TEKNISKA HÖGSKOLAN

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Efficiency indicators for Enterprise Modelling Methods and Enterprise Models

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Abstract

At the present time, when enterprises have tendency for constant improvements, different tools are used to analyze current state of the business and to introduce organizational changes. Enterprise Modeling is one of these tools. Enterprise modeling can be used for different purposes: to restructure or standardize business processes, to develop business strategy, to capture best practices, etc. Evidently, enterprise models creation is resource-consuming job, since it requires variety of resources, for example labor, time and others. However, resources utilization is always aimed at result achievement, which originates the question of efficiency. There is a need to evaluate efficiency in the area of EM, which starts from defining a set of indicators to be checked.

This work presents checklists of efficiency indicators for processes that EM can involve. For this purpose it identifies processes (so-called application areas of EMMs and enterprise models) that EM can involve. All of them are characterized with the help of two concepts: required resources and expected results. Formulated efficiency indicators can be used to analyze efficiency in the area of EM, particularly in application areas of EMMs and enterprise models.

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Key words

Enterprise Modeling, Efficiency, Enterprise Modeling Method, Enterprise Model.

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1 Introduction

Character of contemporary business is movable and variable, since agility became one of the most vital features to remain competitive (Fox and Gruninger, 1998). In order to succeed in business conduction it is important not only to introduce business changes and perform business redesign that are dictated by business environment (competitors, partners and other stakeholders), it is also crucial to have clear understanding about current way of enterprise operation. Enterprise Modeling (EM) ranks high among tools that can be used for these purposes (Whitman and Huff, 2001).

According to Ghidini et al (2008), "*Enterprise modeling focuses on the construction of a structured description, the so-called enterprise model, which represents (a subset of) the aspects relevant to the activity of an enterprise*" (Ghidini et al, 2008, p.1). Over the last decade EM has been applied in different fields, mainly in the fields of Business Process Reengineering (BPR), Knowledge Management (KM), the selection and development of Information Systems (IS) and others. Two aspects are important in problem solving in these fields: stakeholders should have common understanding about present enterprise activity, and understand how to reach the desired manner of enterprise functioning (Kassem et al, 2011; Stirna et al, 2007). Enterprise models are able to solve both of these problems (Stirna et al, 2007). They are able to provide the common understanding of relevant aspects of enterprise activity and give clear picture of business problems and requirements. Further use of enterprise models enables description of how to reach desired enterprise condition and state. The reason is that EM facilitates the identification of different design alternatives and proposes mechanisms to analyze these alternatives for further design implementation (Whitman and Huff, 2001).Generally EM can be used for different purposes: to restructure or standardize business processes, to develop business strategy, to capture best practices, to identify information system requirements, etc (Stirna and Persson, 2009). Thus, enterprise models play vital role in solving complex business problems within different business areas.

Different methods, methodologies and tools exist to support enterprise modeling (Rolstadås and Andersen, 2000; Ghidini et al, 2008). Particularly, they support production of enterprise models (Ghidini et al, 2008). In other words, in order to create enterprise models Enterprise Modeling Method (EMM) is supposed to be applied. Thus, the application of EMM is a basis for further multi-purpose use of enterprise models.

Introduction

Evidently, EM is a complex and composite activity that implies different processes. Among these processes it is possible to mention EMM application for the purpose of enterprise models creation (identical to enterprise models production or development) (Barjis, 2009; Whitman and Huff, 2001; Bernus, 2003), enterprise models use for the purpose of analysis of current business situation, enterprise models use for the purpose of business changes introduction (Stirna and Persson, 2009; Bernus, 2003; Knothe and Jochem, 2007).

All processes require resources. According to the definition given in ISO 9000, 9001, and 9004 Quality Management Definitions, process is a set of activities that are related to each other or that interact with each other. Processes use resources to transform inputs into outputs. Since EM is considered as a process while it is being used, it is possible to conclude that it requires resources as any other process. Among resources that are required for EM accomplishment the following concepts can be mentioned: time, efforts and cost (Larsson and Segerberg, 2004), resources and time (Whitman and Huff, 2001), time and effort (Stirna et al, 2007). At the same time, resources are usually allocated to achieve a result. This relation is emphasized by Stirna et al (2007), Whitman and Huff (2001). Taking into consideration the fact that resources are always scarce, resources-related questions are arising. Have the resources been used in a way that creates the intended results? This question points to the relationship between resources and result. This kind of relation is mainly associated with efficiency. Efficiency is usually considered as the criterion which represents how reasonable and worthwhile resources have been used to get some outcome. Efficiency is always applied to processes. For instance, ISO 9000, 9001, 9004 Quality Management Definitions defines process efficiency as "*relationship between results achieved (outputs) and resources used (inputs)*", enhancement of process efficiency or system efficiency can be gained by achieving more or getting better results (outputs) with the same or fewer resources (inputs). Schuette et al (1998) mentioned: "*With regard to the amount of time and money spent on investments in modeling projects the demand for efficient measures is evident*". They emphasize the need for further research in this area (Schuette et al 1998).

It is also important to mention that the concept of quality in the area of EM (both quality of models and modeling process) is quite widely studied and examined (examples of researches see in Larsson and Segerberg, 2004; Becker and Rosemann, 2000; Hommes et al, 2000; Moody, 2005; Knothe and Jochem, 2007), whereas efficiency of EMMs and enterprise models is an unexplored area. For example, Hommes et al (2000) created a framework to assess the quality of business process

modeling techniques. Among quality properties that were defined within this framework, they defined efficiency. However, they claimed that "*no attention is paid to the evaluation of effectiveness and efficiency of a technique*" (Hommes et al, 2000, p.5). Another example is a research work that was performed by Knothe and Jochem (2007). In this work the authors introduced a set of quality criteria for EM in the context of networked enterprises. Efficiency was introduced and defined as a criterion of quality for EM. However, the way of checking the efficiency fulfillment has not been presented. Researches in this area mainly described factors that can influence efficiency of modeling and models: Rosemann (1998) mentioned re-use of models as a way to improve efficiency; Rosemann (1998); Scheer and Harbermann (2000) emphasized the use for reference models as a potential mean of reaching the efficiency; Murphy and Staples (1998) said that process scope definitions and clear objectives and targets can help to improve efficiency. That is why it is possible to conclude that efficiency in the area of EM has not been studied in depth.

1.1 Problem description

Evidently, enterprise models creation is a resource-consuming job. It requires labor, time, and other resources. The reason for this is not only the fact that a large amount of information has to be considered and analyzed, but also the fact that constantly changing "organic" nature of business makes enterprise a moving target for modelers. That is why any modeling task within enterprise modeling project has to be done during a short period of time (Bernus, 2003). In addition, as it was mentioned above, resources allocated for some enterprise modeling activity are always limited, whereas result expectations are often unbounded. This relation between resources and results leads to importance of efficiency evaluation. That is why the question of efficiency that is arising requires examination and analysis. Thus, there is a strong need to introduce a way to improve efficiency; and improving efficiency first requires a set of metrics to be checked. These metrics should be developed for processes that can be performed within EM. Among these processes there are two directions: EMMs application areas and enterprise models application areas, since EMMs and enterprise models are two core concepts that can be applied within EM. These metrics can be used in future to improve efficiency of EMMs and enterprise models applications.

1.2 Purpose

The present work is supposed to contribute to the area of "Enterprise modeling". The main purpose of the work is to create a way to check efficiency in the area of EM, particularly in the processes that are related to EMMs and enterprise models. The way to check efficiency is supposed to be presented

in form of checklists. Each checklist should consist of efficiency indicators for respective application area of EMMs or enterprise models. To develop these checklists it should be studied what the application areas of EMMs and enterprise models are. Then, for each application area, it is important to investigate what resources it needs and what results it expects to produce. Based on these, it is demanded to define efficiency indicators for each application area of EMMs and enterprise models

1.3 Research focus

This section will present research questions of the work. The rest of the work aims to answer these questions.

1) What are relevant aspects to describe efficiency for EMMs and enterprise models?

This research question is supposed to give understanding of efficiency in relation to EMMs and enterprise models. This research question includes several parts:

- What does efficiency mean for EMMs and enterprise models?

The answer to this question should provide the foundation for the whole research. First of all, it is important to understand, how efficiency of EMMs and enterprise models can be defined. It is needed to study what does efficiency mean for EMM and enterprise model and what concepts should be studied to define it.

- What are the possible application areas of EMMs and enterprise models?

It is important to understand what possible application areas of EMMs and enterprise models are. In other words application areas are processes where EMMs and enterprise models can be applied. To answer this question, the list of application areas (processes) should be formed. These lists will illustrate how people can apply EMMs and enterprise models, what are the possible ways to deal with them.

- What are the required resources and expected results for each application area of EMMs and enterprise models?

This question is based on identified application areas of EMMs and enterprise models. It is important to learn, what required resources and expected results are for each application area, since it is the relation of resources and results that defines the concept of efficiency.

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2) How can identified aspects be translated and structured to evaluate efficiency of EMMs and enterprise models?

The investigation of this research question should introduce a way to evaluate efficiency of EMMs and enterprise models. It should be done based on the aspects that will be identified when answering the first research question. Identified aspects (from research question one) should be associated to each other to facilitate evaluation of efficiency of EMMs and enterprise models. As the result of aspects association it is supposed to develop the set of efficiency indicators that will allow checking if EMMs or enterprise models have been applied efficiently.

1.4 Scope and Limitations

The main purpose of this work is to introduce checklists of efficiency indicators for EMMs and enterprise models. It should be done by identifying application areas of EMMs and enterprise models, descriptions of required resources for each application area and results that are expected to be achieved. However, developing the methods for numeric evaluation of efficiency in mentioned areas is out of this work scope. The results of the thesis can be used further in checking or improving the efficiency in the area of EM.

1.5 Time plan

The time plan of the work is presented below.

Table 1-1 Time plan

Month	Date	Key activity	Task
February	14th	Literature review	Finding related materials Understanding of term "efficiency" in context of enterprise modeling
	24th		Identification concepts to be described in Theoretical Background
March	3rd	Introductory observation of factors that can influence efficiency of EMMs and enterprise models	Preliminary observation of factors that can influence efficiency of EMMs and enterprise models

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	17th		Identification of factors that can influence efficiency of EMMs and enterprise models
	22nd	Identification of application areas for EMMs and enterprise models	Distinguish areas in which EMMs and enterprise models can be applied Identification of resources required for each EMMs and enterprise models applications Identification of expected results
	23rd	Report writing start	
April	9th		Arrangement of application areas for EMMs and enterprise models
	12th	Efficiency indicators finding	Detection of factors that can indicate efficiency of EMMs and enterprise models application
	28th	Half way presentation	Presenting preliminary results
May	2nd	Refinement of preliminary results	Identification of work parts that are supposed to be elaborated: application areas of EMMs and enterprise models, efficiency indicators for these areas
	5th		Refinement of application areas of EMMs and enterprise models
	12th		Refinement of resources and results that are related to identified application areas
	19th		Formulation of efficiency indicators that are related to identified application areas
	29th	Validation of the preliminary results	Formulation of questions for the interviews

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June	6th		Arrangement and realization of the interviews
	11th		Analysis of the interviews
	22nd	Final presentation	Presenting final results

1.6 Working path
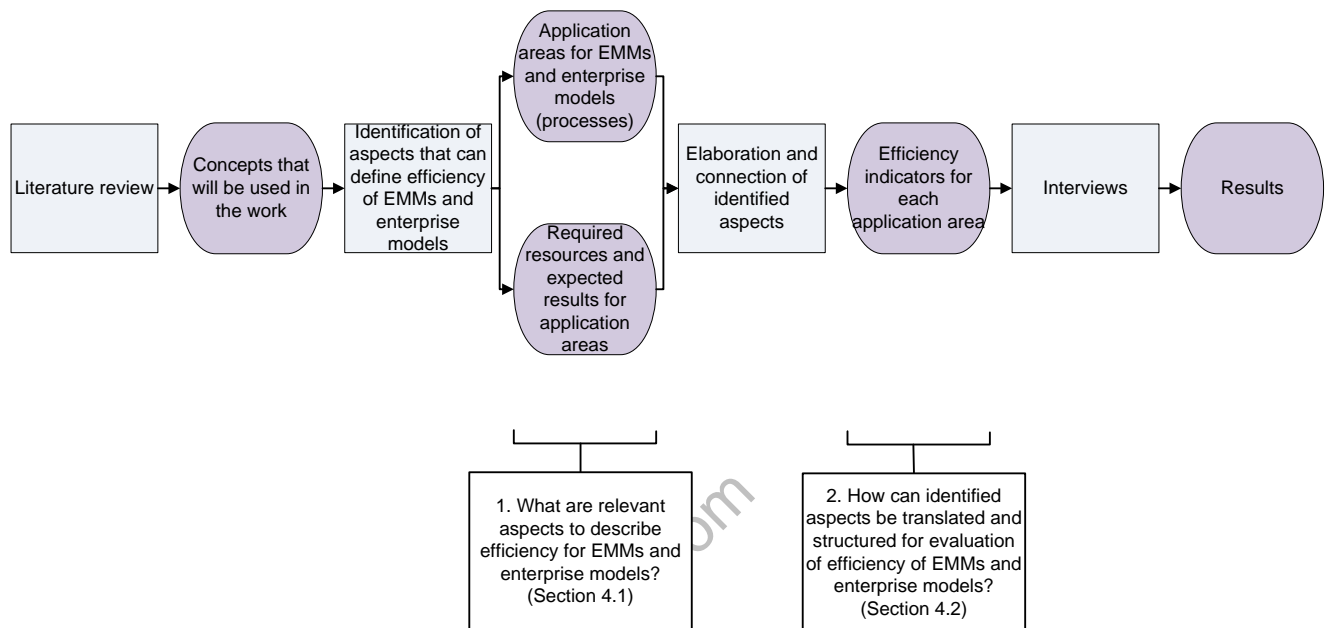
Figure 1-1: Working path

The work starts with *literature review*. This process should to be performed in order to get a general understanding about the research area, problems related to efficiency in the context of EM. This process is supposed to identify *the concepts that will be used in the work*. The next step of the work is *Identification of aspects that can define efficiency of EMMs and enterprise models*. This part has to result in two types of deliverables: *Application areas for EMMs and enterprise models (processes)* and r*equired resources and expected results for each application area*. This stage of research is supposed to answer the first research question. The next step is *Elaboration and connection of identified aspects*. This activity is supposed to be done in order to obtain e*fficiency indicators for each application area*. This stage should answer the second research question. Then

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identified efficiency indicators have to be validated via *Interviews*. This supports production of the final results.

