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A Reference Model Catalog of Models for Business Process Analysis

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ABSTRACT

When results of business processes cannot be measured, the application of numeric Key Performance Indicators fails. Process performance cannot easily be analyzed unless other indirect indicators are applied. So, other existing models for process analysis containing convenient solutions and indicators have to be assessed and validated in order to use them to sufficiently assess business processes. In this article, various existing models were reviewed in an empirical investigation, categorized in systems and put into context to relevant theories. The result of the research is a Reference Model Catalog of Models for Business Process Analysis that also incorporates indirect process performance aspects like soft goals, complexity, maturity or dependencies. It is enabling enterprises and researchers to select a convenient process analysis model for their specific performance problem. Moreover, it is offering a comprehensive overview of models and visualizes correlative voids in their scope.

Keywords

BPM, Process Performance, Reference Model Catalog, KPI, Success Factors, Ontologies

INTRODUCTION

The state-of-the-art instrument to assess process success is the use of numeric Key Performance Indicators (KPIs) since it makes a process measurable and controllable. But when KPIs are used as sole source model for process success control and performance enhancement, there's a certain danger that other relevant or unique features of a process might be not recognized and lost for review and control. This will be the case when processes or their results are non-measurable and can better be described in models with indirect indicators like success factors, soft goals, complexity, maturity, relations or dependencies. These indicators and models containing them must not be neglected, because they might be a better way of understanding a process performance problem. The goal of this contribution is to offer an overview of today's used relevant and implementable models for business process analysis embodied by a Reference Model Catalog (RMC) of Models for Business Process Analysis, explicitly including models with indirect indicators for process performance.

Taking additional indirect indicators and their models into consideration for performance assessments will consume resources. For above mentioned reasons and from an organizational point of view, it is preferable to gain the complete overview of a Business Process' performance to thoroughly understand, reengineer and manage it. In contrary to that, no such overview solution exists, yet. Enterprises and researchers would be forced to browse through many possible matching models in order to assess and validate them for their specific process performance problems. The RMC as an easy-accessible compendium is designed to facilitate this search for an overview as well as the choice of convenient models.

Proceeding with the description of the state of the art, then the used research design is proposed. Finally, the presentation of the Investigation Course and the results frame this paper.

STATE OF THE ART

There's a multitude of unique models for business process analysis available on the market as well as being discussed in research. Since the terms *performance* and *success* in combination with *measurement* are often used synonymously, there is also a lot of literature on process performance that assumes to contain models, but usually points to frameworks. Examples are the Balanced Scorecard (Kaplan and Norton, 1996), the Performance Prism (Neely, Adams, and Crowe, 2001), the Performance Measurement Questionnaire (Dixon, Nanni, and Vollmann, 1990) or the SMART System/Performance Pyramid (Cross and Lynch, 1989). In contrary to the models for process analysis that are in discussion in this paper, they embody recommendations for combining, displaying and interpretation of measures. They cover only numeric KPIs that monitor and control processes according to the Business Process Management approach (Bucher and Winter, 2007) to make the process success measurable. In addition to that, KPIs are often used exclusively in specific functional domains like production, IT or supply chain and deal with the processes' efficiency. This implies also that numeric models concentrate on processes with

value creation and disregard accompanying processes like finance or R&D that *only support*. However, there are more models that suggest verbal descriptions as indicators of success. In contrast to that, few approaches exist that question and assess processes in their overall structural effectiveness and design; they are embodied by maturity models and ontologies for business processes. During the research so far, no other overview construction about indicators or models for business process performance could be found.

RESEARCH DESIGN

A five-stage design approach is chosen to conceptualize an artifact that enables stakeholders to select from a multitude of relevant models for business process analysis. After the presentation of the overall research scope in a semantic map and the postulation of the research questions, relevant theories of Information Science are reviewed to give answers what a business process or, derived from that, a model to analyze it should look like. Fourth, the method of evaluating data is presented. Finally, the construct of the RMC is introduced. Using this research design, the investigation course took place.

