

Although the above points could be retrieved through various references, we have mentioned only references where their presentation (in sense of meaning and wording) are more understandable. Each of these references indeed present their own definition of enterprise models. As can be seen, each point is covered by a subset of the reviewed literature, whereas all the mentioned characteristics are essential for enterprise models. This imposes the need for presenting a definition of enterprise model, that is fulfilled by the author and in this thesis:

*Enterprise model is a symbolic and comprehensive representation of one or several aspects of an organizational structure, following the notational rules for the purpose of knowledge sharing and semantic unification.*

At first glance, it looks as if the presented definition does not cover all the enumerated characteristics. First, it does not mention that an enterprise model is a “simplified” representation. Besides, no indication about “decomposition to any necessary degree” is given. As both of these two points are about providing details to a sufficient level, stating “comprehensive enough” covers both. Second, in this definition it is not referred to the fact an enterprise model contains “elements and relations between them”. Nevertheless, as a model itself means a set of elements and relations, and it is not necessary to emphasize it again, this point can be neglected. Apart from the two mentioned points that are covered indirectly in the definition, the rest are directly emphasized.

### 3.1.2 From Method to Enterprise Modeling Method

The term “method” is introduced and used in many references, ranging from dictionaries to scientific articles, in different fields. In general, a method is “a type form of procedure for accomplishing or approaching something, especially a systematic or established one” (Oxford
It is a broad term and can be explained and defined in different ways. By reviewing different references and checking how different people understand this term we see that method as a particular form of procedure is indeed a “concrete” (Oliga, 1998), “systematic and orderly” (Baskerville, 1991) procedure. Such a process aims at performing a task (March & Smith, 1995) such as “attaining something” (Odell, 2005) or “dealing with a problem situation” (Mingers, 2000).

From what different authors emphasize as the key feature of a method, it can be concluded that a method clarifies “what to do”, “how to do” and “why to do”:

- “What to do” elaborates the ultimate goal that is to be gained, together with intermediate goals. Indeed, achievement of intermediate goals guarantees obtaining the ultimate goal.
- “How to do” has to clarify the phases that have to be traversed and their comprising steps. Each step is a guideline for completing a specific intermediate task. It might also specify the capabilities that involved people should hold in order to be able to follow the phases and guidelines.
- “Why to do” makes it clear for what purpose the method is applicable. This clarification aids stakeholders in understanding the purpose of the available methods and selecting a suitable one.

To complete a task we need to take into account various issues that might influence the work process, including guides and inspirations about how to carry out a work (Seigerroth, 2011). According to what Seigerroth (2011) states, source of guidance and influence can be found in various forms, such as methods, theories, experiences, patterns and tools. In addition to these, action guidelines can be found in the solution space in the form of best practices, and computerized tools, in which methods are implemented (see Figure 3).

Among all the enumerated ways, methods are the ones which are extensively used. According to (Goldkuhl et al., 1998), the characteristic of a method is its Perspective. Method Perspective is the conceptual and value basis of the method and its rationality. All methods build on some implicit or explicit Perspective, which includes values, principles and categories. A method involves procedural guidelines, in short: Procedure, which show how to work and what questions to ask. In a method there exist representational guidelines; what is often called modeling techniques or Notations. Method Notation supports the need for documenting different aspects as well as how answers to the procedural questions should be

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3 www.oxforddictionaries.com
documented. *Procedure* and *Notation* are tightly coupled to each other. The *Procedure* involves some meta concepts, such as process, activity, information, object. Such general concepts are used when the questions are asked, i.e. they are part of the prescribed *Procedure*. They are also part of the semantics of the *Notation*. The Concepts is the cement between *Procedure* and *Notation*. When there is a close link between *Procedure*, *Notation* and Concepts, it is referred to as *Method Component*.

A method is often a compound of several *Method Components*, giving what is often called a methodology (Avison & Fitzgerald, 2006). As stated in (Goldkuhl et al., 1998) *Method Component* tells us how to do a specific step. Different *Method Components* together form a structure, called *Framework* that includes the phase structure of the method. This phase structure tells us what to do, in what order to do, and what results to produce. Another aspect of method is *Cooperation & Collection Principles*. *Cooperation Principles* are about who asks and answers questions. To elaborate this more, we can say that *Cooperation Principles* are about what roles should be involved in the work and how the work division should be, i.e. how different persons interact and cooperate. *Collection Principles* entail principles about how to put questions and collect answers. A *Method Component* can be used within several *Collection Principles*, such as seminars, brainstorming sessions, interviews and modeling sessions. The notion of *Method Component* in (ibid) is similar to Method Chunk in (Ralyté et
The method notion introduced by Goldkuhl et al. (1998) can be seen in Figure 4.

Although Goldkuhl et al.’s method notion is supportive in the way of understanding what a method is, for the purpose of this thesis it is necessary to define a more precise interpretation. This is fulfilled by adding some aspects to it. To fulfill this need, we underline that a Method might contain only one Method Component, or a composition of several Method Components. A Method Component supports investigating a specific focal domain of the enterprise and might be either Vertical Composition, Horizontal Composition or a combination of these two, from two or more Method Components. As (Cronholm & Ågerfalk, 1999) state, Vertical Composition means integration of methods between different levels of development, whereas Horizontal Composition means integration of methods within the same level of abstraction. Regardless of what composition form is followed in a method, the comprising Method Components aim at modeling an enterprise or discourse domain by asking different types of questions; that result in gaining different types of answers and consequently different types of models. Using Horizontal Composition applying different Method Components to a domain of discourse the produced results can be linked to each other and no contradiction is seen between them. On the other hand, Vertical Composition means aggregation of different Method Components in an abstraction level and producing results where linking and integrating them supports the upper abstraction level. The possibility of having a composition of Method Components is shown by presenting a cascade of several Method Components. For
the purpose of this work, we assume that there is a possibility of composition, but do not distinguish between *Horizontal Composition* and *Vertical Composition*. Another method part that requires modification is * Cooperation & Collection Principles*. As we stated above, *Collection Principles* are mainly about how to put questions and collect answers. These forms clearly refer to the issue of asking and answering questions and they are more related to method *Procedure* than being part of another method part. This means the method part * Cooperation & Collection Principles* should be changed to * Cooperation Principles*. The modified method notion that is what we accept for the rest of this work is presented in Figure 5.

![Diagram showing finalized notion of method](image)

**Figure 5: Finalized notion of method**

To receive support from EM, we should follow a systematic way of working, i.e. a method. A method that is specifically developed for the purpose of EM is called an EMM. By applying an EMM we develop enterprise models as results and they can be used for studying the status of the enterprise and planning improvement actions. But what are the specifications for an EMM? In this type of method, *Perspective* clarifies from what viewpoints an enterprise can be studied (and indeed be modeled). For this purpose the *Framework* highlights the phases that are required for developing a comprehensive (set of) model(s) of an enterprise. Each phase clarifies what the aim of completing it is. This imposes the need of applying a *Method Component*. By applying the *Method Component* it will be possible to apply the *Procedure* in order to ask questions about what elements exist in the domain of discourse (as a part of the marked enterprise). Answers to these questions are implemented using the *Notation* part of
the Method Component and are in fact abstract visualizations of the enterprise. According to this, the determining feature of a method, and here an EMM, is its Method Component. By this we mean that it is the presentation of a Method Component that helps the reader in understanding that the output of applying an EMM is a visualization of an enterprise and what this visualization looks like. Investigation of different focal areas as a subject of EM needs to be covered in EMM. This should be supported in phases of a Framework or as part of Method Components, i.e. developing enterprise models as a visualization of particular focal areas are to be covered in Framework or Method Components or both. Concepts as the cement part between Procedure and Notation stress what phenomena and meanings of an enterprise are considered in this EMM. This is a great help for making decision whether this EMM is applicable for team’s objectives. All this is done by a group of people that follow an accepted Cooperation Principles for studying and modeling the enterprise with the help of the other method parts.

3.1.3 Quality & Efficiency
According to (Mevius, 2007), a process is of high enough quality if it is suitable for attaining the pre-defined business processes targets. To carry out a process it is necessary to use different types of resources. Resources are not always cheap and freely available. Hence, we need of take care of resource usage. The extent to which we have been successful in the proper use of resources, is an indicator for the process success. Accordingly, to assess if a process has been (or will be) successful in achieving the specified aims, one issue that has to be studied is the amount of resources consumed. This concept is called Efficiency. Although efficiency seems to be a primitive term that can easily be understood, there is no universally accepted definition for it and its meaning has been introduced and discussed in different ways. Before continuing with the issue of efficiency, a brief about quality and its meaning in EM is presented. Quality is a term that shows the extent to which a process or product is acceptable by the stakeholders and different definitions and explanations are given. The issue of quality is of interest in all fields (such as economics & industrial organization, management, operations & engineering, etc.) but it is perceived and interpreted differently in each field (Golder et al., 2012). This results in “no universal, parsimonious, or all-encompassing definition or model of quality exists” (Reeves & Bednar, 1994).

According to Martin (1989), developing enterprise models is a means to support Information Engineering, which is about “enabling users to understand and monitor the information they are dealing with, as well as the process they are executing” (Duarand & Dubreuil, 2001).
Therefore, the perception of quality that is followed in operations and engineering is applicable in EM. According to Golder (2012) “in operations and engineering, quality means conformance to design specifications or the reliability of internal processes, even though many customers do not find these processes meaningful” (Feigenbaum, 1991; Juran, 1992; Shewhart, 1986). Accordingly a list of specifications that should be met by a process in order to conclude that it is of acceptable quality is needed. There exist literature that focus on this issue and aim at clarifying quality criteria. Among such works, quality models are about quality criteria as well as how criteria affect fulfillment of one another.

As this thesis is supposed to contribute to EM and Information Engineering, which are subjects in IT and IS, relevant quality models should be considered. Although these models are mainly developed for software quality, they can be used in other disciplines of IS, too. Table 3 shows what criteria are listed in each quality model. This is done using a table that is adapted from (Ortega et al., 2003) and extended. According to Table 3, efficiency and maintainability are criteria that are taken into account in all quality models. Consequently, these two criteria should be prioritized fulfilling quality. Between these, “the efficiency criterion determines the choice of alternatives that lead to the maximization of results when scarce resources are applied” (Simon, 1964). But what does efficiency exactly mean? In a general sense and its simplest form, efficiency is about “doing things right” (Gleason & Barnum, 1986; Zokaei & Hines, 2007), in comparison to effectiveness that is about “doing the right things” (Drucker, 2008; Drucker, 1974). The two terms look similar, but convey different meanings. Effectiveness is about the results expected from a process, whereas efficiency has to do with the minimum amount of resources that are required for obtaining a goal. “Doing the things right” refers to the fact that not only achieving the intended results is of interest, but also that a proper way of working has to be pursued. If this is fulfilled, resources will be used in a more sensible way. By evaluating (and measuring) efficiency one can find out whether resources are used properly, i.e. “elimination of waste” (Molina, 2003) is supported through efficiency evaluation. This naturally can be continued by identifying cause of resource waste and dispelling it.

It is often assumed that no definition is required for efficiency, because the meaning of the word is usually established on a common sense basis. It is however necessary to have a mutual understanding about what efficiency means. There exist two attitudes towards efficiency. The first attitude defines this phenomenon as the amount of required resources for obtaining a pre-defined goal. In a process any of input and output might be varying.
Therefore, definitions that have looked at efficiency from an output/input viewpoint can be categorized into three groups:

1. Some authors define efficiency as the varying ratio between output to input (e.g. Farrel, 1957; Lovell, 1993; Chen, 2006).
2. There are authors that consider efficiency as the amount of inputs that should be determined for gaining a fixed output (e.g. Sink & Shuttle, 1989; Neely et al., 1995; Jackson, 2000).
3. Efficiency is also defined as increasing output for using a fixed amount of resources (e.g. Sumanath, 1994; Taylor, 1957; Vakkuri, 2005; Morris et al., 2007; Milikowsky, 2008).

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<tbody>
<tr>
<td>Testability</td>
<td>X X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Correctness</td>
<td>X</td>
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<tr>
<td>Efficiency</td>
<td>X X</td>
<td>X</td>
<td>X</td>
<td>X X</td>
<td>X X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Understandability</td>
<td>X X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Reliability</td>
<td>X X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Flexibility</td>
<td>X X</td>
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<tr>
<td>Functionality</td>
<td>X X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Human Engineering</td>
<td>X</td>
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<tr>
<td>Integrity</td>
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<td>X</td>
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<tr>
<td>Interoperability</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Process Maturity</td>
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<td>X</td>
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<tr>
<td>Maintainability</td>
<td>X X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Changeability</td>
<td>X</td>
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<tr>
<td>Portability</td>
<td>X X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Reusability</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Usability</td>
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<td></td>
<td>X</td>
<td>X</td>
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</tbody>
</table>

There also exists another attitude towards efficiency. As stated above, efficiency is basically about doing things right. Following this, the other viewpoint focus is on the process, but not the resources. This attitude, has been taken less into account by researchers for defining efficiency. A definition that is developed respecting this viewpoints is:
“Efficiency is used for passive or operational activity, which is usually defined technically so that the system and its behavior are foreseeable in advance” (Kurosawa, 1991).

At first it seems that the two identified attitudes do not have anything in common and communicate different messages, but they are two sides of the same coin and support each other. A process that has a foreseeable behavior is more likely to result in producing the required output using resources in a worthwhile way. In practice, the “input-output” attitude is suitable where the work process is not the center of interest and what we care about is the amount of output versus the amount of input. In such a condition it is required and likely possible to measure the input (resource) usage and gained output based on an agreed upon benchmark showing the acceptable ratio of output / input. Finally, by making a comparison between the benchmark and measurement results it will be possible to draw conclusion about the process efficiency. However, there might be cases where the focus is on the work process and not the outputs and inputs (resources). In such a case the expectation is that the working process matches to a set of defined criteria. The better the criteria are covered, the more foreseeable the process is. This means a higher efficiency has been gained.

3.2. Approaches for Quality Evaluation in Enterprise Modeling

This section contains a brief on how the issue of quality evaluation in the field of modeling has been taken into account. This begins by giving an explanation of the existing attitudes towards quality evaluation in modeling. This is followed by introducing some contributions regarding quality evaluation in modeling. The issue of quality in modeling has been important for researchers and several efforts have been carried out regarding that. Bollojy and Leung (2006) emphasize that it is extremely important for the system’s ultimate success to ensure the quality of the modeling methods and tools. In (Siau & Rossi, 2007) a classification for analyzing the underlying philosophies of methods evaluation techniques is presented. According to this classification, the evaluation techniques can be divided into the following categories:

- Feature comparison;
- Theoretical and conceptual investigation; and
- Empirical evaluation

Feature analysis as a common methodology for feature comparison, has the risk of subjectivity (Avison & Fitzgerald, 1995). To resolve this, (Bubenko, 1986) suggests doing:

- theoretical investigations of concepts and languages;
In the modeling field, the quality issue has been approached from different viewpoints. In total, the amount of research and publications that have been dedicated to quality in modeling is considerably high. Table 4 contains examples of contributions developed regarding quality in modeling.

Table 4: Examples of approaches for quality evaluation in modeling

<table>
<thead>
<tr>
<th>Reference</th>
<th>Scope</th>
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<tbody>
<tr>
<td>(Batini et al., 1992)</td>
<td>Quality evaluation of EER models</td>
</tr>
<tr>
<td>(Levitin &amp; Redman, 1994)</td>
<td>Quality criteria for data models</td>
</tr>
<tr>
<td>(Moody &amp; Shanks, 1994; 1998a; 2003)</td>
<td>Quality measurement of data models</td>
</tr>
<tr>
<td>SEQUEL</td>
<td>Quality evaluation of conceptual models</td>
</tr>
<tr>
<td>(Lindland et al., 1994; Krogstie et al., 2006; Krogstie et al., 2012)</td>
<td>Quality measurement of ER models</td>
</tr>
<tr>
<td>(Kesh, 1995)</td>
<td>Quality evaluation of conceptual models</td>
</tr>
<tr>
<td>(Shanks &amp; Darke, 1997)</td>
<td>Quality evaluation of conceptual models</td>
</tr>
<tr>
<td>(Teuw &amp; van den Beg, 1997)</td>
<td>Quality evaluation of conceptual models</td>
</tr>
<tr>
<td>Guidelines of Modeling (GoM)</td>
<td>Principles for quality of models</td>
</tr>
<tr>
<td>(Schuette &amp; Roththowe, 1998, Becker et al., 2000; Blecken, 2010)</td>
<td>Quality measurement of data models</td>
</tr>
<tr>
<td>(Moody, 1998)</td>
<td>Quality evaluation and improvement of data models</td>
</tr>
<tr>
<td>(Moody &amp; Shanks, 1998b)</td>
<td>Quality improvement of information models</td>
</tr>
<tr>
<td>(Schuette &amp; Roththowe, 1998)</td>
<td>Quality evaluation of OO Modeling Languages</td>
</tr>
<tr>
<td>(Opdahl &amp; Henderson-Sellers, 1999)</td>
<td>Quality evaluation of reference models</td>
</tr>
<tr>
<td>(Mišic &amp; Zhao, 2000)</td>
<td>Quality measurement of BP modeling techniques</td>
</tr>
<tr>
<td>Q-ME (Hommes &amp; van Reijswoud, 2000)</td>
<td>Quality evaluation of data modeling process</td>
</tr>
<tr>
<td>(Maier, 1999; Maier 2001)</td>
<td>Quality measurement of UML and EER models</td>
</tr>
<tr>
<td>(Cherfi et al., 2002)</td>
<td>Quality evaluation of reference models</td>
</tr>
<tr>
<td>(Fettke &amp; Loos, 2003a)</td>
<td>Quality evaluation of EM languages.</td>
</tr>
<tr>
<td>(Fettke &amp; Loos, 2003b)</td>
<td>Quality evaluation of EM languages.</td>
</tr>
<tr>
<td>(Breu &amp; Chimiai-Opoka, 2005)</td>
<td>Quality evaluation of models</td>
</tr>
<tr>
<td>(Graeme et al., 2005)</td>
<td>Quality criteria for data models</td>
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<tr>
<td>Quality of Modeling (QoMo)</td>
<td>Quality measurement of process modeling</td>
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<tr>
<td>(van Bommel et al., 2008)</td>
<td>Quality measurement of modeling processes</td>
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<tr>
<td>(Ssebaggwawa et al., 2009)</td>
<td>Quality evaluation and improvement in feature models</td>
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<tr>
<td>(Thorn, 2010)</td>
<td>Quality measurement of conceptual models</td>
</tr>
<tr>
<td>(Fettke et al., 2012)</td>
<td>Quality measurement of conceptual models</td>
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</tbody>
</table>

While some researchers have concentrated only on the quality of models, others have taken quality of methods, modeling languages and other artifacts for model development into account. In both approaches, some contributions focus only on defining quality criteria and
what each of them means. There exist also contributions that present tools for evaluating the quality of models, model development methods or languages, etc. These contributions present criteria, that should be met by the artifact under investigation, together with guidelines for evaluating their fulfillment. In addition to this, some publications present means for measuring the quality of models or model development artifacts.