2 Research method

This section presents the research methodology that will be used in the work.

2.1 Scientific method

The way of investigating a research problem is systematic, which involves a set of methods to produce the results. Thus, the quality of the work can be judged through reliability and validity criteria. Research methods that will be used for data collection are literature review and interviews.

The first part of the work involves definition of relevant aspects to describe efficiency for EMMs and enterprise models (research question 1). This task will be performed basing on of literature review. This working step is supposed to provide an understanding about concepts that should be taken into consideration when defining efficiency for EMMs and enterprise models. This step will be described in the section 4.1.

The second part of the work is translation and integration of identified aspects into a framework for EMMs and enterprise models efficiency evaluation (research question 2). This step includes detailed elaboration and description of identified aspects, creates the associations them and then definition of efficiency indicators for EMMs and enterprise models. This step will be described in the section 4.2.

The third part of the work is the validation of results that will be obtained in the previous work steps. This part of the work will be done with the help of interviews. The final result of the work is checklists of efficiency indicators for EMMs and enterprise models.

2.2 Participants

The selection of informants plays very important role in the empirical investigation, since opinions of the informants will be used for results validation. The informants that were selected for this research have practical experience in the area of EM, but their roles and duties are different. One informant has been selected to give management viewpoint on EM, whereas two others have been selected to provide the viewpoint of experienced EM participant.

The selected interviewees are listed below.

Per Högberg (managing director at Skye AB)

Eva Holmquist (management consultant at Systeam AB)

Research method

Magnus Hellgren (managing director of Center of Information Logistic)

Now onward they will be called as Participant 1, Participant 2 and Participant 3 respectively.

2.3 Data collection

There are different structures of interviews that can be used for data collection. For the present research semi structured interviews are chosen, since it results in collection of bigger amount of data comparably to the other types of interviews. Also it allows researcher to control the direction of the interview, but at the same time, it allows informants to describe their opinions and ideas (Lundqvist, 2007). The interviews will be performed via phone.

Interview questions:

1.1. What processes (EMMs application) do you perform during EM? / What processes do you consider as EMMs application areas?

1.2. What is the order of these processes?

1.3. What resources do you allocate for each application area of EMM?

1.4. What results do you get within each application area of EMM?

1.5. When do you want to analyze your work and evaluate the achievement of results, what resources do you consider as more important than the others?

2.1. What processes (enterprise models application) do you perform during EM? / What processes do you consider as application areas for enterprise models?

2.2. What is the order of these processes?

2.3. What resources do you allocate for each application area of enterprise models?

2.4. What results do you get within each application area of enterprise models?

2.5. When do you want to analyze your work and evaluate the achievement of results, what resources do you consider as more important than the others?

3 Theoretical background

The role of this chapter is to provide the reader with general explanation of concepts that will be used in the work and to give an idea about the state of research that is going on in this area. Firstly, in section 3.1 a general description of enterprise modeling and its basic concepts will be presented, particularly, concepts such as EMM (sub-section 3.1.1) and enterprise model (sub-section 3.1.2) will be covered. In section 3.2 a brief description about models and methods evaluation will be presented. This sub-section is supposed to describe how models and methods can be evaluated; in other words which characteristic people need to assess to understand if model or method is appropriate for the work. In section 3.3 interpretation of the term "efficiency" will be introduced. Explanation of term "efficiency" will start with presenting general meanings of this term and continues with specializing how it can be applied to EMMs and enterprise models. This is the most important section of the chapter, since it will address the question of efficiency for EMMs and enterprise models, as well as identifying relevant aspects to describe it.

3.1 Enterprise modeling

Contemporary enterprises tend to constant improvements and transformation. It is caused by the changeable nature of business environment and high pace of competitors' progress. However, in order to perform any kind of changes or improvements within enterprise, analysis and investigation of current enterprise condition and status need to be performed. For this purpose enterprises use different potentials, one of the most common is Enterprise Modeling (Whitman and Huff, 2001).

Petrie (1992) motivates the importance of enterprise modeling by ability to provide general understanding about the enterprise and its relations, and then to use this understanding to improve and develop these relations.

Enterprise modeling can be used for variety of purposes. According to Bernus (2003) among purposes of enterprise modeling application it is possible to mention:

- To design or redesign such processes as control, production or management;
- To design how different resources (both automated and human) are used within processes;
- To control or monitor some enterprise process based on the model;

Theoretical background

- To attain common understanding or agreement between stakeholders (for example, managers, owners, business partners, workers, etc) about different aspects of enterprise functioning;

In the context of these purposes enterprise modeling is currently considered as practicable and worthwhile tool.

Another classification of EM purposes is proposed by Stirna and Persson(2009). According to them, EM can be used for two kinds of purposes:

1) Business development, for example, development of business vision and strategies, business operations redesigning, development of the supporting information systems, etc.
2) Ensuring the business quality, for example, knowledge sharing about the business, or some aspect of business operation, or decision making.

In order to perform enterprise modeling, Enterprise Modeling Method is supposed to be used. A great variety of Enterprise Modeling Methods (EMM) have been developed and used in practice (Stirna and Persson, 2009). EM implies creation of enterprise models. Below are presented explanation of such concepts as EMM (sub-section 3.1.1) and enterprise model (sub-section 3.1.2).

3.1.1 Enterprise Modeling Method

Different EMMs have been created and used in practice (Stirna and Persson, 2009; Tissot and Crump, 2006). EMMs are supposed to support EM and create enterprise models (for example, data, object, function, processes, and organization models). EMMs provide intuitive and understandable graphical languages to represent relevant concepts and their relationships, so modelers are able to explicitly and clearly capture and present domain knowledge using limited training in the corresponding methods and tools (Tissot and Crump, 2006). According to Vernadat (2002), EMMs provide principles and tools to support creation of enterprise models. EMM helps modelers to focus on the important sides of their work. Generally, as any other method, EMMs provide modelers with guidelines for work (Larsson and Segerberg, 2004).

An EMM likewise any other method consists of several method constituents. However, the set of method constituents can be defined in different ways. For instance, Larsson and Segerberg (2004) say that EMM usually consists of two parts: a meta-model of the modeling language that describes the modeling product, and a suggested way of working (the modeling process, which is suggesting how to create enterprise models). According to Kaschek and Mayr (1998) EMM consists of the

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Theoretical background

following constituents: domain of method application, method task class, method language, method proceeding model, method style, method goal templates, method usage rules and construction rules. Dam and Winikoff (2004) mention EMM constituents as concepts, modeling language and process. That is why it is important to accept one method notion that will be used in this work.

Quite universal and comprehensive description of EMM constituents is introduced by Goldkuhl et al (1998). Schematic representation of this method theory is presented on figure 3.1.

Figure 3-1: Method notion - relationship between perspective, framework, method component and co-operation forms (Goldkuhl et al, 1998)

According to Goldkuhl et al (1998), EMM consists of following parts:

- Method component (procedure, notation and concepts). Procedure explains how to work and what questions to ask; notation describes how answers to these questions should be documented; concepts play connecting role between procedure and notation, it is the overlapping part of procedure and notation. Usually there is a close connection between these three.

- Perspective – philosophy on which method is built (implicit or explicit). Perspective includes values, principles and categories (with definitions) that are fully explained in the method and its method components.

- Framework – it shows how the other parts are related to each other. It includes the phase structure of the method.

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- Co-operation forms (and collection forms) – it deals with roles and division of work in the development process. It explains how people communicate and co-operate when they performing the method-guided work.

Thus, in the present work it will be considered that any EMM consist of method component, perspective, framework and co-operation forms. This method notion has been chosen for the work, because it gives quite clear, universal and comprehensive picture of method constituents. This interpretation of EMM constituents will be used further in chapter 4.

Currently, there is a great number of enterprise modeling methods existing. Among them it is possible to mention IDEF (ICAM Definition Method), GRAI-GIM GIM (GRAI Integrated Methodology), CIMOSA (CIM Open System Architecture), PERA (Purdue Enterprise Reference Architecture), GERAM (Generalized Enterprise Reference Architecture and Methodology) and others (Vernadat, 2002).

However, in order to perform EM successfully and to get expected benefits from it, it is important not only to use EMM, but it is also important to choose EMM properly, in other words, EMM has to fit adequately to the problem situation and the quality of the modeling methods has to be taken into consideration (Barjis, 2009). Thus, EMMs require detailed prerequisite analysis and evaluation. That is why significant part of research in the area of EM is dedicated to evaluation of EMMs (for example, Hommes et al, 2000). The question of evaluation of EMMs will be examined further in sub-section 3.2.1.

3.1.2 Enterprise models

First fundamental term in relation to enterprise modeling is a model, since enterprise modeling serves as a way to develop enterprise models that can be used for different purposes later on. According to the ISO, model can be defined as "*representation of something else*" (ISO/ANSI, 1994). Presley (1997) defines enterprise model as "*a symbolic representation of the enterprise and the things that it deals with. It contains representations of individual facts, objects, and relationships that occur within the enterprise*". The advantage of models use is that model is able to simplify real system and predict some events related to it (Wood, 1994).

Basic purposes of enterprise models can be defined as "*to make people understand, communicate, develop, and cultivate solutions to business problems*" (Rolstadås and Andersen, 2000, p.22).

Theoretical background

Enterprise models represent different aspects of enterprise. There are a number of aspects that can be addresses with the help of enterprise models:

- Processes (business and manufacturing);
- Products (and all related information and technical data);
- Information;
- Organization (issues related to organization and management, for example, goals, organizational charts and others);
- Resources;
- Environment (issues related to enterprise environment, for example, government regulations, business partners and others);
- Raw materials;

Enterprise models can differ from each other by different dimensions, for example, purpose of models, models content, abstraction levels, quality of formalism and others (Rolstadås and Andersen, 2000).

Currently different model classifications which divide models according to their purposes exist. For example, Christensen (1995) proposes three categories of enterprise models with respect to purpose of models:

1. Models with main purpose of human clarification of some enterprise aspects and communication with other actors.
2. Models with main purpose of gaining knowledge about enterprise via simulation or deduction.
3. Models with main purpose of deployment and activation for the reason of integration to enterprise information system.

Brathaug (1999) presents slightly different purposes of enterprise models. Among them he mentioned:

- Demonstrate dependencies and relations in enterprise in order to reach higher level of management and control;
- Support re-engineering of business processes;

Theoretical background

- Give a general understanding about enterprise and aspects of enterprise in order to support analysis and decision making;
- Create a support for enterprise routines on all levels;
- Create a support for design of new parts of enterprise;
- Process simulation;

Thus, model is abstraction of reality which is created with the help of EMM.

3.2 Evaluation of models and methods

Significant part of research in area of EM is dedicated to investigation of what does "good" model mean (Moody, 2005), is model right for your task (Fox and Gruninger, 1998); how comprehensive EMM is and does method fit for use (Juran, 1979; Hommes et al, 2000). In other words, researchers try to evaluate models and methods. This evaluation of models and methods often addresses the concept of quality (Kesh, 1995; Harmsen, 1997; Falkenberg et al, 1996; Aguilar-Saven, 2004), but also it can refer other characteristics, for example, Bernus (2003) defined such characteristic as completeness. Currently different frameworks to evaluate models and methods exist.

3.2.1 Characteristics of EMM

Quality is characteristic of EMM that is used the most to evaluate modeling method. To assess the quality of business process modeling technique Hommes et al (2000) proposes a number of quality properties and define a procedure to make possible objective assessment of these properties (Hommes et al, 2000). Quality properties introduced by these authors are: suitability, completeness, coherence, expressiveness, comprehensibility, arbitrariness, effectiveness and efficiency.

According to Falkenberg et al. and FRESCO report (1996) list of quality properties for business process modeling technique includes expressiveness, arbitrariness and suitability.

Evidently, efficiency often appears as one among several criteria that helps to evaluate EMM. More detailed examination of EMM efficiency will be presented in sub-section 3.3.1.

3.2.2 Characteristics of enterprise models

One of the most common and required characteristics of models is quality. Quality of models can be affected by a number of factors. Among them Rolstadås and Andersen (2000) mentions scope, granularity, precision, generality, efficiency, perspicuity, transformability, extensibility, consistency, completeness, scalability, clarity, uniqueness, validity and others.

Theoretical background

Fox and Gruninger (1998) introduce six evaluation criteria for enterprise model: functional completeness, generality, efficiency, perspicuity, precision granularity and minimality.

Bernus (2003) defines completeness of enterprise model as significant characteristic of model. In this relation he also defines efficiency of enterprise model, since it is always important to create models as efficiently as possible taking into consideration limited time and budget that are allocated to modeling.

It shows that efficiency is often used as one criterion to define model quality. However, the focus of this work is pointed at definition of efficiency indicators, so application of the term "efficiency" to enterprise models will be examined and elaborated further in sub-section 3.3.2.

3.3 Efficiency

In order to understand what is enterprise models efficiency and enterprise modeling methods efficiency, it is important to understand classic meaning of this term. Mainly, efficiency is used as economic or production term, but currently it gains much broader character.

The criterion of efficiency is used by huge amount of organizations that focus on profit. In such organizations efficiency is used for decision making, particularly, to choose one alternative that will bring the greatest money return to the organization among several of them. Efficiency can be considered from two sides: income maximization, if costs are fixed; or cost minimization if income is fixed. In practice it means that the difference between cost and incomes has to be maximized (Simon, 1994).

ISO 9000, 9001, 9004 Quality Management Definitions defines efficiency as a relationship between resources used (inputs) and results achieved (outputs). Enhancement of process efficiency or system efficiency can be gained by achieving more or getting better results with the same or fewer resources.

Cochrane (1972) defined efficiency as optimal use of resources.

Thus, classical understanding of efficiency is related to such characteristics as resources, achieved results and relationship between them.

3.3.1 Efficiency of methods

Efficiency of methods is mainly mentioned in combination with other characteristics, which are used to evaluate quality or success of a method.

Theoretical background

Harmsen defined six quality requirements for methods: suitability, completeness, consistency, efficiency, soundness and applicability. Efficiency is defined as "*the requirement that the situational method fulfills its duty at minimal cost and effort*" (p.253). He also mentioned that efficiency is often neglected; however, it is very important quality requirement for methods (Harmsen, 1997).

