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Towards Evaluating Efficiency of Enterprise Modeling Methods

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Abstract. Each organization should make progress to remain competent in its business. Enterprise Modeling (EM) helps in understanding the current and planning the future states, followed by proposing improvement actions in an enterprise. To receive support from EM, we should start a process of using an Enterprise Modeling Method (EMM), that likewise any other process needs using resources. As resources are expensive, we prefer not only gaining results, rather using resources reasonably, i.e. performing an efficient process that supports the process quality. To realize if we have an efficient EMM, we should evaluate its efficiency. In this paper we present a method for efficiency evaluation of EMMs for general case of application. This method contains efficiency criteria and questions for evaluating their fulfillment. Then it is applied to the Enterprise Knowledge Development for appraising the evaluation method. The paper ends with a number of conclusions about the evaluation method.

Keywords: Enterprise Modeling, Enterprise Modeling Method, Efficiency.

1 Introduction

Any organization aims at making profit and progress to be able to survive in its business area. For this purpose, they have to keep improving different aspects of their business [1]. For making any kind of change or improvement in an organization, it is needed to understand the current (As-Is) state of the organization and figure out the desired/ future (To-Be) state. According to [2], Enterprise Modeling (EM) and Business Process Management (BPM) are two areas that for a long time have been part of a tradition where the mission is to improve business practice and management. EM supports understanding the “As-Is” processes and organizational structures in an enterprise, and developing and specifying the “To-Be” situation as support for process improvement of organizational change processes. A challenge in BPM, that can be found in EM too [3], is the need for moving beyond a narrow focus on one tradition or technology and actually dealing with a number of conceptual ways to slice the business in an integrated way. Performing such a slicing process aids in having knowledge about how an enterprise looks like from a specific viewpoint, followed by marking change needs and figuring out change measures, i.e. planning the

improvement actions for the enterprise. In order to receive support from EM field, we need an EMM. 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 [4].

Process of applying an EMM, likewise any other process, requires having access to resources [5][6][7]. However, resources are usually scarce and using them is costly. Therefore, we require not only obtaining the intended output, which in this case are enterprise models, rather we would like to use resources in a reasonable and worthwhile way [8], i.e. have an efficient EMM application process.

Our desire is working with an EMM from high enough quality. Efficiency is a criterion for quality and its fulfillment supports fulfillment of EMM quality. To have an efficient EMM, we need to know what criteria should be fulfilled by that. A group of these criteria are called “criteria for general case of application”, i.e. criteria that their fulfillment do not depend on the case and should always be in a constant state. On the other hand we have “specific case of application” criteria, i.e. criteria that their fulfillment depends on the case of application. Criteria from the former group should be fulfilled prior to start any modeling case.

According to all above, the purpose of this work is shedding light on the efficiency issue in EM. This is done by explaining what an efficient EMM is, continued by presenting an efficiency evaluation method for general case of application. This method is then applied to Enterprise Knowledge Development (EKD) [9] for evaluating its efficiency in general case of application. This is done in order to support argument about helpfulness of the evaluation method.

The remainder of the paper is organized as follows: section 2 is about the followed research method, section 3 gives explanation about what the *Method Notion* and efficiency mean. This continued by presenting the efficiency evaluation method in section 4. In section 5 result of evaluating of EKD EMM in general case of application is presented. The paper finish by some conclusions about the method and suggestions for the future work in section 6.

2 Method

We started our work by literature review. By doing this, we found out that researchers in EM have worked widely on the issue of quality in EM and developed works for assessing and improving quality of EMMs and models (e.g. SEQUAL [10] and GoM [16]). But the subject of “efficiency” has not been taken into account by the researchers. We considered this as a starting point for a new work for studying efficiency in EM, and specifically EMMs.

The research methodology that we followed in this work was a combination of Deductive, Inductive and Codification. We, as EM experts, had gained some knowledge and anticipation about how an EMM should be by participating in research projects as well as teaching and supervising EM student projects. Based on this, the initial version of the evaluation method was developed by making the tacit knowledge, explicit. This was continued by an iterative cycle of development (build)-

justification (evaluation). To carry out this cycle, we had to evaluate some EMMs, and a candidate in this way was EKD. This evaluation process helped in finding some of the strengths and weaknesses of the framework and making some conclusions on that.