In the entries of Table 4 the focus of developers has been on quality of models, modeling methods or modeling languages. This shows that quality issue has been of high importance and interest. Since people are more keen on outputs of modeling processes, quality evaluation and improvement of enterprise models has been of more interest than modeling processes. In the following sections, examples from Table 4 entries are selected and explained to show how quality in modeling has been investigated by other researchers so far.

Section 3.2.1 contains examples of contributions concentrating on quality of models and section 3.2.2 contains examples of contributions focusing on quality of modeling processes, languages and methods.

3.2.1 Quality Evaluation of Models
In this section brief explanations on the selected works that are used for evaluating quality of models are presented:

**SEQUAL**: According to (Krogstie et al., 2006), SEQUAL is a framework developed based on semiotics theory and aids at quality evaluation of conceptual models. SEQUAL has three properties that make it unique:

- It separates quality goals from quality means (Krogstie et al., 2006; Krogstie, 2012a),
- It is based on a constructivistic world-view, and
- It is closely linked to linguistic and semiotic concepts.

In the earliest version of SEQUAL, three quality levels were considered: Syntactic, Semantic and Pragmatic Quality (Lindland et al., 1994). During time and by extension of the framework the quality levels increased to seven: Physical, Empirical, Syntactic, Semantic, Pragmatic, Social and Deontic (Krogstie, 2012a). Figure 6 shows framework of the relevant version of SEQUAL. Quality of models at different semiotic levels is discussed based on correspondence between statements of the following sets:

- “G, the (normally organizationally defined) goals of the modeling.
- L, the language extension, that is, the set of all statements that are possible to make according to the graphemes, vocabulary, and syntax of the modeling languages used.
- D, the domain, that is, the set of all statements that can be stated about the situation at hand.
- M, the externalized model, that is, the set of all statements in someone’s model of part of the perceived reality written in a language.
- $K_s$, the relevant explicit knowledge of the set of stakeholders being involved in modeling (the audience A). A subset of the audience is those actively involved in modeling, and their knowledge is indicated by $K_M$.
- I, the social actor interpretation, that is, the set of all statements that the audience think that an externalized model consists of.
- T, the technical actor interpretation, that is, the statements in the model as ‘interpreted’ by the different modeling tools” (Krogstie et al., 2006).

![Figure 6: SEQUAL framework for discussing quality of models (Krogstie, 2012a)](image-url)
The principle idea behind developing SEQUAL was evaluating conceptual models in general. It was even extended and modified for evaluating other sorts of models such as interactive models (Krogstie & Jørgensen, 2003), requirement models (Krogstie, 2012b) and process models (Krogstie et al., 2006) in a more detailed and precise way.

**Fettke and Loos’ Proposal:** Fettke and Loos (2003a) used BWW ontological model (Wand & Weber, 1995; Wand & Weber, 1989; Weber, 1977) for evaluating reference models. The main idea of this approach was normalizing references models ontologically. This can be compared with normalization in databases. The difference is in normalizing reference models real structures are taken into account, rather than technical aspects. The proposed evaluation framework is comprised of four main steps:

1. *“Developing a transformation mapping.* In the first step of our method, it is necessary to develop a transformation mapping for the grammar used for representing the reference model. This transformation mapping allows to convert the constructs of the used grammar to the constructs of the BWW-model. The transformation mapping introduces an ontological meaning for each construct of the grammar used by the reference model. The transformation mapping consists of two mathematical mappings: First, a representation mapping describes whether and how the constructs of the BWW-model are mapped onto the grammatical constructs. Second, the interpretation mapping describes whether and how the grammatical constructs are mapped onto the constructs of the BWW-model.

2. *Identifying ontological modeling deficiencies.* The second step is based on the former constructed transformation mapping in general. It is possible that one ontological deficiency is resolvable in various ways or even not resolvable at all. To identify the ontological deficiencies of the reference model all constructs of the reference model must be reviewed. Each construct of the reference model must be examined with respect to whether the construct is used correctly regarding the interpretation mapping.

3. *Transforming the reference model.* In the third step, the reference model will be transformed to an ontological model. The outcome of this step is an ontologically normalized reference model. More formally, an ontologically normalized reference model is a mapping from the constructs of the reference model to the constructs of an ontological model. While mapping a construct of the reference model on to an ontological construct, four cases can arise: adequacy, inadequacy, excess and overload.
4. Assessing the results. In the last step, the reference model can be evaluated regarding the results of the three mentioned steps above. First, the transformation mapping can be assessed in general. Based on the representation and interpretation mappings it is possible to determine the ontological clarity and adequacy of the used grammar. Second, the ontological deficiencies of constructs of the reference model can be assessed in particular. While the ontological deficiencies excess and overload have their roots in the definition of the grammar, the cause of an ontologically inadequate construct of the reference model is the specific application of a grammatical construct employed by the person who developed the model. Third, the ontologically normalized reference model can be assessed. In this case, two different evaluation aspects are reasonable: isolated assessment and comparative assessment” (Fettke & Loos, 2003a).

Guidelines of Modeling (GoM): According to (Blecken, 2010), subjectivity of modeling cannot be removed completely. Thus, it is needed to develop and use a “framework of principles that improve the quality of information models by reducing subjectivism in the information modeling process” (Schütte & Rotthowe, 1998). GoM (Becker et al., 2000; Roseman, 1995; Roseman, 1998; Becker et al., 1995) is the result of selecting relevant aspects of information modeling from Generally Accepted Accounting Principles (GAAP) and elements of the existing approaches for the evaluation of information models. GoM includes six principles for quality of models: Correctness, Relevance, Economic Efficiency, Clarity, Comparability and Systematic Design (see Figure 7).

![Figure 7: The six Guidelines of Modeling (GoM) (Becker et al., 2000)](image-url)

In each guideline clarifications on what and how should be evaluated (and improved). According to (Becker et al., 2000): the guideline of correctness underlines that a model should be syntactic correct (i.e. be consistent and complete against the meta model the model is based on) and semantic correct (i.e. the structure and the behavior of the model is consistent
with the real world and support consistency between different models). The guideline of relevance is about selecting a relevant object system, taking a relevant modeling technique or configuring an existing meta model adequately, and developing a relevant (minimal) model system. The guideline of economic efficiency is a constraint to all other guidelines restricts e.g. the correctness or the clarity of a model. The guideline of clarity means a model should readable, understandable and useful for both modeler and other people that deal with it. The guideline of comparability is about using all guidelines in a modeling project consistently. Finally, the guideline of systematic design postulates well-defined relationships between information models, which belong to different views. Use of syntactic rules besides GoM is a means for improving quality of models.

**Kesh’s Proposal:** Most of the frameworks and approaches that have taken the issue of quality in modeling into account, present a set of guidelines about how to do the evaluation. According to (Moody, 1998), most of these frameworks “rely on experts giving overall subjective ratings of the quality of a data model with respect to the criteria proposed”. However, there have been researchers that addressed the quality evaluation by proposing frameworks for measuring quality in modeling with the purpose of reducing subjectivity (e.g. Kesh, 1995; Moody & Shanlaks, 2003). Kesh’s (1995) can be seen in Figure 8. The proposal is a model for evaluating quality of E-R models, relevant metrics and a relevant methodology. The model is developed based on Artificial Intelligence and Software Engineering disciplines.

![Quality Evaluation Framework](image)

Figure 8: The final framework (Kesh, 1995)

In Kesh’s model, quality is measured based on *Behavior* and *Ontology* of the model. Quality of *Ontology* is calculated based on *Completeness*, *Cohesiveness* and *Validity* if CONTENTS.
Quality of STRUCTURE is also calculated based on Suitability, Soundness and Consistency of relations between the model statements. In addition to quality of Ontology, it is required to know on what factors, quality of Behavior is dependent. Criteria for calculating quality of Behavior are Usability (User), Usability (Designer), Maintainability, Accuracy and Performance of the E-R models.

Equation “Q = w₁s₁ + w₂s₂ + w₃s₃ + w₄s₄ + w₅s₅” shows how to calculate quality of a model; where w₁, w₂, w₃, w₄, w₅ are the weights of the behavioral factors; usability (user), usability (designer), maintainability, accuracy and performance; and s₁, s₂, s₃, s₄, s₅ are the scores on the behavioral factors. The weights and the scores have to be estimated for calculating Q.

Shanks and Darke’s Proposal: Developing quality evaluation frameworks is not always done from scratch. An example of this is Shanks and Darke’s (1997) proposal, which is a composite framework for evaluating quality of conceptual models. This composite framework is built on and is an extension of frameworks proposed in (Krogstie et al., 1995) and (Moody & Shanks, 1994). Krogstie et al.’s (1995) framework, as it is described above, is based on semiotic theory, but at a high abstraction level that makes it difficult to apply. On the other hand, Moody and Shank’s (1994) proposal is about evaluating quality of models in practice, but is not based on a sound theoretical basis. Shanks and Darke’s (1997) composite framework integrates and formalizes links between the two frameworks and how they inform each other. This is done using components in both frameworks that are similar and are explored as a means of integrating the two frameworks:

- **Audience and Stakeholder**: as Audience in Krogstie et al.’s (1995) framework is more general than Stakeholder in Shanks and Darke’s, Audience is selected.
- **Goal, Property and Quality Factor**: “All quality factors in Moody and Shank’s (1994) framework, i.e. correctness, completeness, understandability, flexibility and simplicity, can be mapped to Goals and Properties in Krogstie et al.’s (1995) framework. In order to be able to discuss alternative models, Goal, Property and Quality Factors are taken separately in the composite framework.
- **Activity and Strategy**: Activity concept from Krogstie et al.’s framework can cover both.
- **Model**: from one side Model in Krogstie et al.’s (1995) framework refers to any model. From the other side, Moody and Shank’s (1994) framework supports evaluating all conceptual models. Consequently Model concept is kept and used in the composite framework.
Components that are disjoint can also be incorporated to the composite framework. Applying this framework supports quality assurance in both modeling product and modeling process.

3.2.2 Quality Evaluation of Modeling Processes, Languages, Methods and Methodologies

In studying topic of quality evaluation in modeling, concentration has been mainly towards quality of models, than processes and tools for a modeling process. “Though some have written about detailed stages in and aspects of ways of working in modeling, i.e. its process or procedure, the detailed how behind the activity of creating models is still mostly art rather than science” (van Bommel et al., 2008). Despite less number of contributions in this category, we present examples of this set as follows:

Application of Ontologies for Evaluating Modeling Languages: An approach that has been followed for evaluation purpose of modeling languages is applying ontologies. To shed more light on this, we mention a few of such contributions here. Opdahl and Henderson-Sellers (1999) conducted a series of researches to use ontologies for evaluating OO Modeling Languages (OOML). They report that they applied the same ontology that Fettke and Loos (2003a; 2003b) had applied, i.e. BWW, to evaluate Object Modeling Language (OML) meta-model. They did this to make conclusions for improving OOML meta-model. As OML is a good platform for studying OOMLs, results that were the obtained in this work, could be generalized to other OOMLs. Consequently, a framework for evaluating OOMLs is the result of this evaluation work. Details about ontological evaluation of OML were later published in (Opdahl et al., 2000b). Moreover, Opdahl and Henderson-Sellers (1999) state that BWW was used for analyzing aggregation mechanisms in OOMLs, which its results were later presented in (Opdahl et al., 2000a).

QoMo: Quality of Modeling (QoMo) (van Bommel et al., 2008) is a framework that has taken the issue of process quality in addition to product quality into account. This framework supports quality measurement of process modeling. The outline of QoMo is based on knowledge state transitions, activity costs and a goal structure for activities-for-modeling, which are then linked to SEQUAL framework. QoMO outline is based on knowledge state transitions and goal structure (usage goals, creation goals, validation goals, argumentation goals, grammar goals, interpretation goals and abstraction goals for modeling activities. The goals structure is directly linked to the main concepts of the SEQUAL framework and
expresses different quality notion. QoMo entails a comprehensive set of modeling process
goal types that are dependent on strategy description and means for process modeling
description. The strategies can be used for analyzing models and also guiding modeling
processes. The process descriptions are based on some strategy descriptions (usage strategy,
creation strategy and validation strategy), which may be used descriptively, for
studying/analyzing real instances of processes, as well as prescriptively, for the guiding of
modeling processes. Development of QoMo is an ongoing projects and more details about it
will be accessible after completion.

An Evaluation Framework Based on Analytic Hierarchy Process (AHP): Ssebuggwawo
(et al., 2009) have presented a method for evaluating EM sessions. They state their works is
an evaluation approach for modeling processes. As the main purpose of the work is
understanding and evaluating the modeling process, its emphasis is on the quality of four
artifacts that are used (modeling language, medium-support tool and modeling procedure) or
produced (modeling product) during a modeling process. Quality analysis and evaluation of
these artifacts provides a way for measuring the quality of the modeling process. This
approach is based on AHP, that is borrowed from Operation Research field. AHP as a
technique that helps in making complex decisions by integrating both subjective and objective
opinions, as well as individual and group priorities and combining deterministic and
stochastic to find out interdependencies between models. With the help of AHP one can deal
with the important phenomenon that might be biased by modelers and evaluators towards
evaluation criteria. Applying the proposed approach helps in taking everyone’s judgment into
account and the overall priority is aggregated as a group decision. It serves as a basis for
deriving adequate and theoretically sound and quantified quality criteria for the modeling
process using the AHP method. To follow the approach, three phases should be completed:
The evaluation approach is comprised of the steps: Structural Decomposition, Comparative
Judgment (which itself consists of pairwise comparison, formation of a comparative matrix
and priority vector, and checking consistency) and Synthesizing. Structural Decomposition
step is about identifying the real problem, continued by decomposing it into a hierarchical
structure. The Comparative Judgment step aims at establishing (local) priorities at each level
by comparing, pair-wise, each criterion, sub criterion, etc., in the low hierarchy levels in order
to find out the priority of each. The outcome of the Comparative Judgment step is a
comparative matrix the entries of which are the comparison values between each two criteria.
At the end, Synthesizing consists of determining overall rating and ranking of alternatives.
3.3 Conclusions of the Chapter

According to section 3.1.1, EM is a field that helps in analysis and improvement of organizations. This is done by developing models showing the current (AS-IS) and future (TO-BE) states of an enterprise, that should be analyzed to identify change needs and change measures. As explained in section 3.1.2, in order to develop enterprise models, a suitable EMM should be applied. On the other hand, quality is a broad notion, where its meaning has to be clarified to ensure a unified understanding about it. The topic of quality has been studied in different fields, including IS and different quality models have been proposed (see section 3.1.3, Table 3). In these proposals, the notion of quality is operationalized by specifying its different aspects, i.e. defining a set of criteria for it. As seen in Table 3, among different criteria for quality, efficiency is mentioned as an aspect of quality in all quality models proposed in IS. This shows that efficiency is an effective factor in IS quality.

In an EM process, the quality of models and modeling processes are important issues. As explained in section 3.2, numerous contributions regarding quality of enterprise models and modeling processes have been developed. While some researches concentrate merely on quality evaluation of models and modeling processes, there have been contributions on how to improve the quality of models. Quality evaluation of a modeling process might include assessing different subjects such as quality of modeling languages, quality of modeling methods, the surrounding environment, etc. An EMM is the relevant tool for applying and receiving support from EM. An EM process, likewise other types of processes, is required to be efficient and the selected EMM should fulfill this need. Accordingly, investigating whether the EMM is suitable for this purpose, is a fundamental step in an EM process (or in fact the EMM application process). However, the issue of efficiency evaluation in EM has not been investigated yet. Due to the importance of this topic in EM and the fact that it has not been addressed yet, it was found necessary to begin research about it. The research results are presented in chapter 5.
4. Enterprise Modeling Case Studies

In this chapter, the research projects and EM cases that were used as case studies for conducting the present research are described. To cover this, section 4.1 exposes the rationales of selecting these particular projects and EM case studies. Sections 4.2 and 4.3 go into more details and elucidate more details of the selected projects and the EM case studies. The EM case studies helped in identifying some problems that might happen in EM projects. The identified problems can be seen in section 4.4. The chapter concludes with section 4.5, which entails a summary on problems explained in section 4.4 and the need for performing the presented research work.

4.1 Rationales behind Selection of the Cases

Selection of projects and EM case studies from them was based on some rationales. In this section, the reasons behind these selections are presented. The EM case studies helped in identifying some problems in EM cases. The same EM case studies were followed for developing the research contribution. In fact, the EM case studies formed the background of this research. According to this and also for the reason of simplicity, in the remainder of this chapter the EM case studies are referred to as “background cases” or simply “cases”. In the rest of this thesis, they are referred to as “background cases”.

Diversity: The observed EM cases were selected from the infoFLOW-2 research project (section 4.2) and the EM Course Spring 2012 (section 4.3), which are different from each other from several aspects. The infoFLOW-2 project (henceforth infoFLOW-2) and EM Course Spring 2012 (henceforth EM Course) were different from each other in aspects ranging from the involved modelers to domain experts and from type of cases to the followed approaches. Working with cases from different projects that are selected respecting their differences enhanced the possibility of identifying more problems. Cases from different projects could still have problems in common. It is probable that a vague problem in a case (in a project), was clearer in another case (that might be even from a different project). Even clarity of a problem that is obvious in both, can be considered as an emphasis of its importance and be helpful in understanding its importance and consequently result in taking it into account. Problems that are visible in only one of the cases, would be identified. This contributes to identifying additional problematic issues, especially those that occur less frequently. According to all above, cases from different projects were selected to identify
more (in terms of number and accuracy) problems. Table 5 summarizes the differences between the projects.

Table 5: Comparison between InfoFLOW-2 and EM Course

<table>
<thead>
<tr>
<th></th>
<th>InfoFLOW-2</th>
<th>EM Course Spring 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modelers</td>
<td>3 Experts</td>
<td>5 Novices</td>
</tr>
<tr>
<td>EMM</td>
<td>IDA</td>
<td>EKD</td>
</tr>
<tr>
<td>Number of Sessions</td>
<td>1</td>
<td>5+</td>
</tr>
<tr>
<td>Purpose</td>
<td>Actual improvement in the enterprise</td>
<td>Education</td>
</tr>
<tr>
<td>Type of the Investigated Cases</td>
<td>Real</td>
<td>Dummy</td>
</tr>
<tr>
<td>Approach</td>
<td>Participative</td>
<td>Consultative</td>
</tr>
<tr>
<td>The Thesis Author’s Involvement</td>
<td>Expert modeler</td>
<td>Tutor</td>
</tr>
</tbody>
</table>

**Involvement of the Author:** Another reason for selecting the mentioned was the involvement of the author: in infoFLOW-2 as expert modeler and in EM Course as tutor. Having a role in the EM cases not only as an observer, but rather as an active participant helped in obtaining more pervasive knowledge that facilitated the observance process. The selected projects were carried out by the Information Engineering research group at Jönköping University (School of Engineering). infoFLOW-2 required carrying out several EM cases. The author of this thesis was involved in the project and participated in a number of cases. In some cases, the author conducted the modeling session in collaboration with other modeling experts, while in others, the author was the only modeling expert. In the EM Course, the author was involved not as a modeler, but rather as a project tutor. This role was about supervising students in their efforts towards completing their course projects. By selecting cases that the author was involved as an active member, it became possible to gain a rather clear image about details of the cases, from the followed EMMs to the discourse domain. It also provided the basis for having a more accurate understanding about the modeling process, such as what people refer to during the discussions, and what different parts of the models mean.