Sedera et al (2002) use two characteristics to define process modeling success: effectiveness and efficiency. According to them, process modeling efficiency is "to confirm to the resources (cost and time) assigned to the project" (Sedera et al, 2002, p.333).

Hommes et al (2000) defines efficiency as one of quality properties of business process modeling techniques. The definition of efficiency which is given by these authors is:"*the degree to which the modeling process utilises resources such as time and people*" (Hommes et al, 2000, p.4). They also mentioned that to evaluate the efficiency of a method, the resources use by activities must be described.

Harmsen (1997) define five method quality criteria, efficiency is one of them. According to this author, efficiency is often can be neglected, but it is really important quality criterion for a method. This criterion tries to avoid unnecessary steps and deliverables during project. Efficiency address the issue of "*doing similar things several times and delivering similar products*" (Harmsen, 1997, p.253).

3.3.2 Efficiency of models

As it was mentioned in section 3.1.2, in relation to enterprise models term "efficiency" is mainly used as one of evaluation characteristics, it is used in combination with others characteristics to evaluate more comprehensive and broader concepts as, for example, quality.

Rolstadås and Andersen(2000) in order to evaluate quality of enterprise models mention a number of model evaluation criteria, among them he says about efficiency, characteristic which supposes to evaluate model ability to efficiently solve the problem and perform reasoning without need for transformation.

Fox and Gruninger (1998) also introduce efficiency as one criterion for evaluation of enterprise model quality. In definition of this criterion he makes emphasis on model's ability to perform reasoning, particularly, space and time, without transformation.

Theoretical background

Bernus (2003) defines efficiency of enterprise model in the context of the use of these models. He defines it in a following way:" *An enterprise model is efficient if it conveys the intended meaning concisely between the parties producing or using the model*" (Bernus, 2003, p.215). Author makes emphasis on using word "convey" instead of "contains".

Knothe and Jochem(2007) introduce efficiency among criteria for quality of enterprise modeling as following:"*An Enterprise Model is efficient, if the creation effort is low, but the benefit regarding the intended goals, scope and purpose is high. It is also efficient when the usage duration of the model is long and itself or parts of it are reusable for other goals, scopes and purposes*" (Knothe et al, 2007, p.7)

3.4 Summary of the chapter

The goals of this chapter were to provide the reader with general explanation of concepts that will be used in the work and to give an idea about the state of research that is going on in this area. For these purposes explanations of concepts EMM and enterprise model have been presented. This is followed by giving an explanation about efficiency. Taking into consideration views on efficiency that were described in this chapter, it is possible to conclude that efficiency of EMMs and enterprise models can be defined with the help of three aspects:

- Process that implies involvement of EMM or enterprise model (since efficiency always characterizes some process)
- Resources that are required to perform this process
- Results that are expected to be achieved

Subsequently, in order to identify efficiency indicators for EMMs and enterprise models, these three aspects have to be studied, concretized and combined together to form a way to check efficiency of EMMs and enterprise models. These steps of work will be described in the Chapter 4.

4 Preliminary results

This chapter includes preliminary results that are derived with the help of literature review. The purpose of this chapter is to answer the first and the second research questions that have been presented in section 1.3. In the chapter 3 important aspects in the area of EM are described; and different views on efficiency of EMMs and enterprise models are presented. According to chapter 3, efficiency of EMMs and enterprise models is always related and attached to the process in which EMMs or enterprise models are involved. Having information about the process in which EMMs or enterprise models are involved, makes it possible to define efficiency with the help of two aspects: resources that are required to perform this process and results that are expected to be achieved through the process implementation. Then it is possible to formulate indicators to check efficiency within the analyzed process, since efficiency will be defined through the relation between resources and results. Thus, it is needed to find out what are the application areas for EMMs and enterprise models (i.e. processes in which EMMs and enterprise models can be involved); what resources are required for each application area; what results are expected to be achieved; and then with the help of this information it is needed to form efficiency indicators for each application area.

This chapter consists of two parts: application areas for EMMs and enterprise models that will be characterized by related resources and results (section 4.1 – answers the first research question) and efficiency indicators for identified application areas (section 4.2 - answers the second research question).

4.1 Application areas for EMMs and enterprise models

The first step in the way of identifying efficiency indicators for EMMs and enterprise models is to discover application areas for EMMs and enterprise models, which are processes that show what people can do with EMMs or enterprise models, processes in which EMMs or enterprise models can be involved. Each process requires some resources and gives some results (Figure 4-1).
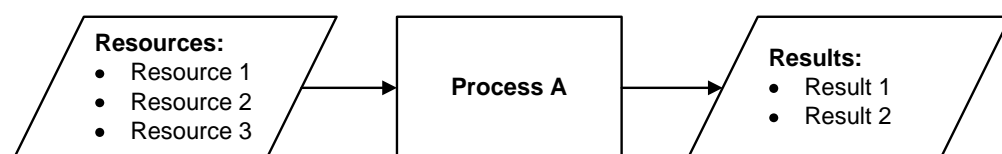

Figure 4-1: Process, resources and results

Preliminary results

A process consumes resources in order to produce results. Resources might consist of different material and immaterial means, for example, labor, time, information, etc. Results also might include material and immaterial means that are supposed to be produced through process performance. Results of a process can consist of material object or information. Processes can be related to each other, since results of one process can serve as a resource for another process (Bubenko et al, 2001).

The purpose of this section is to define application areas (processes) for EMMs (sub-section 4.1.1) and enterprise models (sub-section 4.1.2), including related resources and results.

4.1.1 Application areas for EMMs, related resources and results

There are different application areas for EMMs. An EMM life cycle can be structured with the help of following classification:

1. Pre-use;
2. Use;
3. Post-use;

This classification clearly distinguishes the main application area of EMM – EMM use. The most significant process where EMMs can be involved is use itself, i.e. application of EMM for the purpose of enterprise models creation. Pre-use includes processes that precede it. Post-use is about processes that follow it.

Pre-use can involve EMM evaluation (Cernuzzi and Rossi, 2002; Dam and Winikoff, 2004; Shehory and Sturm, 2001; Hong et al, 1993, Kaschek and Mayr, 1998; Siau and Rossi, 1998; Iivari, 1995), EMM comparison (Siau and Rossi, 1998; Hong et al, 1993; Iivari, 1995; Kaschek and Mayr, 1998), EMM selection (Siau and Rossi, 1998; Hong et al, 1993; Iivari, 1995; Kaschek and Mayr, 1998), EMM learning (Kaschek et al, 1998; Stirna and Persson, 2009), EMM creation, EMMs integration (Saeki, 1998) and EMMs improvement (Kaschek and Mayr, 1998). The group "Use" includes one process: modeling, which is application of EMM for the purpose of models creation. Post-use includes maintenance of EMMs.

Processes, their division into groups and possible relations between some of them are presented in Figure 4-2. EMM evaluation precedes EMM selection (Siau and Rossi, 1998; Shehory and Sturm, 2001, Iivari, 1995, Hong et al, 1993). At the same time, EMMs comparison can precede EMM selection (Siau and Rossi, 1998; Hong et al, 1993; Iivari, 1995; Kaschek and Mayr, 1998).

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Consequently, selection might be dependent on the processes EMM evaluation or EMMs comparison. Modeling (EMM application) can follow EMM selection, EMM learning or EMMs integration.
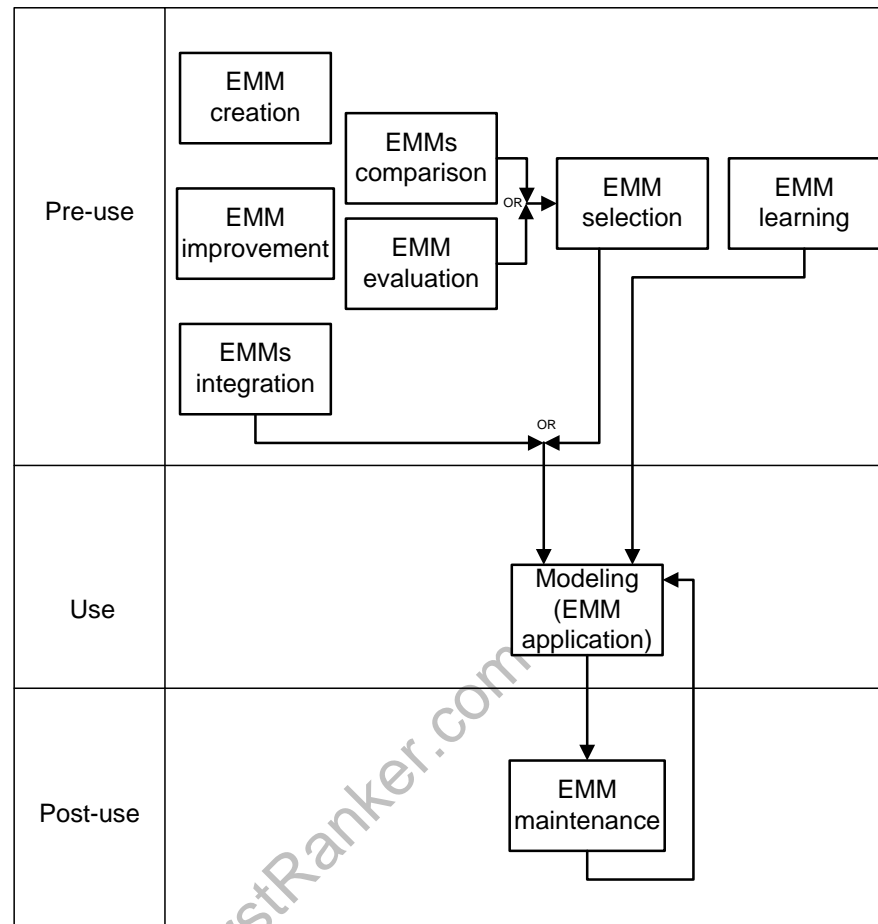
Figure 4-2 Application areas for EMMs

These processes, the required resources and the expected results are described below.

4.1.1.1 EMM creation

EMM creation is the most important activity in the method life cycle. Resources that are required for EMM creation have been divided into three groups:

1) Human resources
2) Knowledge of method designers that is supposed to be structured and presented in order to form an EMM
3) Time

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Human resources that are involved into process of EMM creation are people that are ready to introduce and present a new EMM including all method constituents. These people are method designers. The role of method designers is to structure and present their ideas and knowledge to develop a new EMM method.

The result of EMM creation is a new EMM that include a set of method constituents. As it stated in sub-section 3.1.1, in this work it is considered that method constituents are: method component, perspective, framework and co-operation forms (introduced by Goldkuhl et al, 1998).

Thus, the resources that are required for EMM creation and the results that are possible to achieve are presented in Table 4.1.

Table 4-1 EMM creation - required resources and expected results

Application area	Required resources	Expected results
EMM creation	**Human resources** • Method designers **Knowledge of method designers that is supposed to be structured and presented in order to form an EMM** **Time**	EMM is created. Method constituents are: • Method component (procedure, notation and concepts) • Perspective • Framework • Co-operation forms (and collection forms)

4.1.1.2 EMMs integration

EMMs can often be integrated for the purpose of further application within specific problem solving (Saeki, 1998). The need for EMMs integration can be raised by diversity of problems that are needed to be solved. Some problems can be solved with the help of existing EMM, whereas others can be solved by combination of several EMMs.

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EMMs integration requires the following groups of resources:

1) Human resources
2) Integration technique
3) Resources that provide explanation and description of EMMs
4) Time

Human resources consist of method integrators. Their role is to apply suitable integration technique (one or several) in order to integrate the chosen EMMs. There are different integration techniques; hence it is important to choose a proper one in particular EMMs integration case. One example of integration technique was proposed by Saeki (1998).

The third group of resources is resources that provide explanation and description of EMMs that are going to be integrated. They should be available to method integrators; in this case they can get the necessary information about constituents of the chosen EMMs. This information might be needed in order to understand key issues about the chosen EMMs: what inputs do methods need, what outputs do methods produce, what are the domains of methods applicability, etc. The role of this group of resources is to provide support to people that are involved into integration process, and give clear and full description of EMM constituents (they are method component, perspective, framework and co-operation forms). This group includes any resource, which can provide people with explanation or guidelines regarding method. Among these resources it is possible to mention following:

- Readily available books about the EMM;
- Documentation that contains description of EMM;
- EMM case studies with description of previous EMM use;
- Consulting services that can provide support and give information about EMM;

The results of EMMs integration is a new EMM that includes defined method constituents and the fact that this new method can be applied further in modeling. Produced EMM can contain all constituents of the integrated EMMs or some constituents from each.

According to this, the resources that are required for EMM integration and the results that are possible to achieve are presented in Table 4.2.

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Table 4-2 EMMs integration - required resources and expected results

Application area	Required resources	Expected results
EMMs integration	**Human resources** • Method integrators **Integration technique –** a technique that can be applied to integrate chosen EMMs **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about EMM **Time**	An integrated EMM. Constituents are: • Method component (procedure, notation and concepts) • Perspective • Framework • Co-operation forms (and collection forms) Integrated EMM can be used in modeling

4.1.1.3 EMM improvement

EMMs can be improved. The need of improvement can be caused by different reasons, for example, because of the need to solve particular problem, in the situation when EMM cannot be applied for this problem without improvement. Another reason to improve an EMM is a decision of method designers to develop or modernize the method.

EMMs improvement requires four groups of resources:

1) Human resources
2) Knowledge of method designers that is supposed to be applied and presented in order to improve EMM

3) Resources that provide explanation and description of EMM

4) Time

Human resources that are involved in EMM improvement are method improvers; it can be both designers of original method or other people who need to improve the EMM. The role of method integrators in this case is to apply their knowledge and ideas in order to improve the EMM. The third group of resources (resources that provide explanation and description of EMM) has the same meaning and role as in 4.1.1.2.

The result of EMMs improvement is a new EMM that includes method constituents; either all of the method constituents can be improved or only some of them.

The resources that are required for EMM improvement and the results that are possible to achieve are presented in Table 4-3.