3 Related Work

In this section we clarify what we mean by an EMM (3.1) and what efficiency is about (3.2).

3.1 The Method Notion

According to [11], all EMMs build on some implicit or explicit *Perspective* (philosophy). A *Perspective* is the conceptual and value basis of the EMM and includes value principles and categories (with definitions), which are more fully expressed in the EMM without being explicitly articulated. Parts of the *Perspective* can be inherent in the EMM in a rather tacit way.

An EMM involves procedural guidelines that show how to work and what questions to ask. This set of guidelines is called *Procedure*. Besides, there exist representational guidelines which is often called modeling techniques or *Notation*. A *Notation* prescribes how answers to the questions in *Procedure* should be documented. *Procedure* and *Notation* are tightly coupled to each other. *Concepts* are the cement and overlapping parts of the *Notation* and *Procedure*. When there is a close link between *Procedure*, *Notation* and *Concepts* we call this a *Method Component*. Different *Method Components* together form a structure called *Framework*, which includes the phase structure of the EMM. *Cooperation & Collection Principles* is about how different people interact and cooperate when performing the guided work. A *Method Component* can be used within several different *Cooperation Forms*. Figure 1 summarizes what each part of the *Method Notion* and is about how different parts are related to each other. Henceforth, to prevent confusion wherever we write *Method* (capitalized and italicized), it means we are referring to the *Method Notion* or any of its parts; whereas “method” (nor capitalized, neither italicized) means the contribution of the paper, i.e. the evaluation framework.

Figure 1. *Method Notion*: Relationship between *Perspective*, *Framework*, *Method Component* and *Cooperation Forms* [11].

3.2 Efficiency

Any process is performed with the aim of gaining the expected results and it should be from high enough quality. On other hand, completion of a process requires using resources that are costly and not infinite. Therefore, people need to keep an eye on the resource usage, whilst carrying out the job. In fact, people would like to gain the maximum output in for the required input. This issue is discussed under the name of “efficiency”. Efficiency is an aspect of quality and its fulfillment is a requirement for fulfilling quality of a process. Efficiency has been investigated by different people. By reviewing the works that define this term, we can see that efficiency has been commonly defined as the ratio between output and input [12].

On the other hand, there exists another type of attitude to efficiency that looks at this issue from the viewpoint of “working process and its foreseeability”: Efficiency is used for passive or operational activity, which is usually defined technically so that the system and its behavior are foreseeable in advance [13].

Although in the first glance it looks that these two types of attitudes are different, they are not. They are two different ways of looking at efficiency and making it flexible to work about efficiency, based on the current work. Even having a foreseeable working process supports utilization of resources. An important point here is talking about any of “the used resources” or “foreseeability of the working process” has value only if the required results have been gained. Indeed, efforts in the way of having a foreseeable work process or reducing the amount of used resources should not result in sacrificing the results.

4 Efficiency of EMMs

In this section we shed light on the notion of efficiency in EMMs. To do this, we discuss what an efficient EMM is (4.1), continued by introducing the evaluation method. This method is comprised of a preparation stage (4.2) and its main body (efficiency criteria and their related questions) in 4.3.

4.1 What is an Efficient EMM?

When we talk about an EMM, we are mainly interested in its application process. Therefore, when it comes to efficiency of an EMM, the sort of viewpoint to efficiency that talks about “working process and its foreseeability” is more helpful. Accordingly, we say that if behavior of an EMM (in use) is foreseeable, we firstly can get models closer to our desires, and secondly resources will be used in a more worthwhile way. Respecting [11], an EMM consists of different parts. If behavior of each EMM part is according to the confirmed characteristics (criteria), it supports foreseeability of the whole EMM in use. Fulfillment of these two supports gaining the expected results; and consequently, support its efficiency.

To assess whether the developed models match to the stakeholders’ desires, we can use one of the existing frameworks. But for checking efficiency of the EMM we a method presented in section 4.2 and 4.3.

4.2 Preparation Stage

In the evaluation method that we have developed, each part of the EMM (respecting the *Method Notion* in [11]) should match to the efficiency criteria. However, EMM developers do not present their work in a way that these parts are differentiable. Thus, to do evaluation we, as EMM evaluators, have to reconstruct the EMM respecting this notion, i.e. finding out what the *Perspective*, *Framework*, *Method Component* (*Procedure*, *Notation* and *Concepts*) and *Cooperation& Collection Forms* are. Then we are ready to apply the main part of the evaluation method, that is comprised of efficiency criteria and questions for evaluating EMM parts.