**Accessibility of EM Results:** The observed projects (and cases) were conducted by the Information Engineering research group at Jönköping University, School of Engineering. As a result, access to the output models from different stages of the EM process, was possible. The set of developed models contained different sorts of items, varying from draft models
developed in the modeling sessions on plastic sheets (e.g. cf Figure 9) to finalized models that were presented in the delivered reports (see Figure 10, that is the finalized model of Figure 9). Access to different versions of models was helpful to more appropriately understand the outputs of the modeling sessions. A point, that was missing in one version or is not clearly presented, could be revealed in the future versions. In addition to this, access to various versions of an enterprise model was a useful means even for studying the EM process.

The above stated points were major rationales for selecting EM Course and infoFLOW-2 as background projects (and cases) for observation. This helped in deciding the relevant research questions and developing results to address the questions.

4.2 infoFLOW-2
This section starts by presenting an introduction to infoFLOW-2 project in 4.2.1. The project required performing several EM cases and one of them was selected for the purpose of this thesis. Details of this case are given in 4.2.2.

4.2.1 Introduction to infoFLOW-2
This explanation is written based on the project proposal (Scientific Project Plan, 2009) and final report (Final Report for infoFLOW-2, 2012).

“The infoFLOW-2 project is a continuation of the KK-Foundation funded project infoFLOW. The problem addressed is information overload in industrial enterprises, which results in inefficient work processes, quality problems and unnecessary costs. The industrial demand is to find organizational and technical solutions, and best practices for information flow, which can be reused in different enterprises. The approach taken was to develop information demand patterns capturing organizational knowledge for information flow” (Final Report for infoFLOW-2, 2012). The project runtime was 2010-04-01 through 2012-03-31 and was done as cooperation between five institutes, Jönköping University (School of Engineering), SYSteam, c-Business, Proton Finishing, Centrum för Informationslogistik (CIL) and Fraunhofer ISST, collaboratively (ibid).

According to (Scientific Project Plan, 2009), infoFLOW-2 is relevant to the field of Computer Science. More precisely, it aimed at contributing to Information Logistics, Organizational Knowledge Modeling and Pattern Use. The core problems were addressed in infoFLOW project and imposed the need for further research, i.e. conducting infoFLOW-2. The aim of
infoFLOW-2 was to address industrial demands of enterprises and IT consultants developing solutions. The project contributed in different ways, such as:

- contributing to the area of EMMs, by improving the existing methodology component for information demand analysis;
- advancing the field of EMMs by contributing with practices for information demand modeling;
- contributing to the area of knowledge patterns by advancing the concept of information demand patterns;
- contributing to the areas organizational knowledge management and EM by evaluating the effects of information demand patterns use;
- contributing to the information logistics community in a large by initiating and establishing a community on the web gathering interested researchers for purposes of information demand pattern validation, collection and development (ibid).

Consequently, completing the project resulted in achievement of the following objectives:

- development of a large number of information demand patterns for the application areas covered by the project partners (pattern factory);
- evaluation of the benefits of information demand patterns in practical use (compared to conventional improvement projects and compared to changes in the previous situation);
- establishment of a pattern community on the web for pattern distribution, retrieval (repository) and continuous improvement;
- improvement of the pattern development method in terms of ease-of-use and the pattern representation in terms of visual quality;
- spread the knowledge about pattern development and use (Scientific Project Plan, 2009; Final Report for infoFLOW-2, 2012).

To reach the above stated contributions and objectives, various types of activities such as meetings and modeling workshops (sessions) were pursued. “infoFLOW-2 meetings with all partners were arranged on average 4 to 5 times a year. The major tasks of the meetings were discussion of activities, presentation of results and decision about future work planning. Additionally, many modeling workshops, interviews or work package specific workshops were performed” (Final Report for infoFLOW-2, 2012).

During the modeling workshops and work package specific workshops (aka: modeling cases) the attendants worked with finding out what information demands that a role has. For this
purpose, they selected different roles at different enterprises and identified their information demands. The EMM used in this project and its modeling sessions was Information Demand Analysis (IDA) (Lundqvist et al., 2012). This EMM is developed specifically for modeling information needs of a role in an enterprise. The author of this thesis was involved in a number of meetings and workshops and acted as a modeling expert in a number of modeling sessions, in some cases as the only modeling expert and in other cases in collaboration with other modeling experts.

4.2.2 Observed Modeling Case/Workshop in infoFLOW-2

As mentioned above, a part of this project was to conduct modeling workshops. A modeling workshop was done with the purpose of covering the or a fragment of a particular case. From the different modeling cases where author attended as modeling expert, one was selected as a case study for this thesis. In this section, the selected case is briefly introduced. The explanation is about what role and which enterprise that was elected for information demand analysis and how the sessions went. The explanation has been written based on (Carstensen et al., 2012c).

Application Case Order Planning: Proton Group4 is an assembly of several companies, including Proton Finishing5. Proton Finishing works with surface treatment in different plants in Sweden and Denmark. To do its business, Proton Finishing requires keeping communication with its customers, which is done by the role “order planner”. “The purpose with order planning case is to gain a better view on the information demand that the role of planner has. The planner has to optimize the process between receiving the goods and starting the actual manufacturing where the surface treatment is done. In this process several information objects are handled by different stakeholders and by gaining a better knowledge about this process it is possible to make it more efficient” (ibid).

According to (ibid) two domain experts and three modeling experts (including the author of this thesis) participated. Although the expectation was to includ domain experts that act as order planners at Proton Finishing, alternative participants who possessed other roles joined the session: one QA & environment manager, and one logistics & purchasing responsible. Besides including the (alternative) domain experts, the model from a EM case, that was completed in an earlier session, was used. This session however was later on documented. The modeling participants started the session by giving a brief introduction on their role in the

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4 www.proton.se
5 www.proton.se/en/finishing
relevant organization. As a complement to this, the domain experts gave a presentation about the enterprise and specifically the domain of discourse. After concluding that all participants had the minimum knowledge about the case, the IDA modeling started. Models during the modeling session are subject to constant change. Therefore, modeling was done on a plastic sheet and using post-its. This helped in following a convenient modeling process. To ensure that the “draft” model would not be spoilt, photos were taken of it, which were later put together to make a coherent image (see Figure 9).

![Diagram of Information Demand Model](image)

**Figure 9**: Draft of information demand model for the application case order planning (Carstensen et al., 2012c)

The captured photos and the plastic sheet were reviewed, refined and transformed into electronic form (see Figure 10).
4.3 "Enterprise Modeling (EM)" Course

This section starts by elaborating what the EM Course is about in section 4.3.1. The course covers different activities, from theory to practice. The main practical part of the EM Course was working on a course project. Section 4.3.2 contains explanations about the project group (team) that was observed as a case study for the purpose of this thesis.

4.3.1 Introduction to "Enterprise Modeling (EM)" Course, MSc Level

EM is a course that is included in the syllabus of the master level programs, IT, Management and Innovation (Programme syllabus IT, Management and Innovation Two Years, 2012; Programme syllabus IT, Management and Innovation One Year, 2012) and Information Engineering and Management (Programme Syllabus Master of Science in Informatics, specialization Information Engineering and Management, 2012) at Jönköping University (Högskolan i Jönköping: HJ). According to (Course Syllabus Enterprise Modeling, n.d.) by completing this course the student will be able to use EM in different problem situations, such as organization development, information system development, standardization of enterprise processes, etc. Also, they will be able to develop models using the EKD method (Bubenko et al., 1998) and finally obtain knowledge for learning various other modeling methods. EM course aims at giving students knowledge and skill for developing and analyzing conceptual
The teaching forms selected for covering the underlined topics are giving lectures / seminars and completing a course project (ibid). Although it seems that it is not possible to cover all above mentioned activities, in practice the teachers’ effort was on developing models for a specific case, followed by analysis and identification of the change needs and change measures. To work on the course project students had to form groups and each group should develop enterprise models using EKD for a particular case. The selected EM case was based on a scenario for a dummy company called Dressed for Success (DfS) (Seigerroth, 2012). In the course project the students were asked to develop five (out of six) sub-models of EKD: Goals Model (GM), Business Process Model (BPM), Business Rules Model (BRM), Actors & Resources Model (ARM) and Concepts Model (CM). These models were later used to investigate the AS-IS state of DfS and in the view of that, identify change needs and change measures.
4.3.2 Observed Modeling Case (and Its Workshops) in EM Course

From the activities that are defined for the course, the planned course project was the relevant activity for being followed to prepare the basis for this thesis. To carry out the course project of the EM Course, students were divided into groups of 5-6 members and followed the EKD user guide (Bubenko et al., 1998), lecture slides and other course materials. In the course schedule five supervised sessions were scheduled that project groups were supposed to attend, to continue their modeling task and discuss their questions with the project tutors. The supervised sessions of the selected groups were conducted in parallel with other groups. As the project tutor in the course, the author had access to the models developed by all groups and was in charge of answering students’ questions. Although the observation was concentrating on the selected groups, questions posed and models developed by other groups were not neglected. Students received even more detailed feedback on their work in a pre-final and final tutoring from the project tutors. However, they were told that they should arrange extra sessions to be able to cover the whole task. More explanations on the course project are presented in-line with section 4.3.1.

As support to this particular research and to see how students work in a group, one specific group was selected and their modeling sessions (both supervised and extra sessions) were video recorded. The selected EM group (team) consisted of five MSc level students. These videos were later reviewed to find any problems that occurred. On the other hand, questions and issues that members of other projects groups faced during their work, were also taken into account. Four samples of EKD models that the observed group developed and included in their final report can be seen in Figures 11 to 14. In the caption of each figure, the first part is the title of the figure. The second part of each caption is a short explanation on whether the model is from acceptable quality.
Figure 11: A sample “Business Process Model” developed in the EM Course. The model is developed according to the EKD syntax for BPM (Business Process Models); the given labels are understandable.
Figure 12: A sample “Goals Model” developed in the EM Course. Placements of model components are proper.

Figure 13: A sample "Goals Model" developed in EM Course. Components of the model are placed disordered.
4.4 Identified Problematic States in EM Projects

By observing background cases from infoFLOW-2 and EM Course, some problems were identified. Identification of these problems was rather straightforward. They were indeed obvious issues that occurred during the EM processes and identifying them did not require
After detecting the problems, they were categorized into groups. Elaborations on problems in each group contain examples and references to sample models from the background cases (that are made known in section 4.2 and section 4.3) and/or statements from chapter 5. To prevent redundancy, statements relevant to both the identified problems and research results (that are presented in chapter 5), are not repeated here. In the following, the identified problems and problem categories are presented:

**Low-Quality Enterprise Models:** EM, EA and BPM are areas that for a long time have been part of a tradition where the mission is making improvement in enterprises (Harmon, 2010). Enterprise models as the results of an EM process are usable for such an improvement goal. A challenge during EM is quality of enterprise models (Persson & Stirna, 2009). The quality issue of models has been investigated by different people and several works have addressed this issue (e.g. cf. Batini et al., 1992; Becker et al., 2000; Fettke & Loos, 2003a; Krogstie et al., 2006). Although different authors have approached this issue differently, there are matters that most of the works have taken into account while studying the quality of enterprise models. Understandability of models, as an aspect of model quality (Moody & Shanks, 1994; Frank, 2007), refers to the fact that an enterprise model should be found understandable by the model user and model developer alike (Becker et al., 2000). Conclusion on understandability of models is subjective (ibid), i.e. varies from person to person and her/his capabilities. Not only understandability of models, but their correctness is also underlined as another aspect of models quality (Moody, 1998; Ssebuggwawo et al., 2009), which means enterprise model should reflect the reality in a correct way and not convey the wrong message; in short, it should be semantically correct (Lindland, 1994). Another sort of correctness of models is conformance to syntax of the followed modeling language, i.e. syntax quality (Krogstie, 2012a). After all this, it is also expected that enterprise models are relevant and usable for the intended improvement work (Becker et al., 1995; Krogstie, 2012a).

In the observed EM cases, there were several occasions when low-quality enterprise models were produced. Sometimes the models were not understandable by other people who were going to review the produced models, such as EM teachers that had to guide the students in their project work, tool workers that were going to implement the draft models in computers or those that were going to interpret the models and make decisions. For example, some models were hard to read and follow. A cause of this problem was poor presentation of the models that was a complex of different problems itself. Disordered placement of model components (see Figure 13 as an example of a Goals Model that its components are placed...
disordered; make a comparison with Figure 12 where placement of its components are ordered) was a problem that made understandability of problems difficult. In addition to this, texts and labels, that are not easy to comprehend (see Figure 14 as an example of a Business Process Model where labels of its model components are confusing and not convenient to understand, especially the “Information/Material” components; compare with Figure 11 where elements have with understandable labels), were also a cause of comprehending the models inconveniently. It even happened that modelers developed models by following the EMM syntax in correctly (see Figure 11 as an example of a Business Process Model matching the defined syntax; compare with Figure 14 that violates the relevant syntax in different places). This was mainly about having incorrect understanding of different EMM parts and as a result, using them wrongly.

Occurrence of these problems resulted in gaining low-quality models. This even at some points of time imposed the need for repetition of the modeling process.

**Incorrect Understanding of the EMM:** An EMM or a modeling language is a tool used for developing enterprise models. Understandability of an object-oriented modeling language (OMG, 1997) as a dimension of its quality can be generalized to all types of modeling languages in, including EMMs. Tools used for developing models are required to be understood by users. An EMM, as the relevant tool for developing enterprise models, is comprised of different parts (see Figure 5). There is a need to have a correct understanding of different parts of the EMM: *Perspective, Method Component (Procedure, Notation and Concepts), Framework and Cooperation Principles*.

The issue of incorrect understanding of the EMM was found in both the observed cases and regarding different EMM parts. In the following, a few examples of this are presented. These problems were significant and were identified immediately. To apply the EMMs, it was necessary to ensure they were found helpful by the modeling team. Misunderstanding about *Perspective* and how an EMM can support a purpose, was a problem occurring prior to or even in the beginning of an EM process (e.g. *Statement 3*). After confirming suitability of the EMMs *Perspectives*, their *Frameworks* had to be followed. Uncertainty about how to perform the work, i.e. what phases that have to be completed and how, was a notable problem in applying the EMMs and conducting the EM cases. An example of this can be seen in *Statement 10*. This kind of conditions were misleading or confusing in the process. To perform the phases of *Frameworks*, that aimed at developing models, use of *Method Components* was necessary. This method part was perceived wrongly in different ways. There were occasions when modelers were going to apply an irrelevant *Method Component* (e.g.
It also happened that comprising parts of Method Components were understood incorrectly. For example, team members were confused about how a notational constituent (an element or relation) can be used (e.g. Statement 24) or how to differentiate between different meanings and Concepts (e.g. Statement 29). There were also moments when team members were not on the right track in investigating the enterprise and extracting relevant information about it, which is the topic of Procedure. Examples of this occurred when the team members had not learned the method Procedure correctly (e.g. Statement 17). As can be seen, the identified problems are relevant to Perspective, Method Component (Procedure, Notation and Concepts), but no problem relevant to Cooperation Principles is stated here. This does not mean that in applying the EMMs no problem regarding this part occurs. Rather, this was merely how it went in the observed EM cases.

Incorrect Understanding about the Case: To start studying an enterprise and construct improvement actions, one should have an understanding of the state of the enterprise. “We should inquire the current situation. When the current state is clarified, it is possible to begin the design of future solutions” (Goldkuhl & Röstlinger, 2010). This is mainly about which enterprise components are related to each other in the under studied domain and how things go in the enterprise. This is however not an easy process, since a part of it is about transforming tacit knowledge into explicit knowledge or transforming subjective knowledge into objective knowledge (Wickramasinghe & Mills, 2001). “Tacit knowledge exists in the human’s mind, which is the knowledge that people don’t know; in other words people don’t know what they know” (Allee, 1997); they even do not know what they want. If the process of extracting explicit knowledge results in producing incorrect output, the audience will probably get an incorrect perception on the enterprise.

In the performed cases, it frequently happened that the modeling team members had doubt about a part of the discourse domain. They were not sure of how two elements were related to each other or how an issue is handled. For example, members had doubts about what tasks a role should complete (as an example see Statement 20 together with role Final Planer in Figure 10) or what is needed as input for accomplishing a task (as an example see Statement 21 and Statement 31 together with role Goods Receiver in Figure 10). They realized that there are issues in the enterprise that they had not been aware of. It was seen that people had different or even contradictory perceptions about a specific fact in the enterprise. This resulted in starting discussions about what idea was correct or probably more correct.

There were occasions when team members had to make assumptions in order to proceed the work. Especially, in the EM Course case, the modeling team members did not have access to
the real domain experts and found it necessary to make assumptions. This presented some difficulties, since they had not clarified their assumptions. As a consequence of this, it was difficult at some points to judge if the models were developed fully based on DfS scenario (Seigerroth, 2012) or parts of them are based on assumptions (e.g. Statement 23).

**Deviation from the Proper Working Path**: To reach the objectives of EM that are assisting in better understanding and a unified enterprise, building new parts of the enterprise, and also providing a model used to control and monitor the enterprise operations (Madarász, 2005), relevant models have to be developed. During the process of developing enterprise models, the focus at a time should be on modeling only one state of the enterprise. The resulting model should represent either the current or future state. Different states cannot be included in one model. In case this mistake is committed, the process of identifying the shortcomings will be hindered.

In infoFLOW-2 and EM course the attendants were supposed to concentrate on modeling the current state of the enterprise, identify the shortcomings in the enterprise and figure out the change needs accordingly. During the modeling processes, the team members were sometimes struggling in remaining on the correct working path. It was specifically evident when they were discussing the current and future states of the enterprises. This resulted occasionally in deviating from modeling the current state of the enterprise and instead including information regarding change needs (or the TO-BE state in the AS-IS models (e.g. Statement 29). Such a deviation made the diagnosis and solutions development processes difficult.

**4.5 Summary of the Identified Problems in the EM Projects**

The major problems identified in the performed projects are explained in section 4.4. Having a closer look at these problems, we can divide them into two main groups. The first group, that has really only one member, contains “Low-Quality Enterprise Models”. This issue is the potential cause of further difficulties. Enterprise models are developed to be used as input for improvement purposes and models that violate any of the quality criteria of enterprise models result in inconvenience during further work. As a consequence of this, the audience might get wrong interpretations on the domain of discourse, which itself might result in making wrong decisions. As a consequence, low-quality models impose the need of carrying out extra work for improvement and to make them usable. Such extra work varies from minor changes to even re-modeling the whole case. The second group of problems, that entails “Incorrect
Understanding about the EMM, “Incorrect Understanding about the Case” and “Deviation from the Right Working Path”, affects an EM process (either directly or indirectly). Just like the first set of problems, this set inflicts the need for extra effort to keep the work process according to the requirements and expectations of the modeling team and stakeholders.