Overall Research Scope

Originating from the problem for stakeholders to gain a comprehensive overview or to select a suitable model for their needs, the overall research scope can be formulated and separated into two branches. In this context, the RMC can be considered as a first milestone towards the final future research goal.

First, the review of known models reveals that there are solutions for single process domains and problems as well as some combined models for multiple domains, but no solution exists that displays a broad range of multiple available models. From this *Model System* approach the necessity to evaluate either an overview, combined, or integrated solution is derived. The structural framework of an RMC embodies this goal in a first step. It offers quick access and overview, but still only refers to many models to choose from. So other framework or integration possibilities have to be considered to further facilitate the implementation of performance assessment possibilities in Business processes. Ultimately, a one-step model that combines or integrates the various models has to be deployed in further work.

Second, stakeholders must perform research or consult experts when looking for a suitable model. This and the validation of the specific applicability would be time-consuming. The empirical research in this study, combined with a review of relevant theories on the *Model Design* approach delivers data to design a valid artifact according to the Design Science approach (Hevner, Ram, and March, 2004), offering an overview solution. The product of the Design Theory in this work (Gregor and Jones, 2007), proposed in this contribution is embodied by the RMC. In further research the findings from the RMC design, especially the inherent theories should be described and used to help to build the one-step model with broader scope and enhanced relevance for the stakeholders.

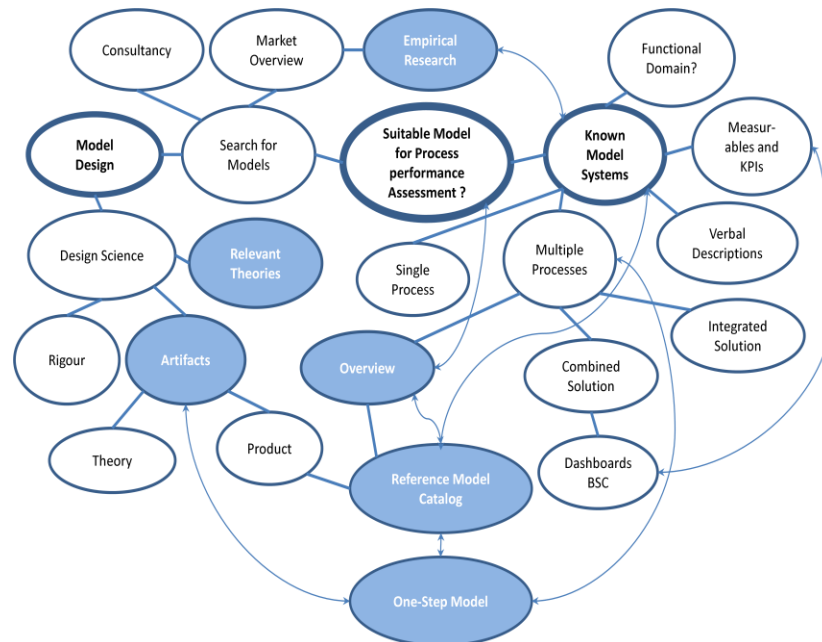


Figure 1. Semantic Map of Overall Research Scope

Research Questions

- Will the RMC enable enterprises and researchers to better select and compare models for business process analysis?
- To what extent does the artifact fulfill the basic business process requirements from the relevant theories?
- Is the RMC easily applicable, extendable, or mutable?
- What constraints are visible using the RMC?
- Can it be seen as a basis for further investigations? What perspectives are visible?