4.3 A Method for Evaluating Efficiency of EMMs in General Case of Application

In this section, we introduce our method for evaluating efficiency of EMMs, for general case of application. Respecting the argumentation in 4.1, this method supports evaluating each part of an EMM. For this purpose, we give explanation about how an EMM part should be. These explanations embody in fact criteria that an EMM part should fulfill. If an EMM part conforms to the defined criteria, it has fulfilled the efficiency criteria. In addition, we require a concrete tool to evaluate whether efficiency criteria are fulfilled. Thus, we have defined a set of questions respecting explanations for each EMM to underline the most considerable points that should be taken into account. By applying these questions, we can discuss each EMM part and evaluate its efficiency. The result of these evaluations can be used to reach conclusion about efficiency of the whole EMM.

Here, we should note that the method applier is not restricted to the suggested explanations (criteria). Rather, (s)he based on his (her) needs can define more criteria and evaluation questions.

In the following, the main body of the framework, i.e. collection of explanation about each EMM part and questions, is presented. As the purpose of this framework is

efficiency evaluation in general application case, our intent was towards a design that supports nor a subjective neither a case-dependent evaluation.

Perspective: In an EMM it should be specified what important in it is and can be expected from it. In other words, we need to know exactly what can be supported by the EMM. It is vital that *Perspective* be clear and understandable. Any change in the *Perspective* means the coverage of (and consequently the expectations from) the EMM should be reconsidered.

According to all these, we suggest the following evaluations:

- *Does the Perspective specify what can be supported by the EMM?* To find out if the EMM *Perspective* is clear enough, we have to assess if the developer has clarified for what purpose it can be applied and supports modeling the enterprise from what viewpoint
- *Does the Perspective clarify what cannot be supported by the EMM?* As a complement for checking the expressiveness of the *Perspective*, it is even supportive that the *Perspective* mentions what cannot be expected the EMM.
- *Has any explanation been given about the meanings that could be mixed up (with similar words)?* Although by reading the EMM *Perspective*, the user might think that (s)he has found the purpose of the EMM, similarities between close meaning can make confusion. Therefore, we should evaluate if any clarification about such issue is given in the EMM user guide. This evaluation can be done even as a part of the previous bullet point.

Framework: When a *Framework* is going to be applied in an EMM, it should support meeting the *Perspective*, i.e. achievement of the points that are determined in *Perspective*, fulfillment of *Perspective* goals and achieving the underlined results. Applying a non-relevant *Framework* might result in obtaining models which are out of stakeholders' focus point.

In addition to supporting the *Perspective*, it is expected that a *Framework* specifies what phases comprise the EMM, what the purpose of completing each phase is, what the inputs and expected outputs for each phase are. It is even necessary that the order of completing phases be prescribed. For example, we need to know whether we should complete the phases in sequence or in parallel and if it is possible to make changes in the order of phases or even perform some sequential processes in parallel.

According to all these, we suggest the following evaluations:

- *(Is it cleared) what type of EMM Perspective can be supported by this Framework?* This has to be checked in case that the *Framework* is an *External Framework*, i.e. the *Framework* is adapted (or imported) and is not specifically developed for the under discussion EMM. This evaluation is done by reviewing the *Framework* user guide and comparing it with the *Perspective*.
- *Does the phase structure of the Framework support meeting the Perspective?* In case of having an *External Framework*, we should assess suitability of its structure for the EMM and *Perspective*. The reason is that an *External Framework* (and its phases) is not developed for supporting this specific

(EMM) *Perspective*. To address this question, we should work on the two following sub-questions:

- *Are all the Framework phases needed for fulfilling the Perspective?* We should find out if completion of all phases of the *External Framework* are indispensable, or some of them should/ could be neglected.
- *Are the needed phases able to support the Perspective fully?* After eliminating the unnecessary phases, it should be evaluated whether the set of remaining phases are strong enough to aid in holding up the *Perspective*, or not.
- *Is the structure of the Framework clearly defined?* Efficiency evaluation of a *Framework* structure means assessing if the comprising phases and relations between them match to the criteria . Hence, we break this question into the following sub-questions:
 - *Is it cleared in what sequence the phases should be completed?* As working with a *Framework* means completing its phases, we should evaluate relations between different phases. This should aim at finding if it is cleared in what sequence they should be completed, and if any alternatives for that.
 - *Is each phase of the Framework well-defined?* This evaluation has to do with the structure of each phase and encompasses issues such as if it is elucidated what the purpose of completing the phase is, what the input(s) and what the output(s) are.