Occurrence of the above mentioned sets of problems in the observed EM cases demonstrated that figuring out solutions for addressing them is important. Besides this, process quality has a direct influence on the product’s quality (see ISO/IEC 9126). A similar topic has been underlined by researchers of EM field. It has been discussed that EM processes influence quality of enterprise models (van Bommel et al., 2008). In an EM project, both the EM process and modeling results are of interest. The produced models should be found relevant and useful by the stakeholders. It is also important that the EM process be performed in a proper way. This need became a motive for conducting the current research. A solution for this is to define a set of criteria that should be covered by the EMM. These criteria underline factors whose fulfillment by the EMM is decisive. An EMM that meets the specified criteria supports performing the EM process correctly. Such a process and the EMM that is used to initiate it, help in developing models closer to the ideal. This idea was developed to deliver the research results, presented in chapter 5.
5. Efficiency Evaluation in Enterprise Modeling

This thesis is done with the purpose of studying the topic of evaluating efficiency (as an aspect of quality) in EM. The result of this investigation forms the current chapter. Section 5.1 clarifies what the notion of efficiency in EM means. This is followed by introducing an approach that supports evaluating efficiency of EMMs in section 5.2.

5.1 Efficiency in EM

An EM process is performed using a relevant tool that is an EMM to develop enterprise models. Therefore, an EM process can even be called an EMM application process. Such a process is expected to be of high enough quality. An aspect of quality in an EM process is conducting an efficient EMM application process. As it is stated in 3.1.3, this thesis pursues Kurosawa’s (1991) definition of efficiency:

"Efficiency is used for passive or operational activity, which is usually defined technically so that the system and its behavior are foreseeable in advance”.

A process should result not only in “results attainment”, but according to Kurosawa (1991) it should “be foreseeable” to ensure efficiency of the process. In case any of these conditions is not fulfilled, efficiency is consequently violated.

To have an efficient EM process, the relevant EMM should support this aim. Thus, application of the EMM should result in fulfilling stakeholders’ needs. It should also fulfill a number of criteria that clarify how the EMM should be, i.e. the EMM should be foreseeable. We call an EMM that covers these needs (as requisite for conducting an efficient EM process) an efficient EMM.

An EMM, as a variation of method, is not a singleton artifact. It is built from and comprised of different parts: Perspective, Framework, Cooperation Principles and Method Component, where Method Component is comprised of Procedure, Notation and Concepts (see Figure 5). Applying an EMM means working with different parts of it. Therefore, it is necessary that different EMM parts aid in conducting EM process. As a result of this, foreseeability of not only the EMM as whole, but its comprising parts matters.

In applying an EMM it should be noted that there are criteria that always have to be fulfilled, always in the same way, and regardless of the current case. Also, there are issues where their fulfillment depend on the ongoing case and vary from case to case. In, short, the need is
having an EMM with parts that support efficiency in “general case of application” as well as “specific case of application”. According to all above, an efficient EMM is defined as follows:

An EMM is efficient if the results of the EM process are according to the needs expressed by the stakeholders and the process defined by an EMM (and each part of it) is performed exactly according to the criteria for the general and specific case of application.

5.2 An Approach for Evaluating Efficiency of Enterprise Modeling Methods

As it is discussed in section 2.1.2, the contribution of this thesis is an artifact. The intended artifact is an “Approach for Efficiency Evaluation of EMMs (A3E2M)”, which is presented in this section. This artifact is developed respecting the notion of efficiency (elaborated in section 3.1.3), the notion of method (see Figure 5), the state of research in quality evaluation in EM field (see sections 3.2 and 3.3) and problems identified in the background cases (see sections 4.4 and 4.5). The same cases were later on used for developing the results. In development of A3E2M, statements from the background cases were used. Each statement is extracted from either the followed handbooks ((Bubenko et al., 1998) and (Lundqvist et al., 2012)) or discussions between the participants of the EM cases. Table 6 contains the list of participants in the background cases.

<table>
<thead>
<tr>
<th>Organizational Role; Organization</th>
<th>Project</th>
<th>Role in the EM Case</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student; HJ</td>
<td>EM Course</td>
<td>Modeler</td>
<td>Participant 0</td>
</tr>
<tr>
<td>Head of Quality Management; Proton Finishing</td>
<td>infoFLOW-2</td>
<td>Domain Expert</td>
<td>Participant 1</td>
</tr>
<tr>
<td>IT, Logistics and P Manager; Proton Finishing</td>
<td>infoFLOW-2</td>
<td>Domain Expert</td>
<td>Participant 2</td>
</tr>
<tr>
<td>Researcher, Associate Professor; HJ</td>
<td>infoFLOW-2 &amp; EM Course</td>
<td>Expert Modeler</td>
<td>Participant 3</td>
</tr>
<tr>
<td>Researcher, Lecturer; HJ</td>
<td>infoFLOW-2 &amp; EM Course</td>
<td>Expert Modeler</td>
<td>Participant 4</td>
</tr>
<tr>
<td>PhD Student, Researcher; HJ</td>
<td>infoFLOW-2</td>
<td>Expert Modeler</td>
<td>Participant 5</td>
</tr>
<tr>
<td>Student; HJ</td>
<td>EM Course</td>
<td>Modeler</td>
<td>Participant 6</td>
</tr>
<tr>
<td>Student; HJ</td>
<td>EM Course</td>
<td>Modeler</td>
<td>Participant 7</td>
</tr>
<tr>
<td>Student; HJ</td>
<td>EM Course</td>
<td>Modeler</td>
<td>Participant 8</td>
</tr>
<tr>
<td>Student; HJ</td>
<td>EM Course</td>
<td>Modeler</td>
<td>Participant 9</td>
</tr>
<tr>
<td>Student; HJ</td>
<td>EM Course</td>
<td>Modeler</td>
<td>Participant 10</td>
</tr>
<tr>
<td>PhD Student; HJ</td>
<td>infoFLOW-2 &amp; EM Course</td>
<td>Expert Modeler</td>
<td>Participant 13</td>
</tr>
</tbody>
</table>

Table 6: Modeling participants of the background cases
In section 5.2.1 it is clarified how the statements are used in developing the results. The remainder of this section is dedicated to clarifying the structure of A3E2M (in section 5.2.1) and explaining how to follow this approach (section 5.2.2)

5.2.1 Structure of the Approach for Efficiency Evaluation of Enterprise Modeling Methods

In this section the structure of A3E2M is presented. Figure 15 gives an overview of how the structure of A3E2M is presented. A3E2M entails a list of efficiency criteria that an EMM should cover to be called efficient. It is explained what criteria for each method part should be fulfilled and how efficiency of each part could be evaluated.

![Figure 15: An overview of A3E2M structure](image)

To do this, the current section is organized as follows: it consists of sub-sections (5.2.1.1 to 5.2.1.4), each covering one EMM part, i.e. Perspective, Framework, Method Component and Cooperation Principles; sub-section 5.2.1.3 consists of three sub-sections (5.2.1.3.1 to 5.2.1.3.3) relevant to the constitutive parts of Method Component: Procedure, Notation and Concepts. Each sub-section starts with elaboration on that particular EMM part. This sheds more light on what is presented in the method notion about each part. This is followed by defining efficiency criteria for different method parts. The criteria are divided into two main categories: Criteria for General Case of Application and Criteria for Specific Case of
Criteria in each category are operationalized by explaining exactly what has to be fulfilled. They are supported by including statements from the background cases. Each criterion is given an alphanumeric identification. The letter part consists of the initial letter(s) of the same EMM part and the numeric part shows the numerical position of the criterion in the EMM part. Some statements are quotations from discussions between the project participants and the rest are written based on the EMM user guides followed in the background cases (see [Bubenko et al., 1998] and [Lundqvist et al., 2011]). Each statement is given an identification. Since efficiency evaluation is indeed checking whether the defined criteria are covered, each sub-section ends with a list of suggested driving questions. These questions can be considered as the starting point of the evaluation process. The user nonetheless, is not restricted to this list and can define additional evaluation questions as well.

Table 6 contains the list of modeling participants, their relevant organizations, the role each individual held in her/his organization and role in the EM case. For simplicity reasons, each participant is given an identification, are used to clarify what statement in the text is stated by what participant. In this table, Participants 1 to 10 are individuals that were involved in the followed modeling cases. Participant 0 refers to students of the EM course that were members of other project groups. They were not directly of interest for this research, but the author was in contact with them as their project tutor. This contact resulted in identification of a number of issues that they brought to the table as questions. Thus, such statements are also considered for developing the results. Participant 13 refers to the author that was involved in both infoFLOW-2 and EM Course. Participants 11 and 12, that are not included in Table 6, are not relevant to this chapter. They were involved later in validating the contribution.

5.2.1.1 Perspective

Perspective is a part of a method that sheds light on what is important and can be supported by the method. Although it might look that it is sufficient to know only this about Perspective, in order to have a Perspective that supports efficiency, one needs to go into more details and specify criteria that should be covered. To develop enterprise models, the modeling team need to get a clear perception about the enterprise. Perspective of an EMM clarifies the viewpoints that can be followed for developing enterprise models using this specific EMM. In an EMM, Perspective can be clarified explicitly, or be implicit in explanations about the other method parts. This is however preferred to be as explicit as possible. The more clear and unambiguous a method Perspective is, the more correct understanding an audience will have about it. Consequently, the possibility of selecting a proper EMM will be higher. Efficiency
criteria for general and specific application cases in an EMM Perspective are presented below:

Efficiency Criteria for Perspective in General Application Cases:

Pe1: Clarification on modeling what aspect(s) of an enterprise are supported by this EMM: An EMM is developed to help its users in studying an enterprise. This is done by modeling the enterprise from one or more viewpoints. An EMM Perspective should clarify how pervasive an EMM is and from what viewpoint(s) the enterprise can be modeled. Hence, it is required to highlight what aspects of the enterprise can be modeled using this method:

<table>
<thead>
<tr>
<th>In the EKD user guide, the Perspective is explicitly exposed by Bubenko et al. (1998). As the EKD user guide state, the purpose of applying this EMM can be formed in a four-item list:</th>
</tr>
</thead>
</table>
| • how the enterprise functions currently  
• what are the requirements and the reasons for change  
• what alternatives could be devised to meet these requirements  
• what are the criteria and arguments for evaluating these alternatives. (Statement 1) |

According to the IDA handbook, “understanding information demand is very much about provision of view about individuals that have such a demand”. Although the title of the EMM implies that it helps in modeling information demand in an enterprise, it is still required to go through the handbook to get a more detailed perception. (Statement 2)

Pe2: Clarification on modeling what aspect(s) of an enterprise are not supported by this EMM: In a definition or delimitation it is preferred to clearly stipulate the borderline between what can and what cannot be covered by the intended meaning. Although, this is not straightforward, fulfilling it is a considerable aid. By making the assumption that Perspective in an EMM is a type of delimitation that clarifies the coverage of the EMM, it should be clear what type of modeling purpose it does and does not support. Users review the method user guide to find out what the Perspective is and to confirm whether the EMM supports the current needs. A common mistake is that people, especially those who are novices in EM or a particular EMM, have unrealistic expectations from EM in general or the EMM that they are using:

"How an EMM like EKD solves problems?  
An EMM does not solve problems for you. It helps you to model the organization. [Then] you will investigate the models to see where the problem is.”

(Statement 3; Participant 10, Participant 13)
Hence, it is necessary to make it clear to the audience what an EMM is and for what purpose it can (and cannot) be helpful.

In addition to this, exposing *Perspectives* that cannot be supported by the method, helps in preventing confusion and misinterpretation:

> “Another important consequent of above is the clear role-based information need that it has. For example, the difference with process modeling is an activity logic, which is not the point of our focus, i.e. when we analyze information need, do not care about in what order activities are done, neither how information objects are manipulated or applied by different activities” (Lundqvist et al., 2012). Therefore, by clarifying what is included in the coverage of the method, the authors help the reader to have a correct image of what supported is and is not by this EMM”. *(Statement 4)*

In developing an EMM, different terms and phrases are defined and used. Definitions of each term and the meaning that it has in a specific context helps the audience to understand the *Perspective* and its application field. It is important that the EMM developer and the potential user have the same understanding of these terms. A part of defining *Perspective* is ensuring that all terms used in it are understandable and clear enough. Although it is expected to see an elaboration on terms used in *Perspective*, especially similar terms, in practice this is a topic relevant to *Concepts*, as it is in the *Concepts* part that EMM developers concentrate on elucidating terms and phrases.

Any change in *Perspective* affects its strength and its coverage. Thus, the expectations from the EMM require consideration after any modification to *Perspective*.

**Efficiency Criteria for Perspective in Specific Application Cases:**

**Pc3: Perspective match with modeling team’s requirements regarding the case:** An EMM is a means that helps in developing models from an enterprise. Enterprise models will be applied for further usage, mainly analysis and investigation of the models with the aim of making decisions. Depending on what part of an enterprise that the modeling team need to study, a specific type of EMM is useful. An EMM where its *Perspective* match the modeling team’s needs and requirements is more helpful for a case. These needs are usually identified and agreed upon before working with the EMM. As part of this agreement, the modeling team and the involved domain experts (including stakeholders) should decide and confirm what they intend to assess and investigate:

> “We have discussed a lot about what can be done to improve these things, but never got that far that we started looking to solutions. But I am sure we can look at some problem areas, as I said... we are very much dependent on that someone provides us with information, what we have to do is to request
it in different ways.

... 
- There are a lot of different roles, we have fine planning, a lot of information going out, driver list, debriefing and ... 
- Whom does the planner send information to? What is the next step? Who is dependent on this person in the manufacturing?" (Statement 5; Participant 1, Participant 2, Participant 3)

In addition to deciding on what needs to be investigated and discussed, it is necessary to decide on how encompassing the enterprise models should be. That is to what degree of detail should the modeling be done, and what parts of the enterprise should be taken into account:

"- If we include order, delivery, transports and all those things here too, the question is how far we can go before time runs out. It will suddenly be very big, or if we should look until production planning.
- Kind of limitation [is required]." (Statement 6; Participant 1, Participant 4)

**Evaluation of Perspective:**

Becoming familiar with the notion of efficiency in EM and how a Perspective should be to be called efficient, is necessary to start the evaluation task. This task is mainly about checking if the defined criteria for the Perspective are covered. This should be done by asking various questions, each taking points from an efficiency criterion into account. In the following a sample list of driving questions, that the evaluator can use as the starting point in evaluation of Perspective is given. In case there is a need, the list can be modified:

- From what viewpoints can the enterprise be modeled using this EMM?
- What output models will be gained by covering each aspect of the enterprise? What will the output models contain?
- Is it clarified what the strengths and weaknesses of this EMM are?
- What image of the enterprise does the modeling team desire to gain?
- What further applications are going to be taken based on the enterprise models (merely analysis, analysis followed by change action suggestions …)?
- Is the EMM pervasive enough to cover all needs of the modeling team?
- Is the complete coverage of the EMM required for the current case?
5.2.1.2 Framework

In a method, Framework is the backbone of the method and clarifies how different parts of a method are related to each other. This is done by showing the phase structure of the method and how this structure aims at fulfilling the method Perspective. In an EMM, a Framework shows the phases for visualizing an enterprise respecting the determined Perspective. A Framework in an EMM should cover some minimal requirements to facilitate the EM process and support efficiency. Below, criteria for the general and specific application cases for Framework of an EMM are presented:

Efficiency Criteria for Framework in General Application Cases:

Fr1: Support provision for the Perspective: In a method, the specification of the phase structure is mainly about how the modeling team apply the Method Component respecting a set of Cooperation Principles to cover the method Perspective. In an EMM, a Framework should comprise phases that when completed result in meeting Perspective of the EMM, i.e. developing relevant enterprise models. The subject of reaching the EMM goals, has to be operationalized by specifying the relevant phases:

“... This is ... what you do today generally. Looking at errors and faults versus all the information about how you would like to do it [and] what we do today, will be the background and controls how we design.” (Statement 7; Participant 3)

There are three main activities in an EM process: “understanding the enterprise”, “modeling” and “analysis”. Therefore, Framework phases should be set up to cover these three main activities. Framework in an EMM is supposed to provide a structure that helps in meeting the Perspective which in an EMM is visualization of an enterprise from a particular viewpoint. If an EMM Framework covers the three highlighted activities, fulfillment of Perspective is more probable. Especially coverage of the first two activities, i.e. “understanding the enterprise” and “modeling” is needed for this purpose:

IDA handbook presents a Framework showing what phases that have to be completed for developing and presenting IDA models. It is even shown that an IDA process is followed by activities that are dependent on the developed IDA models. In this way, it is even required to consider Method Components from other EMMs. All these support the IDA Perspective that is about analysis of information demands of a role in an enterprise. (Statement 8)

Bubenko et al. (1998) in the EKD user guide present an overall schema showing how an EKD process starts by studying the AS-IS state, continued by identifying change needs and followed by identifying the TO-BE state. EKD prescribes developing six different sub-models: Goals Model, Business Process Model, Business Rules Model, Actors & Resources Model, Concepts Model and Technical
Components & Requirements model. Assuming development of each sub-model is done in the “modeling activity”, the proposed Framework supports to the EKD Perspective, although the sequence of completing the phases is not clear. *(Statement 9)*

**Fr2: Clear definition of the Framework structure:** An EMM Framework contains phases that when completing them support the EMM Perspective. To follow this structure, it is important to be aware of how this phase structure works:

> “How [do] we [continue] the work? [Do] you have some suggestion?” *(Statement 10; Participant 9)*

Users of an EMM need to know how such a structure works. As in a Framework the focus is on introducing the phases and their connection with each other, we need to see what the purpose of each phase is and how it is related to the other phases. Accordingly, the current criterion is divided into two sub-criteria:

**Fr2.1: Clear definition of each Framework phase:** A Framework phase as a step of enterprise models development should receive specific types of input and give specific types of output. Clear specifications of what is required for completing a phase (input), what can be expected by the audience as well as prospective appliers (output), and the aim of the phase is what the EMM applier needs to know. It is nevertheless not expected to find details about how the goal of each phase is fulfilled, in the handbook. By fulfilling this set of requirements, the audience will have a clearer picture of what tasks that should be completed in each step:

IDA method is comprised of seven phases: “Scoping”, “ID-Context Modeling”, “Additional Analysis”, “ID-Context Analysis & Evaluation”, “Representation & Documentation” and “SE & BPR Activities” (see Figure 16).

**Figure 16: Overview of information demand analysis process (translated from Swedish) (Lundqvist et al., 2012)**
This figure clearly shows what are the required inputs are for each phase and what outputs that can be expected from them. For each phase, some inputs are provided by other phases, whereas the rest should be supplied through other means. All Framework phases (except “SE & BPR Activities”) show clearly what the purpose of each phase is, what the input and/or condition for each phase is and finally what the output of them will be. *(Statement 11)*

**Fr2.2: Clear definition of the relations between Framework phases:** Linkage between phases of a Framework that aim of each phase in the whole Framework be covered. To pursue a successful EM process, it is necessary to have full control over the practice of completing phases. Therefore, it is necessary to know in what sequence the phases have to be performed. This imposes the need for suggestions on whether the phases should be completed in parallel, in sequence or a combination of both. One expects to see what benefits the different alternatives have relative to each other. The more explicit this is, the clearer image the audience will have. This issue is significant for the “modeling” activity and especially in EMMs that support development of two or more sub-models. In such EMMs, it is important to know which different (sub-model development) phases are related to each other and how. This way it is possible to figure out where from, other than the enterprise, inputs for the current phase can be retrieved and where its outputs should be sent. Poor fulfillment of this criterion might result in confusion about in which a particular aspect of an enterprise should be modeled:

"Is it ok to work on two plastic sheets [i.e. two different sub-models]? Or she (the teacher) didn’t say anything?" *(Statement 12, Participant 6)*

IDA handbook makes it clear how different phases are related to each other and in what sequence the phases of “modeling” activity should be performed. This is done by visualizing the IDA process (see Figure 16) *(Statement 13)*.