Relevant Theories

Among many others, there are some distinguished IS theories worth assessing from the business process point of view as they contain inherent and universal demands for business and their processes and highlight the general direction stakeholders should take when reviewing or designing processes. According to Porter's Five Forces, a successful company can enhance its competitive situation by influencing the balance of power in its market situation by five aspects: branch internal rivalry, buyer power, supplier power, potential substitutes' power and market entry constraints (Porter, 1998). In this context, Porters theory can be applied in three ways to companies who investigate their business processes:

- The mere knowledge of the theory can be a trigger for the company to start moving and question its competitiveness. Without explicitly applying the theory itself, basic process improvement instruments, e.g. the usage of KPIs drive direct and indirect cost reductions as well as a reduction of market entry barriers.
- Applying the theory reveals hidden relations between processes, their building blocks and so highlight entry points for Porter's forces. For example, a process might be detected as unquestionable supplier-orientated. So, the processes become more transparent.
- Finally, hidden rivalries and strategies between departments and divisions become obvious when reviewing similar or equivalent processes. This approach emphasizes the comparability of processes.

The last aspect is being discussed in the Principal-Agent theory in particular. It postulates the existence of a lack of information necessary to make decisions in a Principal-Agent relationship. On the one hand, this comes from information held back for reasons of personal advantage, on the other hand because of the accessible information in most cases being incomplete and unevenly distributed. To overcome this unfairness, so-called agency cost is generated (Jensen and Meckling, 1976). There are three types of agency cost:

- Cost that represent the principal's work to reduce its information lack, called monitoring cost. They occur when the agent delivers too few information and that the principal has to gather additional data. Hence, the principal lacks transparency in the results of the agent's processes.
- Starting new relationships to a principal possibly comes with certain bonding expenditures to the agent. To avoid information dissymmetry, they are necessary for the agent to signal its information to the principal as transparent and useful.
- Residual cost occur whenever the distribution of necessary information is suboptimal, e.g. if a time-consuming workaround has to be established to gain relevant information out of standard software formats. This aspect emphasizes a certain inhomogeneity of necessary data and thus incomparability.

According to the Organizational Information Processing theory, enterprises are not only creating potentially obsolete buffers to balance supply shortages in production but also to catch uncertainties and information shortages in every part of the company (Premkumar, Ramamurthy and Saunders, 2005).

- The more independent regional, temporal or organizational entities exist in Business processes, the more uncertainties are observable, e.g. the existence of multiple repositories for identical documents in different departments because they may are not be working transparent to others.
- Moreover, the theory claims that enterprises tend to avoid these uncertainties at the same time by the use of adequate tools. They should be made available to others as well to design their processes in a transparent and comparable way.

Summing up, all these theories target to make a business and hence it's processes more transparent and comparable irrespective of their functional domains. Subsequently, results, constraints and properties of processes will be more visible. All in all, there is a necessity to examine if models for business processes analysis work towards this needed transparency or comparability in principle.

Empirical Investigation

From the initial standpoint of an exemplary enterprise seeking advice in selecting a suitable model for its business process performance problem, the currently available management approaches, commercial offers and scientific models were evaluated in an empirical investigation. About 30 public available models were collected and reviewed from March 2009 to January 2010 out of online and printed journals, books and practitioner reports by using a systematic review scheme (Denyer and Tranfield, 2009).

They were selected in accordance to the complementing requirement that they were able to satisfy the needs of companies with a certain size, process depth and diversified organizational functions like Marketing, Supply Chain or Finance. Enterprises of this kind, in other words potential stakeholders of this research most likely will be sensitized for or even familiar with concepts of quality systems, reengineering or BPM and the implementation of models like KPIs. Moreover, broadening the business process conceptualization view from industry to adjacent service or administration and research sectors revealed further interesting approaches and methods, so that models with backgrounds in these directions were also taken into consideration. From that point of view, first of all the relevant standards, norms and statistical methods had to be reviewed. Since enterprises themselves will potentially not disclose any or very few information and insights in this delicate domain of doing business, relevant data had to be collected mainly from secondary sources. This was done via the analysis of publications of inter-trade-organizations, branch reports of accountants, examining institutions or other stakeholders. Apart from the valuable facts, they also allowed a deeper look into the originators' various approaches of analyzing processes.