Table 4-3 EMM improvement - required resources and expected results

Application area	Required resources	Expected results
EMMs improvement	**Human resources** • Method designers **Knowledge of method designers that is supposed to be applied and presented in order to improve EMM** **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about	Improved EMM. Constituents are: • Method component (procedure, notation and concepts) • Perspective • Framework • Co-operation forms (and collection forms)

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	EMM	
	Time	

4.1.1.4 EMM evaluation

Modeling methods can be evaluated (Cernuzzi and Rossi, 2002; Dam and Winikoff, 2004; Shehory and Sturm, 2001; Hong et al, 1993, Kaschek and Mayr, 1998; Siau and Rossi, 1998; Iivari, 1995). Cernuzzi and Rossi (2002) also call this process analysis, Siau and Rossi (1998) use term "assessment" to name this process. Method evaluation can serve as a foundation for other processes, for example, Shehory and Sturm (2001), Iivari (1995), Hong et al (1993) say that method evaluation precedes method selection.

Evaluation requires evaluation technique (Siau and Rossi, 1998). There are different method evaluation techniques, for example, to evaluate Agent Oriented Modeling Methods there is a framework introduced by Cernuzzi and Rossi (2002), to evaluate and compare object-oriented modeling methods there is a framework presented by Hong et al (1993) and Iivari (1995). Main goal of modeling methods evaluation is to get understanding on the strengths and weaknesses of each method (Shehory and Sturm, 2001). Dam and Winikoff (2004) also point out that with the help of method evaluation it is possible to understand the domain of method applicability.

Resources that are required for method evaluation have been divided into four categories:

1) Human resources
2) Evaluation technique
3) Resources that provide explanation and description of EMM
4) Time
5) Human resources related to method evaluation process are evaluators and designers. The need for such human resources is mentioned by Cernuzzi and Rossi (2002), Hong et al (1993).

The second group of resources is evaluation technique. In order to perform method evaluation, evaluators need to use an evaluation technique (Cernuzzi and Rossi, 2002; Dam and Winikoff, 2004; Shehory and Sturm, 2001; Hong et al, 1993, Kaschek and Mayr, 1998; Siau and Rossi, 1998, Iivari, 1995). In the present work it is assumed that all kind of resources, which contain information about

evaluation technique, can be considered as resources belonging to this group, for example, scientific article that introduces framework for EMM evaluation.

The third group of resources required for method evaluation is resources that provide explanation and description of EMM that are planned to be evaluated. The role of this group of resources is the same as in 4.1.1.2.

Thus, the resources that are required for EMM evaluation and the results that are possible to achieve are presented in Table 4-4.

Table 4-4 EMM evaluation - required resources and expected results

Application area	Required resources	Expected results
EMM evaluation	**Human resources** • Evaluators • Designers **Evaluation technique –**a way to evaluate EMM that is described and explained **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about EMM **Time**	• Method strengths and weaknesses • Evaluated method can be selected for further application

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4.1.1.5 EMMs comparison

Modeling methods need to be compared (Siau and Rossi, 1998; Hong et al, 1993; Iivari, 1995; Kaschek and Mayr, 1998). EMMs comparison precedes EMM selection (Siau and Rossi, 1998; Hong et al, 1993; Iivari, 1995; Kaschek and Mayr, 1998).

Methods comparison usually requires a technique for comparison – a set of characteristic properties that are supposed to be analyzed for several methods (Kaschek and Mayr, 1998). There are many approaches for comparison of modeling methods. The main result of the methods comparison is finding of methods similarities and differences (Dam and Winikoff, 2004; Hong et al, 1993)

Resources that are required for methods comparison have been divided into four categories:

1) Human resources
2) Comparison technique
3) Resources that provide explanation and description of EMM
4) Time

The need for human resources, which are required for methods comparison, is mentioned by Hong et al (1993). Mainly, it is the same human resources that are involved into modeling project. Among them there are: method providers – people with knowledge of EMM; customer – initiator of modeling and modeling session participants – enterprise key employees and/or hired specialists (Larsson and Segerberg, 2004).

The second group of resources is a comparison technique. In order to perform method comparison, human resources need to use some technique for comparison (Kaschek and Mayr, 1998). In the present work it is assumed that all kind of resources, which contain information about comparison technique, can be considered as resources belonging to this group, such as scientific article that introduces approach for methods comparison.

The third group of resources required for methods comparison is resources that provide explanation and description of EMM that are planned to be compared. This group of resources has the same meaning as in paragraph 4.1.1.2.

Thus, the resources that are required for EMMs comparison and the results that are possible to achieve are presented in Table 4-5.

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Table 4-5 EMMs comparison- required resources and expected results

Application area	Required resources	Expected results
EMM comparison	**Human resources –** some people from: • Method providers – people with knowledge of EMM • Customer – initiator of modeling • Modeling session participants – enterprise key employees and/or hired specialists. **Comparison technique -** a way to compare EMMs that is described and explained **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about EMM **Time**	• Methods similarities and differences • Obtained after methods comparison information can be used for further method selection

4.1.1.6 EMM selection

Method selection is a quite important process that is supposed to be done before modeling (Kaschek and Mayr, 1998). EMM selection can follow EMM evaluation or EMMs comparison (Siau and Rossi, 1998; Shehory and Sturm, 2001, Iivari, 1995, Hong et al, 1993; Kaschek and Mayr, 1998).

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Methods selection requires information about method candidate(s) – either results of EMM evaluation or results of EMMs comparison. The aim of method selection is to choose EMM for further application in modeling.

Resources that are required for methods comparison have been divided into three categories:

1) Human resources
2) Information about method candidate(s)
3) Time

Human resources that are involved into EMM selection are some people from human resources that are involved into modeling project. Among them there are: method providers – people with knowledge of EMM; customer – initiator of modeling and modeling session participants – enterprise key employees and/or hired specialists (Larsson and Segerberg, 2004).

The second group of resources is Information about method candidate(s). Since, method selection can follow EMM evaluation or EMMs comparison, this group of resources can consist in results of EMM evaluation or EMMs comparison.

Thus, the resources that are required for EMMs selection and the results that are possible to achieve are presented in Table 4-6.

Table 4-6 EMM selection- required resources and expected results

Application area	Required resources	Expected results
EMM selection	**Human resources –** some people from: • Method providers – people with knowledge of EMM • Customer – initiator of modeling • Modeling session participants – enterprise key employees and/or hired specialists. **Information about method candidate(s)** ➢ Results of EMM evaluation ➢ Results of EMMs comparison	• Methods is selected • Method can be used in modeling

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	Time	

4.1.1.7 EMM learning

In order to use EMM in modeling, EMM should be learned (Kaschek and Mayr, 1998; Stirna and Persson, 2009). With the help of learning process a method learner can obtain required knowledge about a method.

All resources that are required for EMM learning have been divided into four groups:

1) Human resources
2) Resources that provide explanation and description of EMM
3) Material resources allocated to arrangement of learning sessions
4) Time

Learning process usually implies two sides: "learner" and "tutor". So in EMM learning process we distinguish two kinds of human resources: learner (one person or several people who want to get certain knowledge about EMM), and tutor (one person or several people who provide learner(s) with required knowledge about EMM).

The second group of resources is resources that provide explanation and description of EMM. This group has the same meaning as in sub-section 4.1.1.2. Stirna and Persson (2009) noted that EMM learning should be done not only through practice, but also with the help of "*documented guidelines and advice for carrying out EM*" (Stirna and Persson, 2009, p.408).

The third group is material resources allocated to arrangement of learning sessions. Among these resources it is possible to mention location, computerized tool, projection screen, and other material means that enterprise can allocate in order to organize learning session.

In Table 4-7 presented different kinds of the required resources and the expected results for such activity as EMM learning.

Table 4-7 EMM learning - required resources and expected results

Application area	Required resources	Expected results
EMM learning	**Human resources**	• Method learner has obtained

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	• Learner – person who intends to obtain knowledge about EMM (one or several EMM components) • Tutor – person who gives information about EMM, leads learning process during learning sessions **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about EMM **Material resources allocated to arrangement of learning sessions** • CASE tool(s) • Location • Digital devices (projection screen, computer, etc) **Time**	required knowledge about one or several constituents of EMM • Obtained knowledge can be applied in modeling

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4.1.1.8 Modeling

The most important process that involves EMMs is modeling – application of EMMs for the purpose of enterprise models creation, since EMMs exist in order to support modeling (Rolstadås and Andersen, 2000; Ghidini et al, 2008). Ghidini et al (2008), Barjis (2009), Davies et al (2005), Stirna and Persson (2007), Kaschek and Mayr (1998) describe enterprise modeling as a process that leads to enterprise models production. They say that enterprise modeling can be performed during modeling sessions. Obviously, expected results of modeling process are enterprise models. The expectation is to obtaining models with an acceptable level of quality. The acceptable level of quality should be specified before development by human resources that take part in EM. It is remarkable that some methods enable creation of only one kind of models, whereas others methods allow to create different kinds of models. For example, an EKD-model consists of six sub-models: *the goals model*, *the business rules model*, *the concepts model*, *the business process model*, *the actor and resources model* and *the technical components and requirements model* (Larsson and Segerberg, 2004).

Resources that are required to perform modeling have been divided into five groups:

1) Human resources
2) Resources that provide explanation and description of EMM
3) Enterprise-related knowledge
4) Resources allocated to arrangement of modeling sessions
5) Time

The need for human resources in order to perform enterprise modeling is mentioned by Barjis (2009), Davies et al (2005), Stirna and Persson (2007), Kaschek and Mayr (1998), Larsson and Segerberg (2004). However, different authors propose different set of roles that are required to execute modeling. For example, Barjis (2009) introduce "Collaborative-Participative-Interactive Enterprise Modeling" and propose following set of modeling session participants to be involved: facilitator, consultant, IT professional, social researcher, modelers (people who know modeling method), analysts (experts in analysis and modeling) and key employees of an enterprise. Stirna and Persson (2007) propose other set of roles that is required for modeling process: process owner, facilitator, modeling expert, tool operator and domain expert. Nevertheless, the set of roles that can be involved into modeling process can vary, that is why it is preferable to identify the set of roles that will be used in the present work. Larsson and Segerberg (2004) mention following stakeholders

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in an enterprise modeling process: the method providers, the customers and the modeling session participants. Method provider is a person that has knowledge about EMM that is supposed to be used in modeling; it can be one person or several people. Customer is an initiator of modeling project, one or several. Modeling session participants can be represented by employees of the company or hired for modeling project specialists. This classification will be used in the present work to illustrate, which human resources are required, since it is the most universal and it suits to different ways of modeling sessions organization.

Resources that provide explanation and description of EMM are also needed to perform modeling. This group of resources has the same meaning as in sub-section 4.1.1.2. Larsson and Segerberg (2004); Stirna and Persson (2007) say about set of guidelines for working, which are required for modeling, Kaschek and Mayr (1998) - about available method literature, method descriptions, case studies and method training materials.

The third group of resources is resources that contain information about the enterprise. Barjis (2009) mentions the need for existing enterprise documentation analysis and collection of enterprise-related information via interviews. Stirna et al (2007) say about official documents and systems (for example, strategy and policy documents, internal instructions, web-site), which are supposed to be used during modeling.

The fourth group of resources includes different kind of resources that are allocated to arrangement of modeling sessions. Modeling project, which can contain one or several modeling sessions, usually requires different kind of resources related to modeling project arrangement (Larsson and Segerberg, 2004; Stirna and Persson, 2009). Stirna and Persson (2009) and Larsson and Segerberg (2004) say that it is important to have project description in order to perform modeling. They emphasize that such concepts as scope and focus of the project are needed to be known. Computerized modeling tool is also needed to perform modeling (Davies et al, 2005; Stirna and Persson, 2007; Kaschek and Mayr, 1998). Stirna and Persson (2007) describe the need for projection screen to perform modeling session, Stirna and Persson (2009) mention about resource as location that is required to carry out modeling session.

Different kinds of required resources and expected results for such activity as modeling are presented in Table 4-8.

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Table 4-8 Enterprise modeling - required resources and expected results

Application area	Required resources	Expected results
Modeling	**Human resources** • Method providers – people with knowledge of EMM • Customer – initiator of modeling • Modeling session participants – enterprise key employees and/or hired specialists. **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about EMM **Enterprise-related knowledge** • Existing documentation about enterprise operations • Enterprise internal instructions • Someone's personal knowledge regarding enterprise functioning • Enterprise web-site **Resources allocated to arrangement of**	• Enterprise models are created with an acceptable level of quality • Created enterprise models can be used

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	modeling sessions • Description of modeling project (scope and focus) • CASE tool(s) • Location • Digital devices (projection screen, computer, etc) **Time**	

4.1.1.9 EMM maintenance

Method maintenance is a quite important process that belongs to the group of EMM post-use. The reason for EMM maintenance is caused by the need for further application of EMM. Unlike improvement of EMM, this process does not imply any changes or development in the method constituents. Method maintenance follows EMM application (modeling).

Resources that are required for methods maintenance have been divided into two categories:

1) Human resources
2) Repositories for the resources that provide explanation and description of EMM

Human resources that are involved into EMM maintenance are roles that are responsible to arrangement of maintenance. It can be enterprise key employees and/or hired specialists. The second group of resources consists of repositories that provide explanation and description of EMM. These repositories include physical repositories for material objects that provide explanation and description about EMM (such as readily available books about the EMM, documentation that contains description of EMM, EMM case studies with description of previous EMM use); and electronic repositories for non-material and digital means.

The result of EMM maintenance is possibility to use maintained EMM in modeling.

Thus, the resources that are required for EMM maintenance and the results that are possible to achieve are presented in Table 4-9.

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Table 4-9 EMM maintenance- required resources and expected results

Application area	Required resources	Expected results
EMM evaluation	**Human resources –** some people from: • employees of an enterprise • hired specialists **Repositories for the resources that provide explanation and description of EMM** • Physical repositories for material objects that provide explanations and descriptions of EMM (for example, physical copies of: readily available books about the EMM; documentation where description of EMM is recorded; EMM case studies with description of previous EMM use) • Electronic repositories for non-material and digital means (for example, for electronic copies of EMM documentation,)	• Methods is maintained • Method can be used in modeling

4.1.2 Application areas for enterprise models, related resources and results

There are several application areas for enterprise models. To make description of these processes clearer it is needed to classify them. One way to classify processes that involve enterprise models is proposed by Chapurlat et al (2003). They describe model life cycle with the help of three main processes:

1) Model creation;
2) Model verification and validation;
3) Model use;

Chapurlat et al (2003) also mentioned such process as model improvement; however it is quite close to model creation. That is why it will not be distinguished as a separate process in this work. Each

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group can include several processes, for example, verification and validation of models can involve static analysis of models, dynamic analysis of models and others (Chapurlat et al, 2003). In this work we consider that creation of enterprise models can be performed via EMMs application (modeling) (see paragraph 4.1.1.5).