**Efficiency Criteria for Framework in Specific Application Cases:**

**Fr3: Support provision by Framework to the case:** This criterion is not novel and independent, but is a composition of two non-aligned criteria. This is automatically fulfilled by covering “Pe3: Perspective match with modeling team’s requirements regarding the case” and “Fr1: support provision for the Perspective”. The purpose of Framework is providing support to the EMM Perspective. It is important that the structure of the Framework aids in developing models that match the modeling team’s requirements. Fulfillment of this requires covering of two different topics. First, the method Perspective should match the modeling team’s needs. This subject is to be considered in evaluating the Perspective. An EMM
Perspective should be reviewed to find out whether it helps in getting enterprise models of the required viewpoint. In continuation, we need to know how the Perspective is supported by the Framework. Knowledge about the phases comprising the Framework aids in getting a perception about how the EM results could be achieved and how they will look like. If the modeling team has specified what they need to see in enterprise models, they will be able to confirm whether following a specific EMM and its Framework is enough for obtaining their goals. This knowledge also helps in finding out if all phases need to be completed, or if there are phases that could be skipped. Accordingly, confirming whether this support is provided requires completion of the two mentioned evaluations.

Evaluation of Framework:
To evaluate the Framework part, it is required to ask questions both in general and specific application cases. The following driving questions can be used to start the evaluation process:

- What phases constitute the EMM Framework?
- What is the purpose of each phase?
- What is the required (input) for completing each phase?
- How is each phase related to others of the Framework phases?
- Does the set of phases provide enough support to the modeling team?
- What phases of the Framework are necessary to complete for the intended case?
- In what order should the Framework phases be completed?

5.2.1.3 Method Component
An EM process starts from “understanding the enterprise”, continued by “modeling” and ends by “analysis”. Each of the stated activities has a decisive role in the process, however, most of what is known as an EM process concerns applying the EMM for developing enterprise models. In practice, what mostly is considered as an EMM application process, is using Method Component. This method part itself comprises three parts that are closely related with each other: Procedure, Notation and Concepts (see Figure 5).

In an EMM, Procedure contains questions regarding the enterprise under study, and their answers will be documented using Notation in the form of enterprise models: Concepts show what is mutual between the Procedure and Notation and how they relate to each other. In an EMM, Method Component is the distinguishing part and indicates the type of the EMM. The Notation part has the main role in this contribution. In a Method Component of an EMM,
*Notation* is the part that is applied to expose the EM results. Hence, it has the main role in differentiating between different EMMs.

It is necessary that not only *Method Component*, but rather its comprising parts are efficient. Accordingly, each of the three mentioned parts should be efficient. In the following, efficiency criteria for general and specific application cases in an EMM *Method Component* are presented. Sections 5.2.1.3.1 to 5.2.1.3.3 are dedicated to presenting efficiency criteria for the constituting parts of *Method Component*.

**Efficiency Criteria for Method Component in General Application Cases:**

**MC1: Support provision to relevant *Framework* phases:** In an EMM, *Method Component* is the part that should be used for completing the “modeling” activity in an EMM application process. If the EMM contains more than one *Method Component*, it provides the possibility to model the enterprise from different viewpoints. In such an EMM, all *Method Components* might be needed either in one *Framework* phase or any subset of *Method Components* might be required in a specific phase. All the same, it is essential that each *Method Component* provides suitable support to the related phase:

<table>
<thead>
<tr>
<th>In IDA, the phase “Additional Analysis” suggests using EKD, i* and UECML. The authors motivate their suggestions by explaining the mentioned EMMs and in fact their <em>Method Components</em>, help in providing relevant material to the phase. <em>(Statement 14)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>The more a <em>Method Component</em> matches to the relevant <em>Framework</em> phase, the better the purpose of the phase can be fulfilled.</td>
</tr>
</tbody>
</table>

**Efficiency Criteria for Method Component in Specific Application Cases:**

**MC2: Support provision by *Method Component* to the current application case:** When an EMM is used in a case, it is expected to support visualizing how different elements in an enterprise are related to each other. There exist EMMs that entail more than one *Method Component*, each useful for making models from a particular focal area. In using such an EMM, all or a subset of the *Method Components* might be required. The decision about what *Method Components* that have to be taken into account for the current case is contingent upon stakeholders’ requirements for the case. If a *Method Component* support a provision that is not in the modeling team’s needs, there is no point in using it:

| “Goals and Problems relevant to IS should be modeled using TCRM [not GM]. Working on TCRM is not your job; you should skip it”. *(Statement 15; Participant 13)* |
To make this decision, modeling experts should assess stakeholders’ needs as well as the strengths and weaknesses of a Method Component to conclude whether it is suitable for the case, or not. This even influences the selection of an EMM for a particular case.

**Evaluation of Method Component:**
Evaluating the Method Component part requires asking questions in general and specific application cases. For this purpose different questions can be put. In the following examples of possible questions are presented.

- Are there any sample scenarios and are their models provided, showing how the Method Component fulfills the aims of the phase?
- Is it clear what Framework phase that is supported by each Method Component?
- To what extent does the Method Component covers the phase expectations?
- What Method Components are provided in this EMM?
- Is it clarified what is covered using each Method Component?
- Is the coverage of a particular Method Component helpful for the stakeholders’ purpose?

**5.2.1.3.1 Procedure**
Procedure, as a part of Method Component, is about what questions to ask. Procedure is not always presented in the form of questions; rather it entails explanations and details on the execution of the part. Anyhow, Procedure of an EMM guides what should be considered for assessing the enterprise and how. “What” refers to the facts that should be taken into account in asking questions and “how” refers to the formulation of procedural guidelines. Regardless of whether Procedure is formulated as questions or explanations, it should conform to some criteria. Below the efficiency criteria for a Procedure in an EMM are mentioned:

**Efficiency Criteria for Procedure in General Application Cases:**

**Pr1: Proper formulation of Procedure:** Method Procedure sheds light on how to work and is the reference for the audience and potential user to learn what to ask. In an EMM, this part aids in figuring out how to investigate the enterprise and what questions that should be addressed to provide the basis for producing enterprise models. In formulating a Procedure, it is important that the potential user of the EMM reaches the same understanding as the EMM developers about the Procedure. For this purpose, different constituting parts of the Procedure such as procedural explanations and questions should be explained in detail:
Supplying a properly formulated Procedure is a major step in defining a Procedure, whereas violation of this results in an incomplete understanding about the Procedure and the EMM that might cause several unwanted effects on the EMM application process.

**Efficiency Criteria for Procedure in Specific Application Cases:**

**Pr2: Suitability of the Procedure for the case:** In an EM case, Procedure is applied by the modeling team to ask and answer questions on the enterprise and specifically the domain of discourse. Thus, they need to work with a Procedure that is suitable for the case. A part of suitability of Procedure is that the contents can be perceived conveniently and correctly. On an overall level, a modeling team consists of domain experts and EM (EMM) experts with different experience and knowledge. Each member needs to understand the Procedure, but they might have different perceptions about understandability and ease of working with the Procedure, and its comprising procedural questions:

```
"Why is it [the IDA model] wrong?"
"[In IDA] you should think role-based, not process-based." (Statement 17; Participant 5/Participant 13)
```

Another aspect of the Procedure suitability is determining the appropriate fragments of the Procedure and its procedural questions (guidelines) that are needed for a specific case. A Procedure contains several questions and guidelines that can be used. However, this does not necessarily mean that the whole Procedure should be applied in an EM case. The reason for this is that some cases are simpler and investigating them is therefore simple and does not require going through all details:

```
"You don’t need to think about AND/OR relations between sub-goals and main goals". (Statement 18; Participant 13)
```

Simplicity of a case is depending on the level of details required by the modeling team (specially the stakeholders) and the complexity of relations within the enterprise:

```
"Should we show we have four trucks?"
"If you have a reason [for showing the figures], you can do this”. (Statement 19; Participant 0; Participant 3/Participant 13)
```

**Pr3: Availability of reliable information sources about the case:** Working with a Procedure in an EMM means asking and answering questions about the enterprise. To
provide more accurate answers, the most reliable information sources should be used. Domain experts who are involved in the enterprise, can be considered as reliable information sources. The more experience and knowledge a domain expert has regarding the discourse domain, the more truthful answers (s)he can provide:

“I’m not that good at planning myself; it’s not my field. Some things are new, the handling of the revision; it’s not easy … What does man do when they check the drive plan, Thomas?” (Statement 20; Participant 1)

“- What did we call that, which goes back there?
- good question, no clue! (Statement 21; Participant 4, Participant 1)

In addition to domain experts, different types of documentation such as organizational charts, brochures, already developed enterprise models, etc. should be considered as information sources about the enterprise:

“- We do have some picture on that, Janne, don’t we?
- We have these big activities of course. We could check how it looks. From an order to delivery, in a pure planning view, big activities. Nothing [is] detailed.” (Statement 22; Participant 2, Participant 1)

The contents of documentation might range from information collected on the current or future states of the enterprise to any other type of information required for processing the work:

“- Some of the goals [you have in the model] are not in the [D/S] scenario.
- Actually we have made assumptions.
- Then somewhere in your document you should write the assumptions.” (Statement 23; Participant 7, Participant 13)

Accordingly, it is necessary to be aware of the available information sources. Such awareness can be used for various purposes, including prioritization of the sources.

**Evaluation of Procedure:**

To perform efficiency evaluation of Procedure, we should ask questions that aid in checking whether efficiency criteria for general and specific application cases are fulfilled. To do so, the following questions might be useful:

- Are the different parts of the Procedure clear and identifiable?
- Is the Procedure comprised of guidelines or questions?
- Is each of the procedural questions elaborated?
- How does the EMM expert, as a team member, interpret each procedural question?
- How does the domain expert, as a team member, interpret each procedural question?
- Do EMM experts’ and domain experts’ interpretations of procedural questions match each other?
- Do the EMM and domain experts’, as team members, find the Procedure understandable?
- What fragments of the Procedure (procedural questions/guidelines) are applicable for the current case?

5.2.1.3.2 Notation

Notation, as the second part of Method Component, prescribes how answers to the procedural questions in Procedure should be documented. Notation part of an EMM entails notational constituents (elements plus relations between them) and guidelines on how to document the answers in the form of enterprise models. This is the final step in visualizing the real world elements and the relations between them. A Notation should cover some criteria and specifications as fundamental requirements to it. Below the efficiency criteria for Notation of an EMM are presented and elaborated:

Efficiency Criteria for Notation in General Application Cases:

N1: Proper clarifications about notational constituents: Using this method part is the final step in applying a Method Component and results in visualizing answers to procedural questions. To work with Notation, i.e. to represent answers to the procedural questions, it is necessary to become familiar with Notation and its constituents.

In an EMM, the presentation of element and relation types is the initial step for fulfilling this need. The audience review the notational elements to find out “what they look like”. However, these constituents are presented in an abstract form. Thus, reviewing textual clarifications in the EMM user guide is a necessity, too. The clearer and more detailed the texts are, the more accurate the knowledge the audience will have about the Notation. In addition, it is even useful to assess sample models. Presentation of sample models helps in getting to know the Notation and recognize useful the EMM can be:

"- I don’t get it. What is the difference between AND join and OR join.
  - Have you read the user guide?
  - Yes, but it is not written." (Statement 24; Participant 0, Participant 13)
**N2: Coverage of Procedure by Notation and contrariwise:** A Notation is expected to provide support for documenting answers obtained by following the relevant Procedure. It is crucial that in an EMM, all elements and relationship types, which might appear in answers to the procedural questions, can be depicted by the Notation. Also, the audience should be able to find out which procedural question (guideline) that is supported by each notational constituent. The results of applying a Procedure (answers to the procedural questions) might contain not only elements and relations between them, but also other constituents such as comments or attributes. It should be possible to implement the results gained by following the Procedure using notational elements in the form of models. On the other hand, presentation of each notational constituent should be with the purpose of fulfilling a specific purpose. To be more precise, each notational constituent should be presented with the intention of helping in documentation of answers that will be gained by following the Procedure.

According to all above, the expectation is to see a bi-directional coverage between Procedure and Notation. If this is violated in any of the directions, it is a sign that Notation and Procedure (or indeed Method Component) efficiency is violated:

In the phase “ID Context Modeling” of IDA, a number of driving questions are suggested that are in fact the main part of the Procedure. Answers to these questions can be conveniently documented using the given Notation. On the other hand all of the defined notational elements and relations are applicable in working with the suggested driving questions. *(Statement 25)*

**Efficiency Criteria for Notation in Specific Application Cases:**

**N3: Suitability of the Notation for the case:** When a Method Component is going to be applied in a particular project, the Notation should be found suitable by the modeling team. By suitability we refer to two topics: first the Notation should be understandable by the team members, i.e. they should be able to figure out how to implement the answers using the notational constituents:

| “Could we have one yellow for two [information objects]?” *(Statement 26; Participant 4)* |
| “When you have a Problem and its Sub-Problems, the arrow should go from the Problem to the Sub-Problems, not other way around.” *(Statement 27; Participant 13)* |

This is heavily dependent on the composition of the team. A Notation that is found straightforward and easy to understand by an EM expert might require more effort by a novice modeler.
Understandability and ease of learning of a Notation is a decisive factor in selecting an EMM. In addition to this, team members should find details of the Notation useful and necessary for their purpose:

"We don’t have information overflow [sign] in the model.
-Yes... because we did not have any information." (Statement 28; Participant 13, Participant 5).

The Notation should be found supportive for the modeling team's needs. This however does not mean each and every element in the Notation has to be applied in the case. After ensuring a match between the modeling team’s needs and Perspective, reviewing the Notation and sample models is a measure for selecting a proper EMM.

**Evaluation of Notation:**

In the following some driving questions for facilitating the efficiency evaluation process of Notation are suggested. These questions can be used to begin the evaluation process:

- What types of clarifications about Notation are given?
- Are any sample models included in the user guide?
- Are all notational constituents considered in the clarifications?
- Are all notational constituents required for the current case?
- What shortcomings does the Notation have for being applicable in the intended EM case?

**5.2.1.3.3 Concepts**

The last Method Component Part, i.e. the Concepts, is the cement part between Procedure and Notation to help in understanding terms and meanings used in the two other parts. Coverage of Concepts can even go beyond this and support the understanding of other parts, especially the Perspective. To have a Concepts part support efficiency, it should conform to some specifications. Thus, efficiency criteria for this part are presented as follows.

**Efficiency Criteria for Concepts in General Application Cases:**

**C1: Elucidation about conceptual elements:** Concepts in Method Component underline terms and meanings that are important. Concepts are the cement part between Procedure and Notation; and having a clear understanding about them in an EMM is a requirement to understand how Procedure and Notation cooperate in a “modeling” activity. Accordingly, presenting the Concepts, i.e. highlighting them and explaining their meanings is a necessity. The main cause for this need is that people that are involved in applying an EMM, need to be
able to communicate with each other. For that reason, they should the same language regarding the appointed EMM. In an EMM, there might be Concepts that look as if they convey similar meanings, but are in reality referring to different notions. Such Concepts can mislead the method applier in various ways, such as mixing up terms, gaining contradictory perceptions by different participants and including wrong Concepts into the answers:

| “Many of these [Goals] are in fact changes.” |
|“But… isn’t Goal a kind of change?” (Statement 29; Participant 13 & Participant 8) |
|“Isn’t [Information] “Sequence” the same as [Information] Flow?... When [do] we use Sequence?” |
| (Statement 30; Participant 13) |

Thus, it is necessary to not only include the meaning of Concepts, but rather to help a reader to distinguish and differentiate them.

Although this topic is presented under Concepts, this criterion can be decisive in assessing other EMM parts as well, especially Perspective. By this we mean that clarifying differences between similar terms in Perspective is a necessity that in practice should be fulfilled in Concepts. This helps the potential appliers of the EMM to have a clear picture of the strengths of the EMM.

C2: Coverage of terms and meanings used in Procedure and Notation by Concepts and contrariwise: In Method Component of any method (including EMM), there is a strong relation between Procedure, Notation and Concepts and these three parts should be in harmony with each other. Criteria concerning the relation between Procedure and Notation in an EMM were already discussed under Notation. In addition to this, it is required that the relations between Concepts and Procedure as well as Concepts and Notation be in an appropriate form. Concepts should be operationalized by inclusion in definition of Procedure and Notation. This means the two following topics should be covered:

On the one hand, the Concepts should be covered by both Procedure and Notation. By this we mean that Concepts should be used in the formulation of procedural questions (guidelines). Also, they should have been applied in the presentation of different notational constituents, such as elements, relations, comments, etc. By including Concepts in the other two parts, their meanings and the rationales of their existence become more understandable. The reason for this is that Procedure and Notation bring the discussion of how Concepts are related to each other up on the table:

| “[A] process does not go directly to database. Process gives information, information goes to the database... [first the] process, [then the] information, [at last the] database.” (Statement 31; Participant 13) |

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This last criterion (and its details) presented in Concepts part, is complementary to the criteria for Procedure and Notation. This is a considerable means to improve their understandability; Concepts especially as the thesaurus for Procedure and Notation has a determinant role in making them comprehensible.

On the other hand, the meanings that are pointed out in the Procedure (and the procedural questions) and Notation should be reflected in Concepts. However, we do not insist that it has to be considered as an independent criterion. Rather, it is a complement to the above point. As long as Procedure or Notation are understandable and not confusing, the assumption is that this coverage has been fulfilled.

**Efficiency Criteria for Concepts in Specific Application Cases:**

**C3: Suitability of the Concepts for the case:** Concepts underline terms and phrases that help in understanding the key meanings in a method. In an EMM application case, members of the modeling team should find Concepts suitable for their modeling purpose and matching what they need to use for their further purpose. Suitability of Concepts can be assessed from different viewpoints and is strongly dependent on the people involved in the team and the subject of the case. An aspect of suitability is understandability. In a specific case of application, the modeling team reviews the Concepts and their clarifications to gain a better understanding about the EMM. Accordingly, it is necessary that they find the Concepts understandable:

> “Here [BPM] information means what the process needs as input or gives as output. It doesn’t means information about the process.” (Statement 32; Participant 13)

As another aspect of suitability, the topic of usefulness should be noted. Stakeholders in a modeling case have a set of needs that should be fulfilled by developing enterprise models. These needs might be formally documented. Such documentation can be used as a reference for identifying important meanings, terms and relations between them. On the other hand, there might be needs that are not documented and remain in the form of tacit knowledge in stakeholders’ minds. In such cases, relevant terms and meanings cannot be pointed out. If the team’s requirements are embedded in any of the stated sources, they can be used for discussing suitability of Concepts (and consequently the whole EMM):

> “- We can’t find any Opportunity [elements to include in the Goals Model].
- You do not necessarily have to have Opportunity [element].” (Statement 33; Participant 0, Participant 4)
Evaluation of Concepts:
To evaluate whether the Framework part efficient is, it is required to ask questions both in general and specific application cases. To start the evaluation process, the following questions can be applied:

- Are all listed Concepts defined?
- Is each Concept mapped (or used directly) to a meaning in Notation and Procedure?
- To what extent the team members’ perceptions of each Concept match to EMM developers’ definitions?
- What Concepts have been found useful by the EM team members?
- Do all Concepts need to be considered in the specific case?