Method Component: This part itself is comprised of *Procedure*, *Notation* and *Concepts*. Thus, for investigating efficiency of *Method Component* we should evaluate each of these three parts.

Procedure: In an EMM, *Procedure* is supposed to provide guidelines for modeling work. These guidelines should be represented / regarded as questions that help in gaining the required information on the enterprise. It is important that questions in a *Procedure* be clearly formulated and understandable to the readers. These are in fact questions that will be asked by the modeling expert(s) and answers to them are provided by the modeling participants.

Proper formulation of the procedural questions is not the only requirement in a *Procedure*. As it is mentioned in *Framework* section, completion of each *Framework* phase requires asking some procedural questions. And each of these questions should support/ be supported by the other procedural questions in the same phase, with the purpose of addressing the aim of the phase.

Therefore, evaluating *Procedure* means asking and addressing:

- *Are the procedural questions defined clearly?* Asking this question entails clarifying if each question is understandable. Moreover, we should assess if any question is vague and could be interpreted in various ways.
- *Is it cleared what Framework phase is supported by each question?* To clarify this, we should compare each procedural question and its expected answer with the *Framework* phase (the phase that it is specifically developed for, or even several phases) and their goals to find out if the question fits a phase, and consequently the EMM *Framework*.

Notation: By applying *Procedure* (and its questions) we gain some answers. These answers show which real world elements are related to each other and what the relations between them are. We might even need that documenting features of elements or relations be possible. A part of working with a *Method Component* is using *Notation* to document answers to the procedural questions. For applying *Notation* it is required to be familiar with its elements and relations. EMM workers might require to refer to the user guide from time to time and review elucidations on the *Notation* constituents, which are in general about how to present an element. Such a clarification could be in textual and visual form. Providing this information supports the user in selecting the correct elements and relations.

According to all above, we should answer:

- *Are the notational constituents elaborated?* To answer this question, we should consider both textual and graphical presentations and assess whether it is clarified how representation (and formulation) of each notational constituents (i.e. elements, relations and their features) individually and in relation with the other elements should be.
- *Do the Notation and its constituents support implementing answers to the procedural questions?* To answer this, each procedural question (and its expected answer) should be checked against the *Notation* constituents to find out whether the *Procedure* is supported by the *Notation*.

Concepts: As *Procedure* and *Notation* are applied together to produce models, it is needed to have knowledge about their mutual part, i.e. *Concepts*. Besides, as *Concepts* are the cement part between *Notation* and *Procedure*, there is a strong relation between *Concepts*, *Procedure* and *Notation*. Therefore, it is important that the EMM applier be able to find out what a *Concept* in this specific EMM means, by going through explanations about *Concepts*.

Application of *Procedure* and *Notation* should result in covering the *Concepts*. To support this, it is required to have one-to-one relation between *Concepts* and *Notation* as well as *Concepts* and *Procedure*. In other words, *Concepts* should be fully covered by both *Notation* and *Procedure* i.e., *Procedure* and *Notation* contain several meanings and abstractions that should be understood, either as they are or with the help of *Concepts*.

In order to evaluate if *Concepts* part in an EMM efficient is, we should ask and answer:

- *Are the conceptual elements elaborated?* To answer this question, we should investigate whether it is cleared what each *Concept* stands for in this EMM.
- *Are the defined Concepts covered by the Procedure and Notation?* In order to clear this question, from one side we should check if each *Concept* is covered by the *Procedure* part of the EMM; and from the other side, we check the *Concepts* against the *Notation* to find out if the *Notation* are taken into account in *Notation*, i.e. if *Notation* supports documenting the defined *Concepts*.
- *Are the meanings and abstractions pointed in Procedure and Notation covered by the Concepts?* We do not suggest asking this question as a separate evaluation task, rather we advise keeping an eye on it whilst working with

Procedure and *Notation* to make sure that all terms used in them are understandable, either standalone or by reviewing *Concepts*.