As it was mentioned in section 3.1, enterprise models can be used for the different purposes. That is why it is important to clarify which kind of enterprise models use will be distinguished in this work. It is preferable to distinguish several general application areas of enterprise models use, since more detailed division can be more ambiguous and tangled. That is why use of enterprise models will be divided into two processes according to classification, introduced by Stirna and Persson (2009).

Stirna and Persson (2009) distinguish two purposes of EM (see section 2.1):

- business development (for example, development of business vision and strategies, business operations redesigning, development of the supporting information systems)
- ensuring the business quality (knowledge sharing about the business or some aspect of business operation, decision making)

First kind of purposes implies active changes that are supposed to be done in the enterprise, whereas second one has more passive character and does not intent to introduce any business redesign or reform, but has to provide knowledge sharing.

This classification will be used to distinguish two kinds of enterprise models use:

a) Implementation

This kind of use corresponds with the first purpose of EM use – business development. In this case enterprise models contain information about the state of the enterprise that is planned to achieve, so models has to be used and realized in order to achieve this planned state. Thus, enterprise model is supposed to be implemented to bring planned changes into reality.

b) Analysis

This kind of use corresponds with the second purpose of EM use – ensuring the business quality. In this case models contain information that is supposed to be shared between stakeholders. These activities do not imply active changes within enterprise. That is why enterprise models are just supposed to be analyzed.

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These processes are represented graphically in Figure 4-3. On the left side of the figure there are main stages of model life cycle that were described by Chapurlat et al (2003). Each stage can involve one or several processes, which are presented on the right side of the figure, taking into consideration dependencies between them. Enterprise models creation precedes Verification & Validation of them, whereas Verification & Validation of enterprise models is followed by enterprise models analysis. Enterprise models implementation goes after analysis of enterprise models.
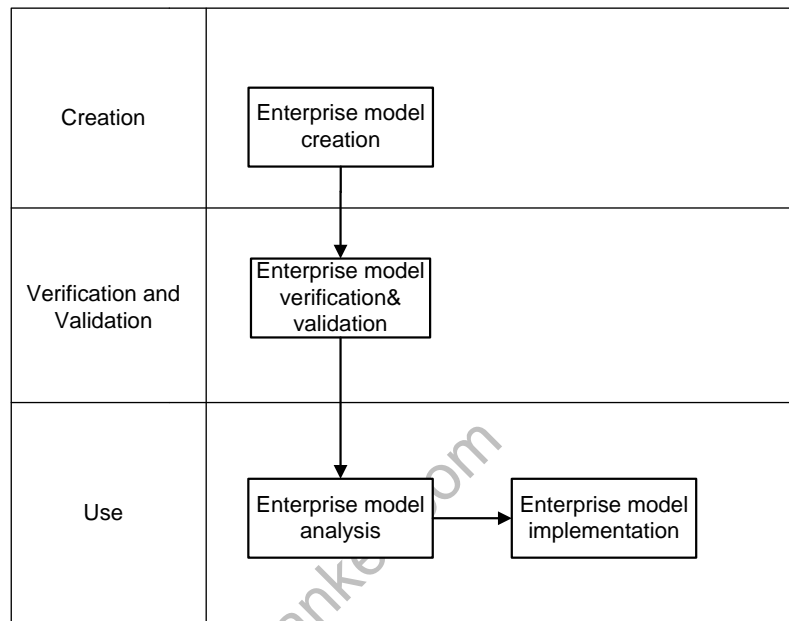

Figure 4-3 Application areas for enterprise models

Description of application areas for enterprise models, required for them resources and expected results will be presented below.

4.1.2.1 Creation of enterprise models

Creation of enterprise models can be also called production, construction or development. The name of this process varies, but the essence is the same: enterprise models can appear after EMM is applied. Thus, the process of enterprise models creation is the same as process of EMM application (modeling). Resources required for enterprise model production and resources required for EMM application (modeling) are also the same. There are five groups of resources:

1) Human resources
2) Resources that provide explanation and description of EMM
3) Enterprise-related knowledge

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4) Resources allocated to arrangement of modeling sessions

5) Time

The essence of presented groups is the same as in paragraph 4.1.1.5.

Table 4-10 Creation of enterprise models - required resources and expected results

Application area	Required resources	Expected results
Creation	**Human resources** • Method providers – people with knowledge of EMM • Customer – initiator of modeling • Modeling session participants – enterprise key employees and/or hired specialists. **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about EMM **Enterprise-related knowledge** • Existing documentation about enterprise operations • Enterprise internal instructions • Someone's personal knowledge	• Enterprise models are created • Created enterprise models can be verified and validated

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	regarding enterprise functioning • Enterprise web-site **Resources allocated to arrangement of modeling sessions** • Description of modeling project (scope and focus) • CASE tool(s) • Location • Digital devices (projection screen, computer, etc) **Time**	

4.1.2.2 Verification & Validation of enterprise models

Verification & Validation of enterprise model is an important stage in the model life cycle. After model creation it is needed to check it. According to Champulat et al (2003) model verification & validation is supposed to answer the following questions: "*Is the model correctly built?*", "*Is the model corresponds accurately to the reality? Is it the good one taking into account the needs and the context?*" (Champulat et al, 2003, p.185). After the process of verification & validation it is possible to use model.

There are five groups of resources that are required to check models:

1) Human resources
2) Enterprise models
3) Checking approach
4) Material resources allocated to arrangement of verification & validation process
5) Time

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Since checking is a process that should be performed within modeling project, human resources that are required for it, are the same as a human resources for modeling project generally - method providers, customers, modeling session participants (see paragraph 4.1.1.5).

To perform checking of enterprise models some approach has to be used. There are different approaches that exist for models checking, since different models can be checked in different ways. For example, Barjis (2009) mentioned that conventional models are usually checked via translation to other formal diagrams using mapping procedures. More concrete example that he mentioned is that for checking UML activity diagrams are often translated to Petri nets.

Material resources allocated to arrangement of verification & validation process include CASE tool(s) that can support checking approach (Barjis, 2009), different digital devices that allow to perform checking, for example, computers.

The results of verification & validation of enterprise models is the fact that models are verified and validated, and then they can be analyzed.

Table 4-11 Verification & Validation of enterprise models - required resources and expected results

Application area	Required resources	Expected results
Verification & validation	**Human resources** • Method providers – people with knowledge of EMM • Customer – initiator of modeling • Modeling session participants – enterprise key employees and/or hired specialists. **Enterprise models –** recorded in any form, for example, paper-based or electronic. **Checking approach -** a way to verify and validate enterprise models that is described and explained	• Enterprise models are verified and validated • Verified & validated enterprise models can be analyzed

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	Material resources allocated to arrangement of Verification & Validation process • CASE tool(s) • Location • Digital devices (computer, etc.). **Time**	

4.1.2.3 Analysis of enterprise models

As it was mentioned in the beginning of this section, enterprise model analysis is a kind of enterprise modeling use for the purpose of ensuring the business quality. Models can be analyzed in order to make stakeholders share same knowledge about the business or some aspect of business operation, which is represented in analyzed models; or for decision making. Analysis of enterprise models can precede implementation of enterprise models.

Resources that are required for enterprise models analysis have been divided into five groups:

1. Human resources
2. Enterprise models
3. Resources that provide explanation and description of EMM
4. Resources allocated to arrangement of analysis process
5. Time

Among human resources that are required to analyze enterprise models there are employees of an enterprise and/or hired specialists. Basically, they can include the same stakeholders as modeling process: method providers, customer, modeling session participants (Larsson and Segerberg, 2004).

Resources that provide explanation and description of EMM should be available to human resources that are responsible for analysis to elucidate and clarify unclear issues regarding EMM; otherwise it can lead to wrong interpretation of enterprise models.

Resources allocated to arrangement of implementing process are clear description of analysis process – goals and reasons for analysis.

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Table 4-12 Enterprise models analysis - required resources and expected results

Application area	Required resources	Expected results
Enterprise models analysis	**Human resources** • Key enterprise employees and/or hired specialists **Enterprise models -** recorded in any form, for example, paper-based or electronic. **Resources that provide explanation and description of EMM** • Readily available books about the EMM • Documentation that contains description of EMM • EMM case studies with description of previous EMM use • Consulting services that can provide support and give information about EMM **Resources related to the organization of analysis** • Description of analysis process (incl. clear goals) **Time**	Enterprise models are analyzed for the purpose of ensuring the business quality. The goal of analysis is achieved, for example: ➢ Stakeholders share same knowledge about the business or some aspect of business operation, which is represented in analyzed models ➢ Decision is made based on knowledge that came from enterprise model analysis Enterprise models can be implemented

4.1.2.4 Implementation of enterprise models

As it was mentioned in the beginning of this section, enterprise model implementation is a kind of enterprise modeling use for the purpose of business development. Models can be implemented in order to change business vision and strategies, redesign business operations, develop the supporting

information systems, etc. (Stirna and Persson, 2009). In this case an enterprise model is a representation of desired state of an enterprise. In order to achieve the desired state, the enterprise model is supposed to be implemented. Larsson and Segerberg (2004) describe the process of enterprise model implementation as putting model into practice.

Resources that are required for enterprise models implementation have been divided into five groups:

1. Human resources
2. Enterprise models
3. Resources that provide explanation and description of EMM
4. Resources allocated to arrangement of implementing process
5. Time

Larsson and Segerberg (2004) mention the need for human resources that are required to implement enterprise models. It can be enterprise employees or hired specialists, but according to Larsson and Segerberg (2004) quite important issue is the assembly of the modeling group – it is important to involve into modeling people with authority, so they can carry out the changes that modeling results suggest. Also implementation of models can involve participation of organization management, since they are supposed to lead changes introduction process. To implement model system developers can also be involved (Larsson and Segerberg, 2004).

Enterprise model should be understandable for the people who will implement it, for example, system developers (Larsson and Segerberg, 2004). That is why it is important to have access to the resources that provide explanation and description of EMM. By this people who are supposed to perform enterprise models implementation can get clarification and explanation regarding enterprise models and interpret them properly.

Resources allocated to arrangement of implementing process are clear directives of implementation process – goals and directions of implementation.

Table 4-13 Enterprise models implementation - required resources and expected results

Application area	Required resources	Expected results
Enterprise models	**Human resources** • Key enterprise employees and/or	Enterprise models are implemented for the purpose of

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implementation	hired specialists	business development. The goal of implementation is achieved, for example:
	Enterprise models - recorded in any form, for example, paper-based or electronic.	
	Resources that provide explanation and description of EMM	➢ Business vision and/or business strategy is changed
	• Readily available books about the EMM	
	• Documentation that contains description of EMM	➢ Business operations are redesigned
	• EMM case studies with description of previous EMM use	➢ Supporting information systems are introduced
	• Consulting services that can provide support and give information about EMM	
	Resources related to the organization of implementation	
	• Description of implementation process (incl. clear goals)	
	Time	

4.2 Efficiency indicators

The purpose of this section is to answer the second research question that was presented in section 1.3. It is needed to translate and structure aspects, which were identified in section 4.1 in order to create a way to evaluate efficiency for EMMs and enterprise models. As it was mentioned in chapter 4, for evaluating efficiency of EMMs and enterprise models it is required to formulate some indicators to be checked first. For this purpose efficiency indicators for EMMs and enterprise models will be formulated. They will be formulated with the help of aspects that were described in

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section 4.1: application areas of EMMs and enterprise models, the required resources and the expected results. Efficiency indicators for EMMs and enterprise models will be described in the following way: first we introduce several types of general efficiency indicators (section 4.2.1). Then in section 4.2.2 and 4.2.3 these indicators are concretized concerning EMMs and enterprise models application areas, which were identified in section 4.1.

General efficiency indicators give a basis to check if a process has been performed efficiently. There are two general efficiency indicators; they arise from different views on efficiency. Hence, each general efficiency indicator is presented in the form of a question that is supposed to be answered in order to check if efficiency has been provided. These questions concede "Yes" or "No" answer, but require significant prerequisite analysis of a process. Negative answer to the question gives us a signal that efficiency has not been achieved; whereas positive answer can indicate efficiency partly. One positive answer is not a guarantee that efficiency has been provided, unless answer to all questions are positive.

After presenting general efficiency indicators, they will be elaborated with respect to the EMMs application areas and to enterprise models application areas. It is important to analyze how each general efficiency indicators can be concretized with respect to defined process. When concretizing general efficiency indicators, several efficiency indicators are formulated for each process related to EMMs application and enterprise models application. Concretized efficiency indicators are also developed in the form of questions. In this way, a list of efficiency indicators is developed for each process (both, for EMMs and enterprise models application areas). Thus, in order to understand if a particular process is performed efficiently, it is needed to check all efficiency indicators from the list related to it. If all of indicators have been observed within analyzed process and all of indicators have got positive answer, then it is possible to conclude that the process has been performed efficiently. The fewer indicators gave negative answer within analyzed process - the process has been performed more efficiently.

4.2.1 General efficiency indicators

Efficiency in this work is about achievement of the planned results for a planned cost. In other words, in order to perform some process efficiently, it is expected that within this process: less than or equal to planned amount of resources should be used in order to get not less than planned amount of results. This dependency can be illustrated with the help of the following question:

- Have we achieved the expected results of the process with the help of used resources?

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Obviously, in order to execute a process efficiently planned results are supposed to be achieved. Subsequently, it is possible to face two situations when process is performed not efficiently: situation when result is not achieved; or situation when desired results have been achieved, but resources have not been used properly. To address these two situations of process inefficiency two efficiency indicators are formulated:

1. Are the planned results achieved?
2. If the results are achieved, have the resources been used properly?

The first question is supposed to check if the result of some process is achieved. It concerns all kind of results: material or immaterial objects; and the result of one process that is supposed to serve as an input for another process. The second question is considering the situation when planned results are achieved. It focuses on analysis of the used resources, particularly, the proper use of them. Some resources can be measured, whereas some others cannot. In case with measurable resource it is possible to consider that proper use of it is when the used amount is not exceeding the planned amount. In case when it is not possible to measure the amount of resources, it is still important to check the proper use of it. In this case the issue of proper use will be defined by the person who is analyzing efficiency of a particular process. It is noticeable, that in some situations even with measurable resources it is not only the amount that has to be considered to define the proper use. Thus, the final decision about what to consider as a proper use of some resource is always left to the user who is performing efficiency analysis.