5.2.1.4 Cooperation Principles
Cooperation Principles of an EMM concentrate on how different people interact and cooperate in performing an EM process, or indeed an EMM application process. This part has to do with what roles for applying the EMM should be involved and what the work division should be. For satisfying this need and having Cooperation Principles that are efficient, this part should conform to a set of criteria. Below the relevant criteria for efficiency of Cooperation Principles in general and specific case of application are presented.

Efficiency Criteria for Cooperation Principles in General Application Cases:
CP1: Clarifications about the required competences: In an EMM user guide, developers present explanations on how to conduct the EM process. Applying any method (including an EMM) requires holding some competences. This means, that there are certain capabilities that people involved in an EM process should possess. This can be boiled down into more facets. In general, in order to work with an EMM it is necessary to include two main groups of people in the modeling group: EM experts and domain experts:

| EKD user guide clearly states what roles and competencies that are required in an EKD process: “the project manager, the steering committee, the reference group, the (domain experts) modeling participants (typically 5-8 people), the modeling facilitators, the modeling technicians, and others. However, not all of these may be needed in a smaller project. (Statement 34) |
| This can be further detailed by adding clarifications for roles in each of the mentioned groups of attendants that are required, the required number of participants or their level of expertise. |

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**CP2: Clarifications about appropriate Cooperation Principles:** An EM process requires people cooperating with each other to apply the EMM. Hence, before starting to apply an EMM, it is necessary to know how people should cooperate with each other in the EMM process, i.e. what Cooperation Principles should be followed:

In the EKD user guide it is stated that the EM progress by interviewing the modeling participants. This is followed by applying the selected EMM. All these are preferred to be in participative form. The EKD user guide also states what Cooperation Principles (consultative) should be avoided and why. (Statement 35)

In addition to this, it is useful to know what advantages and disadvantages each of the mentioned forms has.

In the EKD user guide three reasons about why a participative approach should be followed is given:

- The quality of the enterprise model is enhanced because models are created in collaboration between stakeholders, rather than resulting from a consultant’s interpretation of interviews
- Consensus is enhanced because modeling participants have to collectively expose their thinking, meaning that they have to establish a direct conflict or strive towards consensus.
- Achievement of acceptance and commitment is facilitated because stakeholders are actively involved in the decision-making process.

This list can be considered as a specification of advantages for the participative approach. Although the above mentioned motivations about why participative approach should be followed, no drawbacks about it are explained. Neither is it clarified why a consultative approach should be avoided. (Statement 36)

Having such information helps the potential EMM applier in making comparisons between different and EMMs selecting a correct method for her/his modeling purpose.

**Efficiency Criteria for Cooperation Principles in Specific Application Cases:**

**CP3: Capability of applying the suggested Cooperation Principles** To use an EMM and begin an EM process, it is important that the members of the modeling team are capable of work with the EMM. By capability we refer to having theoretical as well as practical capability:

“My name is Anders Carstensen … I work at Jönköping School of Engineering. I am both teacher and researcher, maybe more teacher. My field is Enterprise Modeling and planning.” (Statement 37; Participant 4)

Although at first glance it seems that theoretical capability (knowledge) in Cooperation Principles is not a critical factor, having this knowledge helps people to gain a clearer and more concrete understanding about what they are going to do. Also, their experience in EM
can be considered as a competence factor. Experiences are usually in the form of tacit knowledge and used unintentionally.

**Evaluation of Cooperation Principles:**

Efficiency evaluation of this part also requires asking relevant question. As a support to this, some questions are suggested to evaluate the *Cooperation Forms* in general and specific application cases:

- What *Cooperation Principles* are suggested for this EMM?
- Is it specified what roles on the modeling experts’ side and what roles on the domain experts’ side that should be involved?
- Is it clarified what level of experience and expertise that is required for each of the stated roles?
- Is any explanation given on each of the *Cooperation Principles*?
- What are the pros and cons of each of the stated *Cooperation Principles*?
- How familiar are the team members with the suggested *Cooperation Principles*?

### 5.2.2 How to Follow the Efficiency Evaluation Approach

Section 5.2.1 contains an approach, called A3E2M, for evaluating the efficiency of EMMs. A3E2M helps in evaluating an EMM and in fact different parts of it. It can be applied for the purpose of evaluating a complete EMM or just parts of it. To perform any of these, a process consisting of two phases has to be completed. First, a Preparatory Phase should be carried out to reconstruct the EMM according to the notion of method. The key point in performing the Preparatory Phase is that the user’s focus should be on the meaning and purpose of each EMM part. To confirm what each method part is about and begin the reconstruction process, the user of A3E2M should go through the structure of this approach (presented in section 5.2.1) and review the elaborations given about each EMM part, in the beginning of each subsection. Since these elaborations are detailed explanations about EMM parts and their purposes, they help in gaining a clearer understanding about the method notion. For reconstructing an EMM, not only the method notion, but rather the EMM user guide (handbook, manual, etc.) should be considered. Explanations of different parts of an EMM might be scattered in various parts of the user guide. Therefore, it is required to review the whole user guide during the reconstruction process. By completing this, the chance of identifying all explanations on each part increase. EMM reconstruction is a decisive step in the evaluation of an EMM. It prevents struggling around how each EMM part has been
covered in the user guide. Moreover, people who are involved in the evaluation process gain common perceptions about the EMM and its different parts.

After completing the Preparatory Phase, the Main Phase (Evaluation Phase) begins. The purpose of this phase is evaluating the EMM. For this purpose, the reconstructed EMM should be checked against the efficiency criteria for general and specific cases of application, defined for each method part. To commence this, a possibility is to start with the suggested driving questions. To continue, the user might find it necessary to add her/his own questions. Hence, we emphasize the suggested driving questions are not the only possible means to begin an evaluation process. The list of driving questions can be tailored according to the current needs by modifying the existing questions or adding new ones to it. In short, conducting the Evaluation Phase means asking questions to realize whether the different parts of the EMM meet the efficiency criteria. Asking these questions provides the basis for discussions about each EMM part and reaching conclusion about the whole method. The answers to these questions and the outcome of the discussions should be documented. This documentation will be used in the following processes (identifying change needs and change measures). Figure 17 contains an overview of how the developed approach should be followed.

![Figure 17: An overview of how to follow A3E2M](image-url)
6. Empirical Validation of the Efficiency Evaluation Approach

The efficiency evaluation approach (A3E2M) that is presented in chapter 5, has to be validated to draw conclusions about the extent to which the contributed results are applicable. For this purpose, two EM cases from infoFLOW-2, different from the one followed in developing the approach, were selected. The current chapter is dedicated to empirical validation of A3E2M. This starts by introducing the validation cases in section 6.1 and reflecting on the efficiency evaluation approach, i.e. A3E2M, in section 6.2. In section 6.3, some refinements for A3E2M that were developed based on the reflection in the earlier section, are presented. Section 6.4 is dedicated to a discussion about what phases of an EM process can be supported using A3E2M. The chapter finishes with section 6.5 that entails discussions about A3E2M and its applicability in evaluating efficiency of EMMs.

6.1 Introduction to the Validation Cases

To validate A3E2M, the author followed two cases from the infoFLOW-2 project. In each case, a modeling expert (the author) and a domain expert were involved. The first case was “Marketing Department at Jönköping University-School of Engineering (Jönköping Tekniska Högskolan: JTH)”, henceforth “JTH Marketing Department”. The involved domain expert was a marketing communicator at JTH. The second case was the “Manager (Head) of Information Engineering & Management Program, Jönköping University-School of Engineering (Jönköping Tekniska Högskolan: JTH)”, henceforth “the Program Manager”. The domain expert was included to identify the relevant tasks and information needs of the same role, was the “Program Manager”. Both cases were performed by the author and at JTH. Both cases were performed to contribute to the infoFLOW-2 project. Specifically, they were done to identify the problems in the way information flows for the investigated roles. As each of the cases was done to contribute to the infoFLOW-2 project, a case report is written about them. To perform these cases, the IDA handbook v 2.0 (Lundqvist et al., 2012) was followed. To read about the infoFLOW-2 project, see section 4.2. Brief introductions regarding each of the cases are presented in section 6.1.1 and section 6.1.2.
6.1.1 Marketing Department at Jönköping University-School of Engineering

In this section the “Marketing Department” modeling case is briefly introduced. This introduction is extracted from (Carstensen et al., 2012b), using both direct and indirect citations.

“For this department the most significant challenge is to obtain reliable information about demanded skills in the job market and on the other hand attracting as many as possible students to the JTH study programs” (ibid). To do this, the marketing department has to perform the following tasks:

- investigating the job market and identifying the skills in demand,
- analyzing and processing the collected information regarding the demanded jobs,
- communicating with the educational departments to transfer information about requirements in the job market,
- retrieving information about the new (and existing) study programs and delivering them to prospective students.

(ibid) shows in detail which activities that were performed in this specific EM case to model and analyze information demands existing at the JTH Marketing Department. The case was done by attendance of one modeling expert and one domain expert. The modeling expert (the author of the current thesis) works as PhD student in Information Engineering research group in JTH, and the domain expert works as marketing communicator at the JTH Marketing Department. Although both attendants had informally met before, the modeling case started by giving a brief introduction by each attendant, mainly the domain expert. As a complement to this, the modeling expert asked the domain expert a series of questions, which can be regarded as an initial interview. To start modeling, the domain expert was asked to mention what roles that the JTH Marketing Department must communicate with regarding the tasks defined for the JTH Marketing Department:

- “Webmaster
- Educational department(s), i.e. computer engineering, mechanical engineering, industrial engineering, built environment and lighting.
- Prospective student
- Study counsellor
- Advertising company
- Current student/ alumni
- Host company (-ies)
While some of the roles that the JTH Marketing Department has to communicate with are inside JTH, others are inside HJ, but outside JTH, or even outside HJ. Identifying what roles that JTH Marketing Department connects to, was based on what information that is needed for completing each task and what roles that expect to receive information from the JTH Marketing Department. The modeling case was carried out in two sessions. The models were done using post-its on a plastic sheet. While working in the modelling sessions, the domain expert stated that there exist models showing how things go in the JTH, including the JTH Marketing Department. He presented these models during the modelling process. As a result, they were also considered as information sources. The produced IDA models were later implemented in electronic form. The final model output can be seen in Figure 18.

Figure 18: Information demand model for “JTH Marketing Department” (Carstensen et al., 2012b)
6.1.2 The Manager (Head) of Information Engineering & Management Program

In this section a brief introduction to “the Program Manager” modeling case is given. Information Engineering & Management is a two-year MSc program given at Computer Engineering Department at JTH. To complete the program, one should pass a number of courses and write a relevant thesis. While most of the courses are mandatory, some elective courses have to be cleared, too (see (Course Syllabus Enterprise Modeling, n.d.)). The introduction is written based on (Carstensen et al., 2011a) using both direct and indirect citations. The program is administrated by a program manager to ensure the quality of the courses and the program as a whole (ibid). The program manager needs to complete a number of tasks and communicate with some other roles to run the program. This is done to exchange information that any side of the communication may need. While a subset of the roles, that should be communicated with, are inside department and the relevant research group, the rest are outside the department but inside JTH, or even outside JTH but inside HJ.

Members of the modelling team for this particular case were a modelling expert (the author of this thesis) and the Program Manager. In contrary to the JTH Marketing Department case, both modeling participants work at the same department and research group. As a result of this, they were familiar enough with each other's roles. Thus, the initial interview was skipped for this case. The roles that the Program Manager communicate with to accomplish its tasks are:

- “Teacher
- Head of the (Computer Engineering) department
- Informatics program manager
- Head of the research group
- Student
- Course responsible
- Administration” (ibid)

During the modeling session, the model was developed using the same material used in JTH Marketing Department, i.e. post-its and plastic sheet. The models were later implemented in electronic form (see Figure 19).
6.2 Reflections on the Efficiency Evaluation Approach

To validate A3E2M the two EM cases introduced in section 6.1 were followed. To increase transparency and prove the applicability of the developed approach, a summary of the efficiency evaluation of the two cases using A3E2M is presented in Table 7. The contents of the table is the results of evaluating IDA using criteria for general and specific cases of application, that are presented in section 5.2. The followed EMM, as well as the aim of both cases, were the same. Thus, all evaluation results are combined and presented in one table. Each criterion in A3E2M is given an identification. The same identifications are used in Table 7 to show whether IDA was found successful, unsuccessful or semi-successful in meeting each criterion.

Using A3E2M against the two cases made it possible to reflect on the approach. Reflections on the Preparatory Phase (see section 6.2.1) and the structure of A3E2M (see section 6.2.2) of A3E2M are explained.
<table>
<thead>
<tr>
<th>Criterion ID &amp; Evaluation Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perspective</strong></td>
</tr>
<tr>
<td>Pe1: Successful; The method provides support for understanding information demands a role has in an organization.</td>
</tr>
<tr>
<td>Pe2: Successful; It does not support process-based investigations.</td>
</tr>
<tr>
<td>Pe3: Successful; Perspective was found supportive to the team’s purposes.</td>
</tr>
<tr>
<td><strong>Framework</strong></td>
</tr>
<tr>
<td>Fr1: Successful; The phase structure of IDA fulfills all three types of activity in a Framework.</td>
</tr>
<tr>
<td>Fr2.1: Successful; It is graphically clarified what the inputs and outputs for each phase are.</td>
</tr>
<tr>
<td>Fr2.2: Successful; It is graphically clarified how different phases are related to each other.</td>
</tr>
<tr>
<td>Fr3: Successful; The Perspective is relevant to the team’s purposes and the Framework supports the Perspective.</td>
</tr>
<tr>
<td><strong>Method Component</strong></td>
</tr>
<tr>
<td>MC1: Successful; The Method Component of IDA supports the relevant phases.</td>
</tr>
<tr>
<td>MC2: Semi-Successful; The Method Component of IDA was found applicable, whereas the Method Components suggested for “Additional Analysis” were not found applicable to the cases. In “Marketing Department” case “another Method Component was applied to complete “Additional Analysis”.</td>
</tr>
<tr>
<td><strong>Procedure</strong></td>
</tr>
<tr>
<td>Pr1: Semi-Successful; Procedure presented in “Scoping”, “ID Context Modeling” and “ID Context Analysis” are explained in detail. To reach explanations about Procedure in “Representation &amp; Documentation” and “Additional Analysis”, referring to other handbooks are prescribed. No Procedure relevant to “SE &amp; BPR Activities” is presented.</td>
</tr>
<tr>
<td>Pr2: Semi-Successful; Procedural guidelines presented for phases “Scoping”, “ID Context Modeling” and “ID Context Analysis” were found applicable and followed. Procedure relevant to “Additional Analysis” and “Representation &amp; Documentation” were not found applicable.</td>
</tr>
<tr>
<td><strong>Notation</strong></td>
</tr>
<tr>
<td>N1: Semi-Successful; No explanation about different notational elements is given. One sample model is presented.</td>
</tr>
<tr>
<td>N2: Successful; All Notational elements were found necessary in working with Procedure. Implementing answers gained by asking the procedural questions is fully supported by the Notation.</td>
</tr>
<tr>
<td>N3: Semi-Successful; IDAs Notation was found relevant. Other (external) Notations were not applicable.</td>
</tr>
<tr>
<td><strong>Concepts</strong></td>
</tr>
<tr>
<td>C1: Successful; A list containing the Concepts and explanations about them is given. The explanations were found helpful for distinguishing the Concepts.</td>
</tr>
<tr>
<td>C2: Semi-Successful; There are Concepts that are not covered by Notation (e.g. Time, Place, Social network). Some terms in Notation are not covered by Concepts (e.g. Indirect Flow, Information Gap, Sequence). All procedural elucidations were found understandable with/without the help of Concepts.</td>
</tr>
<tr>
<td>C3: Successful; All Concepts were understandable and contributed directly/indirectly to the EM process.</td>
</tr>
<tr>
<td><strong>Cooperation Principles</strong></td>
</tr>
<tr>
<td>CP1, CP2: Semi-Successful; Small hints about what roles Cooperation Forms should be involved/followed are given in “Scoping”, “ID Context Modeling”, “ID Context Analysis”. No recommendations about number of attendants or their level of expertise is given.</td>
</tr>
<tr>
<td>No suggestions about relevant roles/ Cooperation Forms are given in “Representation &amp; Documentation”.</td>
</tr>
<tr>
<td>CP3: Successful; All team members (the modeling expert and domain expert) were strongly capable in terms of theory and practices.</td>
</tr>
</tbody>
</table>

### 6.2.1 Reflections on the Preparatory Phase

Below reflections on the Preparatory Phase, that were obtained by validating A3E2M, are presented.
No suggestions about avoiding reference to wrong handbook: According to section 5.2.2, in the Preparatory Phase the EMM should be reconstructed based on the EMM handbook and the method notion (see Figure 5). To initiate the validation process of A3E2M, the author noticed that there exist different versions of the IDA handbook (see Statement 40). This imposed the need to investigate how to work with this set of handbooks. On the other hand, it was realized that no suggestion is presented in A3E2M (and it comprising criteria) regarding how to proceed if there exist different versions of an EMM handbook. As a result of this, it was not clear whether the only allowed source for reconstruction is the version of handbook used in EM sessions or if other versions can be followed, too.

No suggestions about need for repeating the Preparatory (Reconstruction) Phase: According to section 5.2.2, completion of the Preparatory Phase is a prerequisite for starting the Main (Evaluation) Phase. According to this, during evaluation of A3E2M, the intention was towards completion of the Preparatory Phase before continuing with the Main Phase. It was however found that it is inevitable to repeat the Preparatory Phase during the Evaluation Phase, now and then. To reconstruct IDA and its different parts, it was necessary to go through the IDA handbook several times. Once the IDA handbook was reviewed, it was found that there exist lines that can be considered as coverage of more than one EMM part (an example of this can be seen in Statement 38). Furthermore, explanations about each method part are not necessarily presented all together (in one paragraph, under a sub-heading, etc.). They might be scattered in different parts of the handbook (see Statement 39). All this resulted in a need for reviewing lines and paragraphs, that were marked as presentation of EMM parts, to ensure the most relevant fragments of the handbook are marked for each EMM part. Nevertheless, by looking at the presentation of A3E2M (and hints about how to follow this approach) it can be seen that no clarifications about the contingency of repetition of the Preparatory Phase is given.