Cooperation& Collection Forms: To work with an EMM, we should know what working way should be followed, i.e. what *Cooperation& Collection Forms* is appropriate (or even inappropriate). It is even preferred to have knowledge about weaknesses and strengths of the prescribed *Cooperation& Collection Forms*. The expectation is to see all these in the EMM user guide.

Accordingly, we should look for answer for the following questions:

- *Is it clarified what Cooperation& Collection Forms are for the EMM?*
- *Is it clarified what are pros and cons of the mentioned Cooperation& Collection Form?*

5 Efficiency Evaluation of “Enterprise Knowledge Development (EKD)” in General Case of Application

In this section we present results of applying the above introduced method for evaluating EKD. We assume that the reader is familiar with this EMM. Yet, (s)he can refer to the existing publications to get an overview (e.g. [7] and [14]) or deep understanding [9] about it. To carry out this evaluation work, we used [9], which is the complete user guide for it, and answered all questions based on that.

For using this method, first we completed the preparation stage, i.e. reviewed the user guide whilst keeping an eye on the *Method Notion* [11] and reconstructed EKD respecting this notion. This was continued by asking and answering evaluation questions. Results of the evaluation work is presented below. Result of addressing each questions starts with a short answer (Yes/ No/ Partially) to show what we have concluded about efficiency of each EMM part, followed by motivation around it. In this way, the questions were not applicable are determined.

Perspective:

Does the *Perspective* clarify what can be supported by the EMM? Yes. In the EKD user guide, the authors have clearly stated how this EMM can support its potential users: “EKD is an approach that provides a systematic and controlled way of analyzing, understanding, developing and documenting an enterprise and its components, by using EM. The purpose of applying EKD is to provide a clear, unambiguous picture of: how the enterprise functions currently, what are the requirements and the reasons for change, what alternatives could be devised to meet these requirements, what are the criteria and arguments for evaluating these alternatives”.

Does the *Perspective* show what cannot be supported by the EMM? And has any explanation been given about meanings that could be mixed up (with similar words)? No. In the EKD user guide clarification about nor what is not supported by the EMM, neither the terms that have close or similar meanings is given.

Framework:

(Is it cleared) what type of EMM *Perspective* can be supported by this *Framework*?

Does the phase structure of the EMM support meeting the *Perspective*?

As EKD is not developed on an *External Framework*, we do not need to answer any of these two questions.

Is the structure of the *Framework* defined clearly?

• **Is it cleared in what sequence the phases should be done?** No. According to the EKD user guide, six phases should be completed, each results in gaining a specific type of sub-model. By reviewing the user guide we can see that links between various sub-models are shown. Respecting these links we can conclude that relations between different phases are given. Nevertheless, no suggestion is given regarding the starting point, the sequence of performing the phases or the possible list of alternatives.

• **Is each phase of the *Framework* well-defined?** Partially. By going through the description of each phase we can see that the authors have explained what the purpose of each phase is (each phase is supposed to model the enterprise from a specific view point) and what output can be gained from each. On the other hand, it has not been cleared what inputs are required for completing each phase.

Method Component:

Method Component in EKD supports developing six different sub-models: Goals Model (GM), Business Rules Model (BRM), Concepts Model (CM), Business Process Model (BPM) , Actors& Resources Model (ARM) and Technical Components& Requirements Model (TCRM). Therefore, evaluating the *Method Component* means evaluating each of these six *Method Components*. Summary of all these evaluations can be seen below:

Procedure:

Are the procedural questions defined clearly? Yes. In the EKD user guide for developing each type of sub-model some driving questions are suggested. The reader is not restricted to these questions, but can use them for defining relevant questions. By going through the driving questions and evaluating them we found them understandable enough and not vague.

Is it cleared what *Framework* phase is supported by each procedural questions? Yes. In EKD each *Method Component* is developed to support a specific phase, aim of each is modeling the enterprise from a specific viewpoint. Therefore, it is clear what phase each *Procedure* (and its procedural questions) support.