4.2.2 Efficiency indicators for EMMs

This sub-section contains concretization of general efficiency indicators as applied to application areas of EMMs (application areas, the required resources and the results that are expected have been introduced in section 4.1.1). According to section 4.1.1 there are following application areas for EMMs: creation, integration, improvement, evaluation, comparison, selection, learning, modeling (EMM application for the purpose of creation of enterprise models), and maintenance.

4.2.2.1 Creation

To create an EMM, three types of resources are required:

1. Human resources
2. Knowledge of method designers that is supposed to be structured and presented in order to form an EMM

3. Time

Result is the following:

1. EMM is created. Method constituents are: method component (procedure, notation and concepts); perspective; framework; co-operation forms (and collection forms)

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

Is EMM, including planned constituents, created?

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If the EMM has been created:

- *Have the human resources been used properly?*
- *Has the knowledge of method designers been used properly?*
- *Has the time been used properly?*

4.2.2.2 Integration
To integrate EMMs, four types of resources are required:

1. Human resources
2. Integration technique
3. Resources that provide explanation and description of EMMs
4. Time

Possible results are one or several among the following ones:

1. Integrated EMM. Method constituents are: method component (procedure, notation and concepts); perspective; framework; co-operation forms (and collection forms) – integrated EMM might contain all constituents of the integrated EMMs or some of each.
2. Integrated EMM can be used in modeling

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

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- *Has the new EMM been created, including planned constituents?*
- *In case that EMMs integration precedes EMM application in modeling, is the integrated EMM can serve for application in modeling?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If the EMMs have been integrated:

- *Have the human resources been used properly?*
- *Has the integration technique been used properly?*
- *Have the resources that provide explanation and description of EMMs been used properly?*
- *Has the time been used properly?*

4.2.2.3 Improvement

To improve an EMM, four types of resources are required:

1. Human resources
2. Knowledge of method designers that is supposed to be applied and presented in order to improve EMM
3. Resources that provide explanation and description of EMM
4. Time

Possible result is the following:

1. Improved EMM. Method constituents are: method component (procedure, notation and concepts); perspective; framework; co-operation forms (and collection forms)

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

Have the planned constituents of EMM been improved?

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If the EMM has been improved:

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- *Have the human resources been used properly?*
- *Has the knowledge of method designers been used properly?*
- *Have the resources that provide explanation and description of EMM been used properly?*
- *Has the time been used properly?*

4.2.2.4 Evaluation

To evaluate an EMM, four types of resources are required:

1. Human resources
2. Evaluation technique
3. Resources that provide explanation and description of EMM
4. Time

Possible results are one or several among the following ones:

1. Strengths and weaknesses of EMM
2. Evaluated method can be selected for further application

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Have the strengths and weaknesses of EMM been obtained?*
- *In case that EMM evaluation precedes EMM selection, is it able to serve for EMM selection?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

   If the EMM has been evaluated:

a) *Have the human resources been used properly?*
b) *Has the evaluation technique been used properly?*
c) *Have the resources that provide explanation and description of EMM been used properly?*
d) *Has the time been used properly?*

4.2.2.5 Comparison

To compare EMMs, four types of resources are required:

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1. Human resources
2. Comparison technique
3. Resources that provide explanation and description of EMM
4. Time

Possible results are one or several among the following ones:

1. Similarities and differences of EMMs
2. Obtained after methods comparison information can be used for further method selection

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Have the similarities and differences of EMMs been obtained?*
- *In case that EMMs comparison precedes EMM selection, is it able to serve for EMM selection?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If the EMM has been evaluated:

- *Have the human resources been used properly?*
- *Has the comparison technique been used properly?*
- *Have the resources that provide explanation and description of EMM been used properly?*
- *Has the time been used properly?*

4.2.2.6 Selection
To select EMM, three types of resources are required:

1. Human resources
2. Information about method candidate(s) – either results of EMM evaluation or results of EMMs comparison
3. Time

Possible results are one or several among the following ones:

1. Methods is selected

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2. Method can be used in modeling

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Have the EMM been selected?*
- *In case that EMM selection precedes application of EMM in modeling, can the selected EMM be applied in modeling?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If the EMM has been selected:

- *Have the human resources been used properly?*
- *Has the information about method candidate(s) been used properly?*
- *Has the time been used properly?*

4.2.2.7 Learning
To learn EMM four types of resources are required:

1. Human resources
2. Resources that provide explanation and description of EMM
3. Material resources allocated to arrangement of learning sessions
4. Time

Possible results are one or several among the following ones:

1. Method learner has obtained required knowledge about one or several constituents of EMM
2. Obtained knowledge can be applied in modeling

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Has the method learner obtained required knowledge?*
- *In case that EMM learning precedes application of EMM in modeling, can the obtained knowledge about EMM be applied in modeling?*

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The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If the EMM has been selected:

- *Have the human resources been used properly?*

- *Have the resources that provide explanation and description of EMM been used properly?*

- *Have the material resources allocated to arrangement of learning sessions been used properly?*

- *Has the time been used properly?*

4.2.2.8 Modeling
To apply EMM within modeling five types of resources are required:

1. Human resources
2. Resources that provide explanation and description of EMM
3. Enterprise-related knowledge
4. Resources allocated to arrangement of modeling sessions
5. Time

Possible results are one or several among the following ones:

1. Enterprise models are created with an acceptable level of quality
2. Created enterprise models can be used

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Have the enterprise models been created with an acceptable level of quality?*

- *In case that modeling precedes further use of created enterprise models, can the created enterprise models be used for the planned purpose?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If the EMM has been applied and enterprise models have been created:

- *Have the human resources been used properly?*

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- *Have the resources that provide explanation and description of EMM been used properly?*

- *Has the enterprise-related knowledge been used properly?*

- *Have the resources allocated to arrangement of modeling sessions been used properly?*

- *Has the time been used properly?*

4.2.2.9 Maintenance

To maintain an EMM, three types of resources are required:

1. Human resources

2. Repositories for the resources that provide explanation and description of EMM

Possible results are one or several among the following ones:

1. Methods is maintained

2. Method can be used in modeling

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Have the EMM been maintained?*

- *In case that EMM maintenance precedes further application of EMM in modeling, can the maintained EMM be applied in modeling?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

  If the EMM has been maintained:

- *Have the human resources been used properly?*

- *Have the repositories for the resources that provide explanation and description of EMM been used properly?*

4.2.3 Efficiency indicators for enterprise models

Application areas of enterprise models have been introduced in section 4.1.2. According to section 4.1.2 there are following application areas of enterprise models: creation (modeling), verification & validation, analysis and implementation. This section contains concretization of general efficiency indicators as applied to these processes.

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4.2.3.1 Creation

As it was mentioned in sub-section 4.1.2.1, in this work it is assumed that models can be created only via EMM application, particularly via modeling. It means that enterprise models production requires the same resources as modeling, and the same results are expected to be achieved. Obviously, efficiency indicators that are introduced in 4.2.2.8 are also valid for creation of enterprise models.

4.2.3.2 Verification & Validation

To verify and validate enterprise models five types of resources are required:

6. Human resources
7. Enterprise models
8. Checking approach
9. Material resources allocated to arrangement of verification & validation process
10. Time

Possible results are one or several among the following ones:

1. Enterprise models are verified and validated
2. Verified & validated enterprise models can be analyzed

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Have the enterprise models been verified & validated?*
- *In case that verification & validation precedes further analysis of enterprise models, is it able to serve as a basis for further analysis?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If enterprise models have been verified & validated:

- *Have the human resources been used properly?*
- *Have the enterprise models been used properly?*
- *Has the checking approach been used properly?*

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- *Have the material resources allocated to arrangement of verification & validation process been used properly?*
- *Has the time been used properly?*

4.2.3.3 Analysis

To analyze enterprise models five types of resources are required:

1. Human resources
2. Enterprise models
3. Resources that provide explanation and description of EMM
4. Resources allocated to arrangement of analysis process
5. Time

Possible results are one or several among the following ones:

1. Enterprise models are analyzed for the purpose of ensuring the business quality. The goal of analysis is achieved
2. Enterprise models can be implemented

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

- *Have the enterprise models been analyzed, thus, the goal of analysis is achieved?*
- *In case that analysis precedes further implementation of enterprise models, is it able to serve as a basis for further implementation of enterprise models?*

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If enterprise models have been analyzed:

- *Have the human resources been used properly?*
- *Have the enterprise models been used properly?*
- *Have the resources that provide explanation and description of EMM been used properly?*
- *Have the resources allocated to arrangement of analysis process been used properly?*
- *Has the time been used properly?*

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4.2.3.4 Implementation

As it is described in sub-section 4.1.2.4, implementation of enterprise models is a process that uses enterprise models for the purpose of business development. Business development in this case implies considerable changes within enterprise. Changes that can be introduced within enterprise are business operations redesign, development of business visions and strategies, developing the supporting information systems (IS), etc. All these activities should be performed via use of enterprise models, in other words, via enterprise models implementation it is possible to perform particular business development activity, subsequently, it is possible to introduce some changes within enterprise.

To implement enterprise model five types of resources are required:

6. Human resources
7. Enterprise models
8. Resources that provide explanation and description of EMM
9. Resources allocated to arrangement of implementing process
10. Time

Possible result is the following:

1. Enterprise models are implemented for the purpose of business development. The goal of implementation is achieved

The goal of implementation can consist in one or several among following: business vision and/or business strategy is changed; business operations are redesigned; supporting information systems are introduced.

The first efficiency indicator is: *are the planned results achieved?* It is possible to clarify this indicator with the help of the following question:

Have the enterprise models been implemented, thus, the goal of implementation is achieved?

The second efficiency indicator is: *if the results are achieved, have the resources been used properly?* It is possible to clarify this indicator with the help of the following questions:

If enterprise models have been implemented:

- *Have the human resources been used properly?*

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- *Have the enterprise models been used properly?*
- *Have the resources that provide explanation and description of EMM been used properly?*
- *Have resources allocated to arrangement of implementing process been used properly?*
- *Has the time been used properly?*

4.3 Preliminary results: efficiency indicators for application areas of EMMs and enterprise models

The purpose of this section is to present preliminary results: application areas for EMMs and enterprise models; the required resources and the expected results for identified application areas; and efficiency indicators for each of identified application areas. This information is presented in Table 4-14.

Table 4-14 Preliminary results: efficiency indicators for application areas of EMMs and enterprise models

	Application area	Required resources	Expected results	Efficiency indicators
1.1	EMM creation	- Human resources - Knowledge of method designers to form an EMM - Time	EMM is created.	*• Is EMM, including planned constituents, created?* *• If the EMM has been created:* *a) Have the human resources been used properly?* *b) Has the knowledge of method designers been used properly?* *c) Has the time been used properly?*
1.2	EMMs integration	- Human resources - Integration technique - Resources that provide explanation and description of EMM - Time	- Integrated EMM - Method can be used in modeling	*• Has the new EMM been created, including planned constituents?* *• In case that EMMs integration precedes EMM application in modeling, is the integrated EMM can serve for application in modeling?* *• If the EMMs have*

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				been integrated: *a) Have the human resources been used properly?* *b) Has the integration technique been used properly?* *c) Have the resources that provide explanation and description of EMMs been used properly?* *d) Has the time been used properly?*
1.3	EMM improvement	• Human resources • Knowledge of method designers to improve EMM • Resources that provide explanation and description of EMM • Time	Improved EMM	• *Have the planned constituents of EMM been improved?* • *If the EMM has been improved:* *a) Have the human resources been used properly?* *b) Has the knowledge of method designers been used properly?* *c) Have the resources that provide explanation and description of EMM been used properly?* *d) Has the time been used properly?*
1.4	EMM evaluation	• Human resources • Evaluation technique • Resources that provide explanation and description of EMM • Time	• Method strengths and weaknesses • Evaluated method can be selected for further application	• *Have the strengths and weaknesses of EMM been obtained?* • *In case that EMM evaluation precedes EMM selection, is it able to serve for EMM selection?* • *If the EMM has been evaluated:* *a) Have the human resources been used properly?* *b) Has the*

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				evaluation technique been used properly? *c) Have the resources that provide explanation and description of EMM been used properly?* *d) Has the time been used properly?*
1.5	EMMs comparison	• Human resources • Comparison technique • Resources that provide explanation and description of EMM • Time	• Methods similarities and differences • Obtained after methods comparison information can be used for further method selection	• *Have the similarities and differences of EMMs been obtained?* • *In case that EMMs comparison precedes EMM selection, is it able to serve for EMM selection?* • *If the EMM has been evaluated:* *a) Have the human resources been used properly?* *b) Has the comparison technique been used properly?* *c) Have the resources that provide explanation and description of EMM been used properly?* *d) Has the time been used properly?*
1.6	EMM selection	• Human resources • Information about method candidate(s) • Time	• Methods is selected • Method can be used in modeling	• *Have the EMM been selected?* • *In case that EMM selection precedes application of EMM in modeling, can the selected EMM be applied in modeling?* • *If the EMM has been selected:* *a) Have the human resources been used properly?* *b) Has the*

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				information about method candidate(s) been used properly? *c) Has the time been used properly?*
1.7	EMM learning	• Human resources • Resources that provide explanation and description of EMM • Material resources allocated to arrangement of learning sessions • Time	• Method learner has obtained required knowledge about one or several components of EMM • Obtained knowledge can be applied in modeling	*• Has the method learner obtained required knowledge?* *• In case that EMM learning precedes application of EMM in modeling, can the obtained knowledge about EMM be applied in modeling?* *• If the EMM has been selected:* *a) Have the human resources been used properly?* *b) Have the resources that provide explanation and description of EMM been used properly?* *c) Have the material resources allocated to arrangement of learning sessions been used properly?* *d) Has the time been used properly?*
1.8	Modeling (EMM application)	• Human resources • Resources that provide explanation and description of EMM • Enterprise-related knowledge • Resources allocated to arrangement of modeling sessions	• Enterprise models are created for further use • Created enterprise models can be checked	*• Have the enterprise models been created with an acceptable level of quality?* *• In case that modeling precedes further use of created enterprise models, can the created enterprise models be used for the planned purpose?* *• If the EMM has been applied and*

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Preliminary results

		• Time		*enterprise models have been created:* *a) Have the human resources been used properly?* *b) Have the resources that provide explanation and description of EMM been used properly?* *c) Has the enterprise-related knowledge been used properly?* *d) Have the resources allocated to arrangement of modeling sessions been used properly?* *e) Has the time been used properly?*
1.9	EMM maintenance	• Human resources • Repositories for the resources that provide explanation and description of EMM	• Methods is maintained • Method can be used in modeling	• *Have the EMM been maintained?* • *In case that EMM maintenance precedes further application of EMM in modeling, can the maintained EMM be applied in modeling?* • *If the EMM has been maintained:* *a) Have the human resources been used properly?* *b) Have the repositories for the resources that provide explanation and description of EMM been used properly?*
2.1	Creation of enterprise models	• Human resources • Resources that provide explanation and description of	• Enterprise models are created for further use • Created enterprise	see 1.8

Preliminary results

		EMM ● Enterprise-related knowledge ● Resources allocated to arrangement of modeling sessions ● Time	models can be checked	

2.2	Verification & Validation of enterprise models	● Human resources
		● Human resources
		● Enterprise models
		● Checking approach
		● Material resources allocated to arrangement of Verification & Validation process
		● Time
			● Enterprise models are verified and validated for the purpose of further analysis
			● Created enterprise models can be analyzed
				● *Have the enterprise models been verified & validated?*
				● *In case that verification & validation precedes further analysis of enterprise models, is it able to serve as a basis for further analysis?*
				● *If enterprise models have been verified & validated:*
				   a) Have the human resources been used properly?
				   b) Have the enterprise models been used properly?
				   c) Has the checking approach been used properly?
				   d) Have the material resources allocated to arrangement of verification & validation process been used properly?
				   e) Has the time been used properly?