6.2.2 Reflection on the Structure of A3E2M
In performing the validation EM cases, the reconstructed IDA method was checked against the efficiency criteria. Lines and fragments in the IDA handbook that were marked as support for each EMM part, were compared to the relevant efficiency criteria. In this way the suggested driving questions were used as a starting point. For example, the part of IDA handbook that is marked as clarification of Perspective (see Statement 2) was checked against the driving question “from what viewpoints can the enterprise be modeled using this EMM?” to begin discussion about coverage of IDA method. By following the defined efficiency
criteria and the proposed driving questions, it was possible to evaluate each part of the EMM individually as well as in relation with the other parts. For example in a method, the Method Component consists of three inter-related parts (Procedure, Notation and Concepts). Each of these three parts should be efficient in their place and in relation with the other two. To fulfill this, criteria presented in sections 5.2.1.3.1 to 5.2.1.3.3 should be fulfilled. In addition to this, Method Component itself should cover the efficiency criteria defined for it (see section 5.2.1.3).

It was necessary to confirm the suitability of the EMM for the intended cases. To do this, questions like “is the EMM pervasive enough to cover all modeling team’s needs?” had to be asked for each EM case. Not only the Perspective, but also other EMM parts had to be checked against the intended (validation) cases. For example, it had to be determined what notational elements that were suitable for each of the cases. In the “JTH Marketing Department” case, a question was whether “JIBS/HLK/HHJ Marketing Department” should be depicted as a “role”, an “organizational unit” or an “external unit” (see Figure 18). In both EM cases it had to be decided whether all Framework phases should be completed, i.e. conducting discussions to answer the question “what phases of the Framework are necessary to complete for the intended case?” was necessary. The phase “Additional Analysis” in IDA (see Figure 16) is optional. This phase was not needed in the “Program Manager” case, whereas it was found helpful in the “JTH Marketing Department”. As explained in section 6.1.1, in the “JTH Marketing Department” case the already existing models were reviewed to obtain additional information other than what the domain expert was providing.

A3E2M and in fact the defined efficiency criteria for different EMM parts, are presented in a generic style. Elaborations on efficiency criteria are simple and straight forward. This has made them flexible and convenient to work with. For example in the efficiency criteria for Cooperation Principles, the criterion “CP1: clarifications about the required competences” has to be interpreted and operationalized by the audience. It is the audience that should specify what competences should be possessed to this criterion. In elaboration about efficiency criteria for Method Component, “MC1: support provision to relevant Framework phases” is stated as an efficiency criterion. The audience should go through the given explanation about the criterion to interpret and specialize it. However, during application of A3E2M it was realized that some parts of the approach are too general and still have room for improvement to become a mature approach. Two points indicating this type of shortcoming in the presentation of the structure of A3E2M are presented below.
**Promising presentation of efficiency criteria for Framework:** In evaluating the Framework part of IDA, fulfillment of the criterion “Fr1: support provision for the Perspective” (presented in section 5.2.1.2) was also evaluated. A part of this evaluation was to check if all three activities “understanding the enterprise”, “modeling” and “analysis” are covered in the IDA handbook. From these three activities, A3E2M underlines “understanding the enterprise” and “modeling” as the most decisive activities. The “modeling” activity is already the focus point of A3E2M and aided in efficiency evaluation in the validation cases. It was however realized that A3E2M does not support evaluating the efficiency in “understanding the enterprise”.

**Promising presentation of efficiency criteria for Method Component:** While performing the validation cases, it had to be checked whether applying the Method Component developed specifically for IDA is sufficient, or if Method Components suggested for “Additional Analysis” phase (see Figure 16) had to be used as well. To evaluate each Method Component it was necessary to go through its three constitutive parts. Each of Procedure, Notation and Concepts parts were evaluated individually to draw conclusions about whether applying that particular Method Component was suitable for the case. In other words, fulfillment of each of the three criteria “Pr2: suitability of the Procedure for the case”, “N3: suitability of the Notation for the case” and “C3: suitability of the Concepts for the case” had to be assessed. However, if it was possible to perform an initial evaluation on the suitability of each Method Component, evaluation of the three mentioned criteria could be facilitated or even skipped. This issue has not been taken into account in A3E2M.

### 6.3 Refinements to A3E2M based on the Reflections

Based on reflections on A3E2M (presented in section 6.2) some complementary points that should be taken into account while following the developed approach, were developed. They are in fact details of A3E2M that were not recognized during development of the approach. The main body of A3E2M consists of criteria for each EMM part that are supported by statements from the validation cases. A similar style is followed in the current section. Each complementary point is given an identification, formed of one or more fragments and supported by relevant statements from the validation cases. The statements are either written based on the user guide followed (the IDA handbook) or quotations from the EM team members. Table 8 shows the list of participants in the cases used for validating A3E2M. The table shows the involved modeling participants, their organizational role and their role in the EM case. Also, each participant is given an identification. Three individuals were involved in
the validation cases: one modeling expert (the author of the thesis) who conducted both cases (Participant 13) and one domain expert per case (Participant 11 and Participant 12).

Table 8: Modeling participants of the validation cases

<table>
<thead>
<tr>
<th>Organizational Role; Organization</th>
<th>Role in the EM Case</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Engineering Program Manager; JTH</td>
<td>Domain Expert</td>
<td>Participant 11</td>
</tr>
<tr>
<td>Marketing Communicator; JTH</td>
<td>Domain Expert</td>
<td>Participant 12</td>
</tr>
<tr>
<td>PhD Student; JTH</td>
<td>Expert Modeler</td>
<td>Participant 13</td>
</tr>
</tbody>
</table>

A subset of the identified refinements are concerns relevant to the Preparatory Phase (presented in section 6.3.1) and the rest are additional efficiency criteria for different EMM parts (presented in section 6.3.2).

6.3.1 Implications regarding the Preparatory Phase

Validation of A3E2M resulted in identifying problems in the way it is applied. A group of these problems are relevant to the Preparatory Phase. They imposed the need for figuring out implications in order to dissolve the problems. The identified implications are “Prep1: the iterative nature of EMM reconstructions” and “Prep2: following the correct reference” to address the problems “following the correct reference” and “dispersed presentation of EMM parts in the handbook”, respectively. Since these implications are relevant to the Preparatory Phase, their identifications start by “Prep”, as the alphabetical part.

Prep1: The iterative nature of EMM reconstructions: In practice, an efficiency evaluation process should not be expected to be completed in one iteration. Rather, it is an iterative task. During application of A3E2M, it is required to switch between the evaluation and the reconstruction phases. This does not necessarily mean that the reconstruction results are incorrect in the beginning. Rather, it means that they should be improved or presented in different ways and respect the current status of EM case. Changes that occur in the EM case and the EM team are two important factors that make the reconstruction phase, iterative. In addition to this, each iteration of the Reconstruction Phase might be necessary to repeat several times. The reason for this is that there are statements that can be considered as support for understanding more than one EMM part. Although this facilitates comprehension of the EMM, it results in continuous revision of such lines and paragraphs to ensure that demarcation of EMM parts has been done in the most suitable way.

The IDA handbook contains a section specifically for clarification the Perspective: 3.1 Perspective-
what is important in IDA. This section however is not wholly dedicated to Perspective. In-line with this, elucidations on applicable Cooperation Principle, and motivation about why it is the most appropriate choice, are given. As information demand analysis is about identifying information needs that a specific role has, making a differentiation between fragments related to Perspective and Cooperation Principles was completed in more than one iteration.

Also in the same section, it is emphasized that the IDA process should be performed role-based and not process-based. This on the one hand can support clarifying the Perspective definition, and on the other hand, is a hint and part of Procedure. (Statement 38)

Another reason for the iterative nature of the reconstruction phase is that in practice, the authors of handbooks do not follow a particular notion of method. As a consequence of this, the coverage of different EMM parts are scattered in different parts of the handbook, which imposes the need for reviewing the handbook several times.

In the IDA handbook, Procedure (procedural guidelines) relevant to the phases “Scoping”, “ID-Context Modeling” and “ID-Context Analysis & Evaluation” are presented under the sub-heading “Activities”, that makes it convenient to find a presentation of this EMM part. On the other hand, in the phase “Representation & Documentation”, Procedure is diffused in among lines and phrases and in “Additional Analysis” the audience has to refer to the handbook of other EMMs to see the procedural guidelines. “SE & BPR Activities” are not elaborated in this handbook. Thus, its Procedure cannot be evaluated. In addition to this, as explained in Statement 38, hints regarding the point that the IDA process should be role-based and not process-based are stated under the Perspective heading in the handbook. Accordingly, it is inevitable to review the IDA handbook several times to ensure that all fragments relevant to Procedure of IDA have been identified (Statement 39).

**Prep2: Following the correct reference:** An EMM might be changed and modified over time. This might result in a need for writing a new handbook (aka user guide or manual) or other types of reference material that reflect the applied changes. As a consequence of this, there might exist several versions of a handbook. The reconstruction process should be carried out respecting the same version that is selected to for the EM process. In case the modeling team has planned to follow more than one handbook during the EM case, this should also be taken into account when reconstructing the EMM.

At the time when this research was under progress, different versions of IDA handbook were available, e.g. cf version 1.0 (Lundqvist et al., 2009), version 1.6 (Lundqvist et al., 2011) and version 2.0 (Lundqvist et al., 2012). The validation cases were conducted using the latest version, which was
the most complete version. In view of that, the efficiency evaluation had to be done based on the same version. (Statement 40)

In case a different version of the handbook, other than the one(s) used in the modeling, is selected for the efficiency evaluation, the results might not be reliable.

### 6.3.2 Additional Efficiency Criteria for Different Parts of EMM

The validation process of A3E2M contributed in giving reflections on the Structure of A3E2M (see section 6.2.2). The reflections involve problems and shortcomings of A3E2M, to resolve these problems, A3E2M was refined by adding criteria to it. The result of this refinement is presented below. While “Fr3: suggestion on approaches for understanding the enterprise activity in Framework” intends at resolving “promising presentation of efficiency criteria for Framework”, “MC3: clarification on coverage of the Method Component” addresses “promising presentation of efficiency criteria for Method Component”.

**Fr3: Suggestion on the approaches for “understanding the enterprise” activity in Framework:** According to section 5.2.1.2, Framework of an EMM should support meeting the Perspective by covering the activities “understanding the enterprise”, “modeling” and “analysis”. It might be possible that each of the mentioned activities are effectuated in different ways and following different approaches. From the three mentioned activities, “understanding the enterprise” has a crucial role in an EM process. Gaining a correct and comprehensive perception about the enterprise is a necessity. Thus, criteria and specifications about this activity should be covered in an EMM handbook. This can be done in different ways, e.g. interviewing the domain experts, arranging a presentation about the discourse domain, and reviewing the relevant documents.

Lundqvist et al. (2011) suggest a number of approaches for carrying out the first phase of an IDA process, i.e. “Scoping”. This however, can be generalized and followed as a means for “understanding the enterprise”: “the typical way of achieving this is conducting meeting and interviewing the key stakeholders within customer’s organization.” (Statement 41)

“- We start by your roles and (then) your tasks. Please tell me what roles you have.
- I am program manager and teacher....” (Statement 42; Participant 13, Participant 11)

As stated above, each of the mentioned activities, including “understanding the enterprise”, can be performed by following different approaches. As each activity type has pros and cons, it would be even more helpful if suggestions on the most suitable alternatives were provided:
The IDA handbook suggests approaches in addition to interviewing to fulfill the need of "understanding the enterprise": “It is also possible to do this with more comprehensive approaches such as observation of typical work situations, reviews of existing business descriptions or quality documentation by participant, etc”. From the suggested alternatives, business descriptions can be presented in different models, including graphical models of the enterprise. *(Statement 43)*

“This is how our webmaster modeled the department. Do you think it you could use them?” *(Statement 44; Participant 12)*

**MC3: Clarification on coverage of the Method Component:** In an EM process, it is using *Method Component* that results in generating enterprise models. It is necessary to have a correct and clear image about what output models that will be gained by applying a specific *Method Component*. Understanding *Perspective* provides an overall and abstract understanding about the viewpoint of an enterprise that can be modeled. This however requires to be more operationalized. Thus, giving an understandable clarification of the *Method Component* is necessary. Such clarification could be provided in different forms such as textual description, sample models or a mixture of both. Especially, if the EMM prescribes applying more than one *Method Component*, meeting this criterion helps in gaining a clearer understanding about what focal area that can be modeled using each *Method Component*.

In IDA, different *Method Components* are to be used, where only one of them is specifically developed for this EMM. The authors present one sample model that can be used to find out what an IDA model looks like, but not an explicit textual elaboration on IDA *Method Component*. For the *Method Components* that are imported from other EMMs no clarification is provided (To learn about and assess *Method Components* imported from other EMMs, one should refer to the relevant reference). *(Statement 45)*

**6.4 Future Work: Support of Different Phases of an EM Process**

While applying A3E2M for the purpose of empirical validation, one shortcoming in A3E2M, other than what are presented in section 6.2, was identified. According to chapter 1, this thesis should contribute in answering the research question “in what phases of an EM process could efficiency of the applied EMM be evaluated?”. By reviewing chapter 5 it can be seen that this question cannot be answered with the use of the developed results, i.e. A3E2M. Thus, the topic is discussed here.

During different phases of an IS Development (ISD), people frequently need to evaluate the produced results and the process itself. Beynon et al. (2004) present a model showing how different forms of evaluation approaches fit to an ISD. Beynon et al. (2004) also distinguishes
between strategic, formative, summative and post-mortem analysis. Strategic evaluation (or 
pre-implementation evaluation or pre-development evaluation) helps in assessing whether 
conducting an IS/IT project can deliver benefits against costs. Strategic evaluation has a 
decisive role in establishing both long term and short term IS strategies. Formative evaluation 
supports the assessment of an IS during its development process. This type of evaluation is 
about determining whether the decided objectives have been met and if any crucial change in 
the design of the IS is required. Summative evaluation (or post-implementation evaluation) 
involves checking whether the costs and benefits have been according to the strategic 
evaluation. This is done either by evaluating if the system specifications have been covered or 
the system usability. Summative evaluation might end in suggesting ways for system 
modification. The reason behind this type of evaluation is that even if a project reaches 
completion, there is a risk of failure in delivery. Post-mortem analysis is a variant of 
summative evaluation, which is followed for identifying the cause of failure in case of project 
abandonment.

According to section 3.1.3, EM is a subject relevant to IS. An evaluation approach (method or 
framework) that is developed in EM should support the four activity types of IS evaluation on 
an EMM. Below, it is discussed how different evaluation forms of EMMs are supported by 
A3E2M:

- **Strategic evaluation:** Before applying an EMM and conducting an EM process, it is 
necessary to carry out a feasibility study and strategic evaluation. Strategic evaluation 
of an EM process is about clarifying if any EMMs could be followed, and even what 
alternative that is the most suitable one. Performing a strategic evaluation facilitates 
the EM process, even in a state where the EM process has not started yet. In applying 
A3E2M reviewing general and specific cases of application criteria is what the 
potential EMM users should consider. This is followed by concentrating on the 
specific case, and finding the extent to which, a candidate EMM is suitable for it. 
Although, before starting the EM process many details are unknown, reviewing the 
enterprise, especially the domain of discourse, and checking the criteria for the 
specific case of application still provides the basis for discussions about suitability of 
an EMM and making an appropriate selection.

- **Formative evaluation:** By starting an EM process, i.e. applying the selected EMM, 
parts of enterprise models start to become visible. The evaluation process should be 
conducted in parallel with the EM process. In this way, two types of evaluation are 
notable: evaluation of the enterprise models and evaluation of the EM process. As a
part of evaluating the EM process, it should be investigated whether the EMM has lived up to the expectations of the application process. For this purpose, one can apply A3E2M to evaluate the EMM against the criteria for a specific case of application. This evaluation can be done at any time during the EM process, and making the decision about the proper point in time for it is left to the potential applier. For evaluating whether the enterprise models meet the requirements, use of a method or technique that is specifically developed for this purpose, can be helpful. Accordingly, a formative evaluation of an EMM application process is partially supported by this approach.

- **Summative evaluation:** Once an EMM application process has been completed, enterprise models are developed and all relevant parts from different EMM parts have been used. Although at this time, the mission of conducting an EM process is completed, it should be confirmed whether the process has been according to expectations. This means, we should check whether the models meet the defined requirements, and also if the application process has been according to the defined criteria. Unlike formative evaluation, in summative evaluation it is necessary to evaluate only one set of models, i.e. the final enterprise models. Also, checking the conformance of different EMM parts to the defined criteria done only once. To do this, one can receive support from A3E2M in studying the whole EMM, as well as each individual part of the EMM in the process. Following this, conclusions should be drawn based on the evaluations. Studying different EMM parts in a process is done by specifying points in time, assessing the behavior of the EMM at each time using A3E2M, and converging all interpretations. Like formative evaluation, summative evaluation is partially supported by A3E2M. By partially we mean for evaluating enterprise models, and means that are specifically developed for the purpose of models evaluation should be applied as well.

- **Post-Mortem Analysis:** With the help of this variant of summative evaluation, recognition of the cause of failure in an abandoned EM case will be feasible. To perform this activity using A3E2M, one can review elaborations about how summative evaluation is supported by A3E2M and apply them for the purpose of this activity.

The four evaluation forms in an EM process can be adjusted into three activities “pre-modeling”, “modeling” and “post-modeling”. Consequently, A3E2M is applicable in the three activities constituting an EM process.
6.5 Discussion on the Applicability of A3E2M

The purpose of this section is to discuss applicability of A3E2M. The remainder of this section consists of two main points regarding the approach. Each point contains discussions about a feature of A3E2M, its pros and cons, and suggestions of changes to eliminate the cons.

**Tentative presentation of Preparatory Phase:** A feature of A3E2M is its division into the Preparatory Phase and the Main (Evaluation) Phase, where the former is about reconstruction of an EMM and the latter supports efficiency evaluation of the EMM. This phase structure helps the potential user of A3E2M in keeping in mind that both the Reconstruction Phase and the Evaluation Phase are decisive and should be completed. Especially, mentioning EMM reconstruction as a separate phase helps keeping in mind that it should be considered as a particular task. According to the implication “Prep1: the iterative nature of EMM reconstruction” (presented in section 6.3.1), by any change in demarcation of EMM parts, the results of the Evaluation Phase should be revisited to confirm their validity. The iterative nature of the reconstruction that results in iterating the whole evaluation process, might cause extra work and extra burden. Although reconstruction is stated in section 5.2.2 as a “phase”, and in section 6.3.1 it is mentioned an iterative process, explanations on this phase still has room for improvement. For this purpose, it should be explained how to decide on whether to proceed with more reconstruction iterations. According to the explanations on the same implication, a handbook might contain lines and paragraphs fitting into more than one EMM part. Users need to know how to distinguish if an explanation is about a particular method part. Thus, it is necessary to enrich the presentation of A3E2M by adding explanations about how to work with such lines and fragments and prevent confusion about their coverage.

**Generic Presentation of A3E2M:** This approach is presented on an overall level. By this we mean that explanations in each efficiency criterion are generic, which make them flexible for adaption. As a result of this generic presentation, interpretation and even modification can be done in different ways. As an example, “C1: elucidation about conceptual elements” (presented in section 5.2.1.3.3) mentions that Concepts should be explained and clarified. However, details about what the suitable means for fulfilling this are and what steps that should be passed to reach this purpose are left to the user. The same style is followed in section 6.3 for suggesting refinements for A3E2M. For example, in criterion “Fr3: suggestion on approaches for understanding the enterprise” (presented in section 6.3.2), examples of suitable means for understanding an enterprise, such as interview and presentation sessions,
are given. It is nevertheless, not specified what sort of interview is more suitable. Moreover, no restriction regarding other ways of understanding the enterprise is given.