Notation:

Are the notational constituents elaborated? Partially. The EKD user guide contains enough graphical clarification (in the form of plain *Notation* and sample models) for developing all six *Method Components*.

On the other hand, textual clarification in different *Method Components* is poor or missing. In GM, BRM and TCRM the reader can find how to

formulate labels of links by reviewing the general *Notation* and sample models. In GM a detailed explanation about how to write the “goals” and “problems” is given, whereas in TCRM just a small hint can be seen on this. In BPM, ARM, CM and BRM no textual clarification on respectively how to write the “business processes”, “actors”& “resources”, “concepts”& “attributes” and “business rules” has been given. In CM small notes can be seen beside the *Notation* about what each cardinality sign mean.

Do the *Notation* and its constituents support implementing answers to the procedural questions? Yes. The EKD *Notation* for CM fully supports its *Procedure*. Also, in GM, BRM and TCRM the *Notation* is general and can be specialized to the obtained answers, i.e. supports answers gained from the *Procedure*. Yet in ARM *Notation*, *Concept PartOf* has been left uncovered.

Concepts:

Are the conceptual elements elaborated? Yes. In the EKD user guide all *Concepts* introduced for different sub-models are explained in detail.

Are the defined *Concepts* covered by the *Procedure* and *Notation*?

- **Are the defined *Concepts* covered by *Procedure*?** Partially. In all *Method Components*, except CM there exist *Concepts* that are not covered by *Procedure*: “Constraint” in GM, differentiation between different types of “rules” and “processes” in BRM and BPM respectively, “organizational unit”, “non-human resource”, “individual” and “role” in ARM, and finally “information system goal”, “information system problem” and “information system requirements” (“information system functional requirements” and “information system non-functional requirements”) in TCRM.

- **Are the defined *Concepts* covered by *Notation*?** Partially. In CM and BPM *Notations* support the *Concepts* fully. The general *Notation* in GM, ARM and TCRM can be specialized to support all *Concepts*, except “information system requirements” in TCRM, and different relationship types (“binary”, “PartOf”, ISA) in ARM. In BRM different types of rules are defined: “derivation rules”, “event action rules” and “constraint rules”, whereas they are not differentiated in the *Notation*.

Are the meanings and abstractions pointed in *Procedure* and *Notation* covered by the *Concepts*? Yes. Whilst working with different *Notations* and *Procedures*, we (as EM experts) did not find any term that seems to be vague, but is not elaborated by the *Concepts*.

Cooperation& Collection Forms:

- **Is it clarified what *Cooperation& Collection Forms* are for the EMM?** Yes. According to the EKD user guide, the suitable way for *Cooperation*, in contrast to consultative approach.

Is It explained what are the pros and cons of each? Partially. A list of advantages of participative approach is given in the user guide, which are “enhancement of models quality and consensus” and “achievement of acceptance and commitment”. Nonetheless, it is not explained what are the disadvantages of this *Cooperation Form*.

6 Conclusions& Future Work

6.1 Conclusions

An EMM is comprised of different parts that are related to each other and should remain in coordination. This issue has been taken into account by the proposed evaluation method. This method includes two main sets of efficiency criteria and questions: one set supports evaluating each EMM part as an individual unit and the other set supports evaluating relations between different parts have are defined.

The evaluation questions are developed to help in conducting discussions around efficiency of an EMM part. This means, answers to these questions are preferred to be motivations about why the evaluating person believes this part efficient is or is not. For addressing these questions a “Yes/ No” (or in some cases “Partially”) answer might be useful as an initial answer, but it is required to support it with more detailed clarifications. Although a “short” answer can be useful to show our conclusion about efficiency of that specific part, we should still present reasons to help the reader in understanding the logic of the reached conclusion.

After all these, the intention of conducting this work was developing a method that is not case-dependent or subjective. But by reviewing the framework and results of applying it to EKD we can see that there are questions that are inevitable to be subjective. In these questions, answers are mainly about EMM evaluator’s deductions about a specific criterion. This means by involving another group of evaluators, the answers to the questions might differ.

6.2 Future Work

After defining efficiency criteria for general case of application, it is needed to be concerned about how to evaluate efficiency in specific application cases. Therefore, the future work will be finding out what criteria should be covered by an EMM to say it is efficient in specific case of application, plus questions that help in evaluating them.

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