2.3	Analysis of enterprise models	● Human resources ● Enterprise models ● Resources that	Enterprise models are analyzed for the purpose of ensuring the	● *Have the enterprise models been analyzed, thus, the goal of analysis is*

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Preliminary results

		provide explanation and description of EMM	business quality. The goal of analysis is achieved.	*achieved?*

		• Resources related to the organization of analysis
		
		• Time
				• *In case that analysis precedes further implementation of enterprise models, is it able to serve as a basis for further implementation of enterprise models?*
				• *If enterprise models have been analyzed:*
				  a) Have the human resources been used properly?
				  b) Have the enterprise models been used properly?
				  c) Have the resources that provide explanation and description of EMM been used properly?
				  d) Have the resources allocated to arrangement of analysis process been used properly?
				  e) Has the time been used properly?

2.4	Implementation of enterprise models	• Human resources
		• Enterprise models
		• Resources that provide explanation and description of EMM
		
		• Resources related to the organization of implementation
		
		• Time
			Enterprise models are implemented for the purpose of business development. The goal of implementation is achieved.	• *Have the enterprise models been implemented, thus, the goal of implementation is achieved?*
				• *If enterprise models have been implemented:*
				  a) Have the human resources been used properly?
				  b) Have the enterprise models been used properly?
				  c) Have the resources that provide

Preliminary results

				explanation and description of EMM been used properly?
				d) Have resources allocated to arrangement of implementing process been used properly?
				e) Has the time been used properly?

5 Validation of the preliminary results

This chapter presents the validation of preliminary results: application areas of EMMs and enterprise models, resources and results that are related to them and efficiency indicators that can be applied for efficiency checking in each application area. The validation is done by interviews. During the interviews participants were asked about application areas of EMMs and enterprise models, resources that they allocate to each application area and results that they expect to get after each application. Then the interviewees were asked about their way of analyzing and evaluating the achievement of results. It was important to know what resources participants consider as more important than the others when they are analyzing obtained results. This question was supposed to give an idea of how participants can perform efficiency check in practice. This chapter includes the following parts: brief description of application areas that were mentioned by participants (section 5.1) and result tables that were formed after interviews analysis (section 5.2).

5.1 Application areas, required resources, expected results and efficiency indicators

Brief descriptions of application areas of EMMs and enterprise models that were mentioned by interviewees are presented below. Each application area is presented in the way that shows opinions of interviewees regarding an application area, resources that they allocate to it and results that they expect to get. Descriptions of application areas also include the views of participants on how to evaluate the achievement of results.

Creation of EMM

Creation of an EMM is quite widespread process that can be caused by different reasons. Often modeling task cannot be solved with the help of existing EMMs. In this case it is needed to create a new EMM that can be applied for this specific problem. Other reason to create an EMM is to have universal EMM that can be applied to solve the majority of modeling tasks. The required resources are human resources; time; and literature about EM and/or related areas. Human resources that are involved in the process of EMM creation are experienced people that implement their knowledge and ideas into a new EMM. The result of EMM creation is EMM that can be applied in modeling. Often it is needed to create a description of the planned application of EMM and documentation of EMM. One interviewee has mentioned that the way to evaluate creation of EMM is to apply it in modeling.

Validation of the preliminary results

Statement 1

"...the approach that we developed during the research is what I am using..."

Participant 1

Statement 2

"...we created it [EMM] ourselves..."

Participant 3

Statement 3

"...literature: it does not have to be EMM literature; it can be from the related areas. It can give some ideas of how you can do certain things..."

Participant 2

Statement 4

"I only measure this [efficiency of creation of EMM] in the application of the method..."

Participant 2

Integration of EMMs

Integration of several EMMs can be caused by the same reasons as creation of an EMM. Several EMMs can be combined together in order to create one EMM that can solve a specific kind of modeling tasks. Resources that are required for integration of EMMs are human resources; time; and description of EMMs in different forms, for example, literature about EMM, resources in the Internet, research papers. Human resources are experienced in EM people who have knowledge about EMMs that they want to integrate. The result of integration of EMMs is that created EMM can be applied in modeling. Often there is a need to develop documentation of EMM and a description of the planned application of EMM. According to the Participant 2, the achievements of results in this case can be evaluated through application of created EMM in modeling.

Statement 5

"...in many cases it [EMM] is combining of different methods..."

<div align="right">Participant 2</div>

Improvement of EMM

The reason for EMM improvement is to develop it and make it applicable for wider range of modeling tasks. According to interviewees, the required resources are human resources; time and description of EMM in different forms, for example, EMM documentation, EMM handbook, literature, resources in the Internet, research papers. Human resources are competent people who have ideas about improvement of EMM. The main result of improvement of EMM, according to interviewees, is that improved EMM can be applied in modeling. Often it is also needed to develop documentation of EMM and description of the planned application of EMM. In some situations CASE-tool that supports EMM has to be improved according to changes of EMM.

Statement 6

"I do not believe that there is any mature enough method for just using… It is all the time the need for enhancement and development."

<div align="right">Participant 1</div>

Statement 7

"…it can be a method that is theoretical…then we can improve it, so it becomes more practical…"

<div align="right">Participant 2</div>

Selection of EMM

Selection of EMM has to be done in order to choose EMM that will be applied in modeling. Resources that are required to select EMM are human resources; time; description of the modeling task; description of the enterprise that is supposed to be modeled; description of EMM(s) outcomes; description of EMM(s) in different forms, for example, literature, resources in the Internet, research papers. Human resources that are performing selection of EMM are people that have experience in EM. In some cases they select EMM with the help of their experience of applying different EMMs, in other cases they select between EMMs that they have not used with the help of analysis of EMMs descriptions. To select EMM one or several EMMs have to be considered. Result of the selection of EMM is that selected EMM can be applied in modeling. One interviewee has mentioned that the way to evaluate selection of EMM is to apply selected EMM in modeling.

Validation of the preliminary results

Statement 8

"Problem often determines what method we should use…"

Participant 2

Statement 9

"…I use my experience of different methods to choose between them…"

Participant 2

Learning of EMM

According to interviewees, learning of EMM is quite important process that has to be done before applying EMM in modeling. People that want to apply an EMM have to study the necessary aspects of it. Resources that are required for EMM learning are human resources; time; trainings that can be provided by specific courses or conferences; and description of EMM in different forms, for example, EMM documentation, literature, resources in the Internet, research papers. Human resources in this case can include different people who will be involved into modeling in future, EM architect, and CASE-tool experts. There are two sides in the process of learning: one side gives the knowledge, another side receives it. According to one interviewee, possible way to evaluate learning of EMM is to apply selected EMM in modeling. Other interviewee mentioned that human resources are the most important among all other resources to evaluate the achievement of learning results, however, time can also be taken into consideration to analyze how EMM have been learned.

Statement 10

"…they [people] could quite easily understand it [EMM] and take it into their mindset… But it is a complicated domain, so they first of all need to read it."

Participant 1

Statement 11

"We try to teach each other the methods that can be used with other customers."

Participant 2

Application of EMM in modeling

Validation of the preliminary results

The main application area of EMM is modeling. According to interviewees, often the purpose of modeling is to describe and illustrate the functioning of an organization. Mostly it is done with the help of enterprise models that are supposed to be created after application of EMM, however, in some cases creation of enterprise models is not the main goal of modeling. Resources that are required for application of EMM in modeling are human resources; time; CASE-tools; different material resources that are required during modeling sessions, for example, computers, mp3-players, location, plastic, paper; general description of enterprise functioning; description of the purpose of the models creation; and EMM documentation. Among human resources that were mentioned by interviewees there are different roles: EM architect (person who drives modeling process), tools expert (person who has knowledge and experience of CASE-tool that is used during modeling), domain expert (person who has knowledge about the area that is supposed to be modeled), key employee of the enterprise (person who has detailed knowledge about processes and constrains of the modeled organization). The most important results of this process are enterprise models that have planned level of quality and that can be used for the planned purpose. They can be divided into two kinds: executable models that are useful from the technical perspective and description models that are useful from the management perspective. In rare cases the results of EMM application is a description of the processes in the modeled organization that is expressed in some unstructured form. The reason to create this description is to perform knowledge sharing about the processes of the modeled organization between people who are involved into these processes. To evaluate the achievement of results of EMM application it is needed to analyze that human resources have been used properly. Proper use of human resources is defined differently by different interviewees. One interviewee emphasizes the competence of human resources that are involved into modeling, other one highlights active participation of all modeling session participants. Time can often play a vital role for evaluation of modeling results achievement. Another way to evaluate the achievements of modeling results is to analyze further use of created enterprise models.

Statement 12

"… we have described and discussed all the components of our processes. The aim for that was to see that there is no uncertainty about tasks that we do…"

Participant 3

Statement 13

Validation of the preliminary results

"There is a need for several different resources enabling this [EMM application in modeling]… The technique of writing and making model as such; it is important to have good resources around it: people that are able to draw these models within these different tools… You need to have people that are very well known within the area that should be modeled… You need couple of resources that know in detail the processes, the product, the constraints between different areas… And of course on the top is enterprise modeling architect… that understands entire picture: what is important to focus on, what is not important to focus on and how these different parts fit together"

Participant 1

Statement 14

"…normally you start from the high level description: what do you want to do, what do you want to describe…"

Participant 1

Statement 15

"There are two results that we are looking for. The first are models that are executable from process or activity perspective. The other part is description and clarification model for the organization management."

Participant 1

Statement 16

"Time is always important. But time is not the main resource or the main constraint… You cannot add time to repair lack of competent resources [human resources]."

Participant 1

Maintenance of EMM

After application of EMM it has to be maintained, since it might be applied in future for new modeling tasks. Maintenance of EMM can often be neglected, so the resources that interviewees allocate for this process can vary from case to case. Mainly they are human resources. One of the interviewees is sure that it is important to maintain the documentation of EMM and description of

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the application case. The results of EMM maintenance is that EMM can be applied in modeling. Possible way to evaluate maintenance of EMM is to apply maintained EMM in modeling.

Statement 17

"...we try to maintain it [EMM] and make description of it."

Participant 2

Creation of enterprise models

See "Application of EMM in modeling".

Verification & validation of enterprise models

According to one of the interviewees, after creation of enterprise models they should be verified and validated. It has to be done in order to be sure that models are consistent and that they capture the reality. Resources that are required to verify and validate enterprise models are human recourses; time; enterprise models; and questions to verify the models. The results of this process are verified and validated enterprise models. Possible way to evaluate the results of this process is to implement resulting enterprise models.

Statement 18

"... I always verify models, so people that were participating have the possibility to look them over... I often have some questions to verify the models... "

Participant 2

Analysis of enterprise models

Analysis of enterprise models often precedes the process of enterprise models implementation. However, in some situations analysis is performed in order to describe the way of enterprise functioning and to perform knowledge sharing between the people who are involved into this functioning. Resources that are required to analyze enterprise models are human resources; time; description of the purpose of the models analysis; and documentation of EMM, which was used to create enterprise models. Human resources usually include the same roles that were involved into modeling. It is important to have clearly defined purpose of the enterprise models analysis, since this purpose has to be achieved. In case when analysis precedes implementation of enterprise models,

results can involve report of the suggested improvements and plan of actions to implement improvements. These deliverables can be used for the next phase – implementation of enterprise models. Possible way to evaluate the results of this process is to implement analyzed enterprise models. Among resources that are more important than the rest for evaluation of the results achievement one interviewee mentioned human resources and time.

Statement 19

"… we need to analyze the problem to see what can be the possible solution for the problem… Use of enterprise models is a mean to analyze the enterprise."

Participant 2

Implementation of enterprise models

Enterprise models are supposed to be implemented in order to bring planned changes into reality. Changes can concern different aspects of the enterprise functioning. Resources that are required to implement enterprise models are human resources; time; description of the purpose of enterprise models implementation; report of the suggested improvements; and documentation of EMM, which was used to create enterprise models. Human resources can include the same roles that were involved into modeling, but often it can include people from the modeled enterprise who are responsible for implementation. The result of implementation of enterprise models is that planned purpose of implementation is achieved. The way to evaluate the achievement of results is to check that the planned changes have been realized.

Statement 20

"…we often have … the report of the suggested improvements and plan how to do them."

Participant 2

5.2 Interviews resulting tables

This section presents the results of interviews. Each interview has been analyzed to find out the views of the interviewees on the following concepts: application areas of EMMs and enterprise models, resources and results that are related to these areas and possible ways to evaluate the achievement of results in these areas. The results of interviews analysis are presented below. Resources that were mentioned by interviewees are listed without classification; however, in result

Validation of the preliminary results

table in the section 5.3 they will be classified. Some fields of the following tables will be empty, since in some cases participants did not mention anything about resources, results or their way to check efficiency.