The generality of A3E2M has made it flexible in terms of use: the user is able to understand it conveniently and interpret its different parts according to the modeling participants' knowledge and further plans. On the other hand, the general presentation of A3E2M and the potential need for customization is a challenge to the user. The audience need to know how to interpret criteria for different EMM parts. To resolve this, one possibility is adding guidelines to the approach regarding how to adapt it. This helps a user of A3E2M in following a more concrete way for adapting the approach.

Accordingly, A3E2M is a proper means to study whether an EMM supports conducting an efficient EM process. This however, does not mean that it is a fully mature process. Rather it still has room for being improved and becoming more mature.
7. Discussion

This chapter contains discussions on different topics. It starts with section 7.1, which includes answers to the research questions that were defined in chapter 1. This is followed by reflection on the applied research discipline, i.e. design science, in section 7.2. Development and validation of the research results were done based on EM projects and cases. Some lessons that were learned during observation of these EM cases are presented in section 7.3.

7.1 Answering the Research Questions

Below, answers to the research questions defined in section 1.1 are given:

RQ 1. What is the meaning of efficiency in the context of EMM? EM aids in developing models for visualizing the current and/or future states of an enterprise, followed by planning the improvement actions. For this purpose, it is necessary to apply a relevant tool, which is an EMM. Like any other process, application of an EMM needs resources. Taking care of resource usage is a crucial need, as resources are scarce and costly. On the other hand, focus on the issue of resource usage should not end in developing improper models. Indeed, application of an EMM should support minimum resource usage, while at the same time developing of enterprise models matching to the specified needs, i.e. we require an efficient EMM. To have an efficient EMM, it should fulfill criteria and terms regarding the EMM, and to be more precise, regarding each part of it and relations between different parts. If this is fulfilled, it will help in conducting a correct modeling process and gaining models of high quality. On the other hand, attainment of correct models and correct behavior of the EMM is a sign of efficiency fulfillment. Especially, correct behavior itself has a decisive role in resource utilization, since it helps staying on the right track and reduces the number of extra iterations.

While there are terms that always have to be fulfilled, determining the suitability of the EMM for each new case is necessary. This imposes the need for defining criteria for general and specific cases. If both types of criteria are fulfilled by an EMM and its parts, the EMM is efficient.

Accordingly, an efficient EMM is defined as follows:

An EMM is efficient if the results of the EM process are according to the needs expressed by the stakeholders and the process defined by an EMM (and each part of it) is performed exactly according to the criteria for the general and specific case of application.
RQ 2. How can efficiency of an EMM be evaluated? A method, such as an EMM, is comprised of different parts, Perspective, Framework, Method Component (Procedure, Notation, Concepts) and Cooperation Principles, which are related to each other. An EMM part or a relationship between two parts, should match and cover some fundamental criteria. These criteria can be divided into two main groups: one group entails criteria that should always be true, i.e. regardless of the application case, whereas fulfillment of another group depends on the application case, especially on the enterprise and the modeling team. Criteria from any of the two groups have to be reviewed and agreed on by the whole team.

In an EMM, different parts are related to each other and working with one particular part requires seeking support in the other parts, too. Thus, evaluating a specific part imposes the need for studying it as a part of the whole EMM and also evaluate the other parts. For conducting the evaluation process, the set of defined and agreed upon criteria for each EMM part and relation should be checked. Prior to that, the defined criteria should be understood by each team member, and the team members have to reach a mutual agreement about each criterion. Due to the fact that the potential applier of A3E2M is not restricted to these criteria, the evaluation process can be continued by using more criteria and questions related to them.

To commence the evaluation process, the first step is reconstructing the “artifact” under study according to the method notion. As evaluation is done on the result of the reconstruction step, it has a decisive role on the evaluation process and its results. After specifying the EMM parts, the evaluation process, i.e. assessing whether each part matches to the defined criteria for general and specific case of application, starts.

RQ 3. In what phases of an EM process could method efficiency be evaluated? An EM process consists of three main phases: pre-modeling, modeling and post-modeling. An EMM should fulfill the efficiency criteria during each of the stated phases. It is necessary to be ready to carry out efficiency evaluation during the whole modeling process, i.e. in all three parts of it. In the pre-modeling phase, a strategic evaluation aids in finding out whether the EMM will support to the case. During the modeling phase, formative evaluation assists in identifying what change needs that ought to be considered for the currently used EMM. In the end, during activities of the post-modeling phase, which are summative evaluation and post-mortem analysis, efficiency evaluation helps in figuring out if the completed EM process was efficient, or what the failure causes were. Since not all three phases could be investigated with
a sufficient number of cases during the course of this thesis, more research with focus on RQ 3 is required.

7.2 Reflection on the Followed Research Discipline

As elaborated earlier in section 2.1.2, of the different research disciplines in IS, design science (Hevner et al., 2004) was selected and followed in this thesis. The focus of this thesis was on developing an approach for efficiency evaluation of EMMs. Design science as a discipline was an appropriate choice to this aim. Especially, following the seven guidelines of Hevner et al.(2004) facilitated the research process. Guideline 1 (Design as an Artifact) helped the author in making clear that the expected outcome of the research has to be an artifact. As the result, taking this guideline into account supported development of an artifact, which is an approach for efficiency evaluation of EMMs. According to section 3.3, the identified problem (research gap) was the issue of efficiency evaluation in EM, which has not been investigated by other researchers. Following Guideline 2 (Problem Relevance) ensured that the developed artifact is relevant to the identified problem. In fact, following Guideline 1 and Guideline 2 was helpful in producing an artifact for the purpose of addressing the specified problem. Since the developed artifact had to be evaluated, it was necessary to find out what evaluation methods that are available and which of them that were best suited. Guideline 3 (Design Evaluation) in (ibid) contains a list of evaluation methods that can be followed. This opened up a wide range of evaluation methods that could be followed, but also resulted in spending more time on investigating different options and choosing the most suitable method. In the end, the observational (case study) method was selected. Following Guideline 4 (Research Contribution), that is the aim of any research, was automatically considered. It was nonetheless, a reminder that helped keeping in mind that the research results should be both clear and verifiable. This guideline helped in considering the fact that output results should be represented in a clear form. Fulfilling this was rather complex and time consuming. The author was familiar well enough with her own work, which resulted in finding it clear. However, deciding whether other people also found it understandable, was not an unambiguous process. It was also unclear in the beginning how the presentation of the output results should be in order to be verifiable. Consequently, to ensure this guideline was followed properly, it was necessary to go through the results repeatedly and revise the presentation style. Guideline 5 (Research Rigor) emphasizes that both construction and evaluation (validation) processes should be performed following rigorous research methods. This assisted in paying more attention to the fact that a concrete research strategy should be
pursued. It included looking for rigorous research methods and ensuring they were followed. According to Guideline 6 (Design as a Search Process), in a design science-based process, the researcher should focus on looking for results. The main positive point of applying this guideline was receiving a green light saying that searching for the results is allowed or even necessary and at the same time iterative. It was however not helpful in figuring out where the iterating should be stopped. Presentation and packaging of results has a decisive impact on how the audience judge the outcome result. This was a challenge in this thesis, too. Guideline 7 (Communication of Research) made it clear that the contributed artifact (approach) should be understandable to both a technology-oriented and a management-oriented audience. This guideline was a means to present the results in a way that from one side are on an overall level and understandable by management-oriented audience and on the other side, the results are understandable by a technology-oriented audience with sufficient detail.

All in all, following design science was suitable and appropriate for performing this work. The main advantage was emphasizing the fact that a design science-based research is an iterative process, consisting of construction and evaluation. The seven guidelines of (Hevner et al., 2004) provided a list of concerns that had to be taken into account during the work. These guidelines constituted a concrete measure, which helped ensuring that the correct process was performed.

7.3 Lessons Learned on Conducting EM Projects

During development and validation of A3E2M, some lessons relevant to EM sessions were learned. These lessons are not separate from contribution of this thesis. Rather they indicate how following different combinations of efficiency criteria facilitate conducting efficient EM processes. The lessons are presented in sections 7.3.1 to 7.3.3.

7.3.1 Access to the Relevant Information Sources

According to criterion “CP1: clarifications about the required competences, in an EM process, involvement of people that are competent enough is a necessity. In a modeling team, modeling experts have relevant knowledge about the EMM and know how to use it to conduct a smooth EM process. Domain experts are reliable information sources about the enterprise (see criterion “Pr3: availability of reliable information sources about the case”. The assumption is that they have pervasive knowledge about the enterprise and the events that are likely to occur in it. However in practice, members of an EM team might encounter confusion
even about their field of expertise and require further informational assistance. A modeling expert might become doubtful about whether (s)he is pursuing the EM work correctly. For example, one might need to know how to document details of a notational element. Domain experts might also get confused about different issues in the enterprise, such as work-flows, rules, relevant individuals, etc. As an alternative, it is necessary to access different information resources relevant to the case. Organizational brochures, charts, existing models (as it is stated in “Pr3: availability of reliable information sources about the case”) or other available sources of information on the enterprise can be helpful. To learn about the EMM, the method handbook should be considered as a relevant source.

Access to different information sources about the enterprise and the EMM should be taken into account in any EM case. When doing so, the decision about what sources are most helpful has to be made by the EM team. This choice is based on different factors such as what resources that are available and what information that is required. In this way, domain and modeling experts are also valuable information sources about the enterprise and the EMM and should not be neglected.

Ensuring access to the relevant information sources is the requisite for “following the same language by members of the modeling team regarding the case”, discussed in section 7.3.2.

7.3.2 Following the Same Language by Members of the Modeling Team regarding the Case

People who cooperate with each other to pursue a systematic work, need to have a clear understanding of it. It is necessary that not only each individual understands the work, but also that they reach unified perceptions about different topics. In an EM process, the subject is to use an EMM to model an enterprise from particular viewpoints. For such a process, team members can be divided into two main groups: one group consists of domain experts and the other group consists of modeling experts. It should be confirmed that the modeling experts and the domain experts use the same language about the EM case. This need itself can be divided into the two following needs:

- **Same understanding about terms and phrases in the enterprise:** In every enterprise or organization people use specific phrases to refer to different facts. These phrases might be unknown for people who do not work in that enterprise or department. People, who are outside the enterprise and intend at to communicate with the enterprise members, should have the same perception about the set of (regularly)
used phrases and terms. When it comes to EM processes, modeling experts should have a comprehensive understanding about terms and phrases relevant to the enterprise. Even domain experts that work in different parts of the enterprise should have such a uniform understanding. Fulfillment of this set of requirements results in establishing and following the same language, and to cover this need, it is necessary that all people involved in the EM process have access to reliable information sources about the enterprise. This is a benefit of meeting the efficiency criterion “Pr3: availability of reliable information sources about the case”.

- **Same understanding about terms and phrases in the EMM:** As in enterprises, in EMMs there also exist terms and phrases that should be understood to provide the basis for applying the EMM and expediting the EM case. Not only the modeling experts, but also the domain experts should have understood the EMM as well as its terms and phrases correctly. To ensure that the EM team members have the correct understanding about terms and phrases in the EMM, fulfillment of efficiency criteria for *Concepts* in the general case of application (“C1: elucidation about conceptual elements” and “C2: coverage of terms and meanings used in *Procedure* and *Notation* by *Concepts* and contrariwise”) is necessary. The more *Concepts* used in a handbook that are understandable, the more accurate and unified the understanding will be by modeling and domain experts.

These two points should be considered in an EM process to make sure that the whole team is following the same language. Nevertheless, violation of this might result in disparate insights about the enterprise and the EMM, which itself might cause a deviation from the right working path and development of improper enterprise models.

### 7.3.3 Following a Concrete Action Plan

In applying an EMM and developing enterprise models, like in any other process, having a concrete action plan is an effective factor. Without such a plan, the modeling process might deviate from the correct path. According to (Farrington & Stachenko, 2010), an action plan is about what should be done, by whom, and when. This requires confirming what should be achieved and how. Accordingly, in an EM process the following points should be covered:

**Mutual agreement about what should be achieved:** In an EM process, domain experts should be confident about what they expect from the case. Also, when several domain experts are involved in the process, their expectations should match to each other and not be conflicting. For instance, the “application order planning” from infoFLOW-2 (introduced in
section 4.2.1) was done to support gaining a clear image of what information demands the role “planner” has, whereas the EM Course (introduced in section 4.3.1) was conducted to support students in learning EKD and the essentials of EM. A prerequisite of clarifying what is expected from an EM case is to specify the domain of discourse. Depending on what EMM that is being followed, this might be done different ways. For example, in applying the IDA method, it is done by specifying the roles that the investigated role communicates with. This was followed in all cases presented from infoFLOW-2. This specification is a sort of guide for both the domain experts and the modeling experts to know what parts of the enterprise they should take into account, and what parts they should not. Other agreements such as where the modeling and assessment should start from, and what degree of detail the developed models should be, have to figured out based on the stakeholders’ further plans. Such a discussion was conducted more or less in all background cases and validation cases. For instance, it was discussed what elements should be included in the models (examples of this can be seen in Statement 15 and Statement 19).

**Establishing time plan and work division:** Completion of any project or process requires following a time plan. All expectations from an EM process, such as what competences are required (see criterion “CP1: clarifications about the required competences”), what phases should be completed (see criterion “Fr3: support provision by Framework to the case”) or what Method Components should be used in a Framework phase (see “MC1: support provision to relevant Framework phases”), should be drawn up respecting not only the stakeholders’ requirements, but the time plan as well. Moreover, a member of the modeling team needs to know what role (s)he has in the project, i.e. which of roles specified by the EMM handbook is going to be assigned to her/him. Although most of the time a team member possesses one specific type of role, i.e. an enterprise modeler or a domain expert, this will still be helpful in case more than one role is assigned to a team member.
8. Conclusions & Future Work

After developing the results, validating them and conducting discussions, it is time to draw up final conclusions about the extent to which the contribution matches to the aims and expectations for starting the project. This is covered in section 8.1. This is followed by stating some possibilities for further research, in 8.2.

8.1 Conclusions

By conducting this research the author aimed at studying the issue of efficiency in the EM field and especially for EMMs. For this purpose, focus was on developing an approach for the evaluating efficiency of an EMM. The approach supports evaluating criteria that have to be true in the same way as well as criteria that their fulfillment varies from case to case. By the latter we mean that there are criteria, whose their fulfillment for a described case is not necessarily generalizable to further cases.

For writing this dissertation three research questions were defined:

- RQ 1. What is the meaning of efficiency in the context of EMM?
- RQ 2. How can the efficiency of an EMM be evaluated?
- RQ 3. In what phases of an EM process could method efficiency be evaluated?

Development of the results was based on case studies and EMMs that were used in the cases. This was followed by validating the results and answering the research questions. Using the gained results and validation outcomes, it is possible to investigate whether an EMM is efficient (supports efficiency in an EM process). Evaluating this feature of an EMM has become possible by developing an efficiency evaluation approach, called A3E2M.

This thesis contributes to both the scientific domain and the practice domain. Investigating and evaluating quality of models and modeling processes have been the topic of different research efforts (see section 3.2). Efficiency is mentioned as an aspect of quality in all quality models relevant to IS (see section 3.1.3). This thesis contributes to the scientific domain by presenting an Approach for Efficiency Evaluation of EMMs (A3E2M), which can be regarded as a support for quality evaluation in EM in a more concrete way. The approach itself still has room for improvement. A number of possibilities for further research are suggested in section 8.2. In addition to this, the idea of efficiency evaluation in EM itself is a novel topic and can be the basis for further research.
The outcome of this research is useful not only to the research community, but to the practice community as well. The developed approach made up of efficiency criteria for different EMM parts and suggested driving questions, assists the audience (potential applier) of A3E2M, providing a basis for starting an efficiency evaluation process and reach a common language about how a particular EMM should be. Presentation of A3E2M is flexible. It is presented here on an overall level thus the practitioners may interpret and adapt it based on their knowledge and purpose of use. By applying this contribution the user cannot expect gaining satisfactory results right away. Rather, they should be aware that this is an iterative process that has to be continued and repeated during the whole life time of the EM process.

8.2 Future Work
This dissertation includes an approach for evaluating efficiency of EMMs, this however is not the end of this work and there exist areas for further improvement. In addition to what already has been discussed in 6.4, the identified areas for further development are briefly explained in sections 8.2.1 to 8.2.3:

8.2.1 Expanding the Efficiency Evaluation Approach
The proposed approach is still in its first stage of development and has to be expanded to become a more mature evaluation approach. To support this, the following suggestions for expansion of A3E2M are mentioned.

The approach currently supports evaluating EMMs that are already developed and are going to be applied. In real life, other application types of EMMs might occur, such as developing an EMM from scratch to fulfill an uncovered Perspective. It might also be necessary to compare or integrate two or more EMMs to utilize their strengths and counter their weaknesses. In such cases, it is also important to develop an efficient EMM. Thus, the current version of A3E2M should be enriched by adding criteria and driving questions for other application types of EMMs. In addition to this, it should be clarified in what sequence the evaluation of different parts should be carried out.

An evaluation process is executed by asking (driving) questions developed for this purpose. The driving questions should be improved with the purpose of reaching an exhaustible list of questions. In the driving questions relevant to each EMM part, it should be clarified from what questions the evaluation process should start, how to pose further questions and how to end the questioning, in all different application types of EMMs.
Another suggestion for expanding A3E2M is relevant to documentation and presentation of evaluation results. By performing an evaluation approach, a user of A3E2M obtains answers and results regarding the efficiency of the investigated EMM. Accordingly, another opportunity for expansion of A3E2M is to provide guidelines for how to document evaluation outputs.

8.2.2 Moving from an Evaluation Approach to an Improvement Approach
Evaluation is the first step in an EMM efficiency improvement process. Such an evaluation process is expected to result in identification of the shortcomings and consequently the change needs for the EMM under study. To conduct the improvement process of the EMM, it is necessary to have suitable change measures in place. By change measures we refer to actions that are required for performing change needs discovered in an EMM. Thus, the evaluation approach is required to be completed in a second phase that supports identifying and implementing the change measures. Since there exist different application types of EMMs and the efficiency evaluation process is dependent on the planned application, it should be identified what change measures that are relevant to what application type. In other words, suggested change measures should be categorized according to the possible applications of EMMs. By following a concrete approach for setting up the change measures, team members will have a mutual language about what changes that are possible for each EMM part and details of each part.

8.2.3 Developing Guidelines for Conducting an Efficient Evaluation Process
The suggested approach is a general set of criteria for different EMM parts. Each EM case is done to fulfill a specific and new purpose, probably in a different enterprise and/or by a new modeling team. To evaluate and improve the efficiency of an EMM, an evaluation followed by an improvement process should be performed. Both of these additional processes, require extra effort and use of extra resources. Hence, it is necessary to consider the issue of efficiency for these purposes as well. Having a clear and concrete understanding about how the evaluation and improvements processes should be conducted, helps in delivering the required results while a reasonable amount of resources are used. In other words, development of an artifact that entails criteria and guidelines about how an evaluation and improvement process of EMMs should be done in order to be called efficient, is another part of future work.
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