Table 5-1 Results from interview with Participant 1. Application areas of EMMs

	Application area	**Required resources**	**Expected results**	**Efficiency indicators**
1.1	Creation of EMM	Human resources	EMM that can be applied in modeling	
1.2	Improvement of EMM	Human resources EMM documentation EMM handbook	Improvement of EMM Technical enhancement of the CASE tool that supports EMM EMM documentation	Human resources Time
1.3	Learning of EMM	Human resources: - EM architect - Tool experts EMM documentation CASE tools	Human resources obtain knowledge about EMM	Human resources Time
1.4	Application of EMM in modeling	Human resources - EM architect - Tools experts - Domain experts - Key employees of the enterprise CASE tools Digital devices Location Description of the purpose	Enterprise models - Executable models (technical perspective) - Description model (management perspective)	Human resources Time

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		of the models creation EMM documentation Time		
1.5	Maintenance of EMM			

Table 5-2 Results from interview with Participant 1.Application areas of enterprise models

	Application area	**Required resources**	**Expected results**	**Efficiency indicators**
2.1	Creation of enterprise models	See 1.4 in Table 5-1	See 1.4 in Table 5-1	See 1.4 in Table 5-1
2.3	Analysis of enterprise models	Human resources • EM architect • Tools experts • Domain experts • Key employees of the enterprise Description of the purpose of the models analysis EMM documentation	Planned purpose of analysis is achieved	Human resources Time
2.2	Implementation of enterprise models	Human resources • EM architect • Tools experts • Domain experts • Key employees of the enterprise EMM documentation Description of the purpose of models implementation	Planned purpose of implementation is achieved	Human resources Time

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Table 5-3 Result from interview with Participant 2. Application areas of EMMs

	Application area	**Required resources**	**Expected results**	**Efficiency indicators**
1.1	Creation of EMM	Human resources Literature about EM and/or related areas Time	EMM that can be applied in modeling EMM documentation Description of the planned application of EMM	Created EMM can be applied in modeling
1.2	Integration of EMMs	Human resources Descriptions of EMMs • Literature • Resources in the Internet • Research papers Time	EMM that can be applied in modeling EMM documentation Description of the planned application of EMM	Created EMM can be applied in modeling
1.3	Improvement of EMM	Human resources Descriptions of EMMs • Literature • Resources in the Internet • Research papers	EMM that can be applied in modeling EMM documentation Description of the planned application of EMM	Improved EMM can be applied in modeling
1.4	Selection of EMM	Human resources Description of modeling task Description of the enterprise that is	EMM is selected EMM can be applied in modeling	Selected EMM can be applied in modeling

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		supposed to be modeled Description of EMMs outcomes Descriptions of EMMs - Literature - Resources in the Internet - Research papers Time		
1.5	Learning of EMM	Human resources: Trainings - Specific course - Conferences Descriptions of EMMs - Literature - Resources in the Internet - Research papers Time	Human resources obtain knowledge about EMM	The knowledge of EMM can be applied in modeling
1.6	Application of EMM in modeling	Human resources Computers MP3 player Plastic and paper General description of enterprise functioning Time	Enterprise models (with planned level of quality) Models can be used	Human resources Time
1.7	Maintenance of EMM	Human resources Time	Documentation of EMM Case description of	Maintained EMM can be applied in modeling

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			the EMM application	
			EMM can be applied in future	

Table 5-4 Results from interview with Participant 2.Application areas of enterprise models

	Application area	**Required resources**	**Expected results**	**Efficiency indicators**
2.1	Creation of enterprise models	See 1.4 in Table 5-3	See 1.4 in Table 5-3	See 1.4 in Table 5-3
2.2	Verification & validation of enterprise models	Human resources Enterprise models Questions to verify the models Time	Verified & validated enterprise models	Verified & validated models can be implemented
2.3	Analysis of enterprise models	Human resources Enterprise models Time	Report of the suggested improvements Plan of actions to implement improvements	Analyzed models can be implemented
2.4	Implementation of enterprise models	Human resources • Customer • Person(people) who performed analysis Description of the purpose of enterprise models implementation Report of the suggested	The purpose of enterprise models implementation is achieved	The planned results of implementation of enterprise models are achieved

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		improvements Time		

Table 5-5 Result from interview with Participant 3. Application areas of EMMs

	Application area	**Required resources**	**Expected results**	**Efficiency indicators**
1.1	Creation of EMM	Human resources Materials about the area that is supposed to be modeled • Rules • Regulations • Description of routines in the organization Time	EMM that can be applied in modeling Description of the planned application of EMM	Human resources
1.2	Application of EMM in modeling	Human resources Computers Detailed description of organization functioning CASE tool Time	Workbook with recorded resulting data Results of modeling have been achieved: • Processes of the organization have been described • Knowledge sharing about the processes	Human resources

			of the modeled organization has been performed	

5.3 Final results

This section presents the final results of the work. Results that are related to the identified application areas of EMMs are presented in Table 6-1, results that are related to the identified application areas of enterprise models are presented in Table 6-2. Each application area is a process that is characterized by resources that are required for it, results that have to be achieved and efficiency indicators that can help to check the efficiency of it. Resources related to each application area have been classified into several groups. For example, one group of resources is human resources. It can consist of people with different roles within particular process, but in some cases the roles are not clearly defined. All application areas require experienced human resources that use their knowledge and ideas to perform respective process.

Table 5-6 Final result table. Application areas of EMMs

	Application area	Required resources	Expected results	Efficiency indicators
1.1	Creation of EMM	Human resources Literature about EM and/or related areas Materials about the area that is supposed to be modeled • Rules • Regulations • Description of	EMM that can be applied in modeling EMM documentation Description of the planned application of EMM	• *Has EMM been created?* • *Has the documentation of EMM been created?* • *Has the description of the planned application of EMM been created?* • *In case that EMM creation precedes application of EMM in modeling, can the created*

Validation of the preliminary results

		routines in the organization Time		*EMM be applied in modeling?* • *If the EMM has been created, have the human resources been used properly?*
1.2	Integration of EMMs	Human resources Resources that provide explanation and description of EMM: • Literature • Resources in the Internet • Research papers Time	EMM that can be applied in modeling EMM documentation Description of the planned application of EMM	• *Has EMM been created?* • *Has the documentation of EMM been created?* • *Has the description of the planned application of EMM been created?* • *In case that EMM integration precedes application of EMM in modeling, can the created EMM be applied in modeling?* • *If the EMM has been created, have the human resources been used properly?*
1.3	Improvement of EMM	Human resources: • EM architect • Tool experts Resources that provide explanation and description of EMM: • Literature • Resources in the	Improved EMM that can be applied in modeling Technical enhancement of the CASE tool that supports EMM	• *Has the EMM been improved?* • *Has the CASE-tool that supports EMM been improved?* • *Has the documentation of EMM been created?* • *In case that EMM improvement precedes*

Validation of the preliminary results

		• Internet • Research papers • EMM documentation CASE tool(s) Time	EMM documentation	*application of EMM in modeling, can the improved EMM be applied in modeling?* • *If the EMM has been improved, have the human resources been used properly?* • *If the EMM has been improved, has the time been used properly?*
1.4	Selection of EMM	Human resources Resources that provide enterprise-related information: • Description of modeling task • Description of the enterprise that is supposed to be modeled Resources that provide explanation and description of EMM: • Literature about EMM in paper form • Description of EMMs outcomes • Resources in the	EMM that can be applied in modeling	• *Has the EMM been selected?* • *In case that EMM selection precedes application of EMM in modeling, can the selected EMM be applied in modeling?*

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		Internet • Research papers Time		
1.5	Learning of EMM	Human resources: • EM architect • Tool expert(s) Resources that provide explanation and description of EMM: • Literature about EMM in paper form • Resources in the Internet • Research papers CASE tool(s) Time	Human resources obtain knowledge about EMM EMM is learned and can be applied in modeling	• *Have the human resources obtained required knowledge about EMM?* • *In case that EMM learning precedes application of EMM in modeling, can the learned EMM be applied in modeling?* • *If the EMM has been learned, have the human resources been used properly?* • *If the EMM has been learned, have the time been used properly?*
1.6	Application of EMM in modeling	Human resources • EM architect • Tools expert(s) • Domain expert(s) • Key employee(s) of the enterprise Resources that provide enterprise-related information: • Description of	Enterprise models are created and have planned level of quality: • Executable models (technical perspective) • Description model (management	• *Have the enterprise models been created with planned level of quality?* • *In case that modeling precedes further use of created enterprise models, can the created enterprise models be used for the planned purpose?* • *If the EMM has been applied and enterprise*

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		enterprise functioning	perspective)	*models have been created, have the human resources been used properly?*
		Description of the purpose of the models creation	Enterprise models can be used	*If the EMM has been applied and enterprise models have been created, has the time been used properly?*
		Resources that provide explanation and description of EMM: • EMM documentation		
		Resources allocated to arrangement of modeling sessions: • Digital devices (computer, MP3 player, etc.) • Location • Plastic and paper CASE tool(s) Time		
1.7	Maintenance of EMM	Human resources Time	Documentation of EMM Case description of the EMM application EMM can be applied	*• Has the EMM been maintained?* *• In case that EMM maintenance precedes application of EMM in modeling, can the maintained EMM be applied in modeling?*

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			in future	

Table 5-7 Final result table. Application areas of enterprise models

	Application area	Required resources	Expected results	Efficiency indicators
1.1	Creation of enterprise models	See 1.6 in Table 5-7	See 1.6 in Table 5-7	See 1.6 in Table 5-7
1.2	Verification & validation of enterprise models	Human resources Enterprise models Checking approach: • Questions to verify the models Time	Verified and validated enterprise models that can be implemented	• *Have the enterprise models been verified & validated?* • *In case that verification & validation precedes further implementation of enterprise models, is it able to serve as a basis for further implementation?*
1.3	Analysis of enterprise models	Human resources • EM architect • Tools experts • Domain experts • Key employees of the enterprise Description of the purpose of the models analysis	Planned purpose of analysis is achieved In case if analysis precedes implementation of enterprise models: • Report of the suggested improvements • Plan of actions to implement	• *Has the planned purpose of analysis been achieved?* • *In case that analysis precedes further implementation of enterprise models, has the report of the suggested improvements been created?* • *In case that analysis precedes further implementation of*

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		Resources that provide explanation and description of EMM: • EMM documentation Time	improvements	*enterprise models, has the plan of actions to implement improvements been created?* • *In case that analysis precedes further implementation of enterprise models, is it able to serve as a basis for further implementation of enterprise models?* • *If enterprise models have been analyzed, have the human resources been used properly?* • *If enterprise models have been analyzed, has the time been used properly?*
1.4	Implementation of enterprise models	Human resources • EM architect • Tools expert(s) • Domain expert(s) • Key employee(s) of the enterprise Resources that provide explanation	The purpose of enterprise models implementation is achieved	• *Has the planned purpose of implementation been achieved?* • *If enterprise models have been implemented have the human resources been used properly?* • *If enterprise models have been implemented, has the time been used properly?*

Validation of the preliminary results

		and description of EMM: • EMM documentation Report of the suggested improvements Description of the purpose of models implementation Time		

6 Conclusion and discussions

This chapter contains the main findings related to the work purpose.

The main purpose of the work was to create a way to check efficiency in the area of EM, particularly efficiency in application areas of EMMs and enterprise models. Each application area is a process that is characterized by resources that are required for it and results that it produces. To achieve the main purpose of the work checklists with efficiency indicators have been developed. To create these checklists it was needed to identify what the application areas of EMMs and enterprise models are. Then, for each application area, it was investigated what resources it needs and what results it has to produce. Efficiency indicators have been formulated for each application area on the ground of these findings. Efficiency indicators have been formulated in the form of questions. A set of efficiency indicators that are related to the particular application area forms a checklist, which should be used to analyze if this process has been performed efficiently. The results of the work have been empirically grounded, because preliminary results have been validated with the help of interviews done with people from the EM field.

Research questions that have been presented in the chapter 1 were directing and aiming the research. The extent to which they have been addressed is discussed below.

1)   What are relevant aspects to describe efficiency for EMMs and enterprise models?

The question involved several sub-questions. They have been analyzed in order to find relevant aspects to describe efficiency for EMMs and enterprise models.

● What does efficiency mean for EMMs and enterprise models?

The first important issue in the research was to understand what efficiency means for EMMs and enterprise models. This step has been performed with the help of literature review. It was found out that efficiency is always applied to processes. Usually it is defined with the help of two concepts: resources and results that are related to the process. It was concluded that efficiency can be defined for any process with the help of these two aspects. Thus, to define efficiency of EMMs and enterprise models it was needed firstly to identify the processes that are related to them and then to identify resources and results that are related to these processes. In other words, it was needed to understand how people usually apply EMMs and enterprise models.

Conclusion and discussions

- What are the possible application areas of EMMs and enterprise models?

Application area is a process that shows how EMM or enterprise model can be applied. The answer to this question involves the list of processes that are related to EMMs and the list of processes that are related to enterprise models. This question has been answered with the help of literature review and interviews. The interviewees were asked about their ways to apply EMMs and enterprise models. On the ground of this it was possible to define application areas of EMMs and enterprise models

- What are the required resources and expected results for each application area of EMMs and enterprise models?

This question played important role in defining efficiency for EMMs and enterprise models, since efficiency of a process is usually addressed with the help of these two aspects. The list of required resources and the list of expected results have been formed for all identified application areas. This question has been answered with the help of literature review and interviews. The interviewees were asked to list resources they use and results they expect to achieve in each application area.

2)   How can identified aspects be translated and structured to evaluate efficiency of EMMs and enterprise models?

After defining EMMs application areas together with related resources and results, it was required to create a way to check efficiency within identified application areas. To fulfill this goal efficiency indicators have been formulated for each application area. Efficiency indicators were formulated in the form of questions that concede "yes" or "no" answers. A set of efficiency indicators that is related to the particular process forms a checklist that can be used to investigate if a process has been performed efficiently. This research question has been answered with the help of literature review and interviews. Interviewees were asked about resources that they consider as the most important when evaluating the achievement of results. Resources that were emphasized by interviewees were taken into consideration to formulate efficiency indicators. Interviewees also were asked about their ways to evaluate efficiency of performed processes, but they could rarely formulate specific descriptions how they do it.

Thus, the results of this work can be used to check efficiency in EM area, particularly in the application areas of EMMs and enterprise models.

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