After review and assessment of the contents, about 15 unique and reproducible models that were likely to be used at least in this range of enterprises remained for detailed examination.

Reference Model Catalog (RMC)

Statistics, tables, Balanced Scorecards or mind maps are valid concepts of visualizing results and suitable for various purposes. Among them, a RMC offers a handy and easy-readable standardized tabular overview which is suitable to display various descriptive features of a subject; it originates from construction catalogs in engineering science. RMCs should contain at least a main part in which the subject is nominated sufficiently, an access part in which the features are compared systematically and an introduction that contains the guiding principles like domain, purpose and relevant branch as well as a basic description, used abbreviations and technical terms. If necessary, an additional classification part can be put in front. Fettke and Loos (2001) recommend to use it in particular for IS reference models because it offers quick access to any knowledge or concept that has already been methodically evaluated and categorized in a given framework. An RMC can even be easily included in a web database for researchers as well (Fettke, 2010).

INVESTIGATION COURSE

To categorize the models in the RMC, a certain distinctive feature has to be defined. In this context, the relevant 'model' for Business process analysis shall allow

- to describe the process analysis and assessment approach to a certain meaningful extend
- to perceive the domain of its validity as well as
- to assess its performance with a meaningful indicator.

As the performance of a process does neither has to be measurable nor numeric by default, the concept of the generic 'indicator' has to be defined and is being used in this work.

An indicator can be

- a numeric parameter that evaluates the process (puts a certain value to the performance) or
- a verbal description (factor) that rates the process (describes and judges the performance).

It is used to assess process performance by two different means:

- process success (indicating efficiency) or a
- process outcome (indicating effectiveness) respectively.

Performance Assessment	Process Success / Efficiency		Process Outcome / Effectiveness	
Indicator	Parameters	Factor	Parameters	Factor

Table 1. Overview of Process Performance Systems and Indicators

Browsing through the reviewed models, it can be observed that they all can be categorized into these four process performance systems dependent on the occurrence and application of their indicators.

Parameters for Process Efficiency

The simplest example for numeric parameters of process success are KPIs. They are very common in production surroundings, but usable for Service or Support processes as well.

Apart from production, in service domains of organizations, KPIs begin to spread. In a McKinsey study, IT departments used productivity, timeliness and quality as parameters (Bloch and Hoyos-Gomez, 2009) thus being borrowed from classical KPIs for production. Apart from productivity parameters, financial KPIs like the EBIT (earnings before interest and tax), or liquidity exist for a long time. In another study, 51% of all enterprises mentioned the use of financial besides productivity and quality indicators (PriceWaterhouseCoopers, 2009). In fact, some more sources claim the display, combination, weighing and balancing of financial as well as production KPIs as one of the most important usages of a KPI system (Philip, 2009; Eckerson, 2010). This particularly is the concept of the Balanced Scorecard (BSC). It discloses only numeric parameters from four different sources: financial, customer, internal business processes and learning and growth. It also combines these measurables with strategic goals (Kaplan and Norton, 1996) and is used with a usual review frequency of no less than a month (2CG, 2009). So basically, BSCs display parameters that were generated elsewhere, and this concept it is no generic model for process analysis that actually generates KPIs.

Moreover, there are so-called SD-KPIs (sustainable development-KPIs). E.g. by German law, suitable related indicators have to be disclosed as soon as they are of importance for the understanding of the business development, result or the situation (Baetge and Hesse, 2008), e.g. environmental or labor indicators. They are primarily used to display a certain overall responsibility and cannot be broken down into department or individual performance values like classical KPIs. Though, they serve the assessment paradigm and try to make enterprises comparable, at least within a given branch or timeframe.

The widespread concept of Lean Manufacturing enables enterprises to identify and eliminate waste in processes with a clear focus on countable results (measured via KPIs) in value creating processes. Outside of the boundaries of manufacturing or value creation, Processes usually are not taken into consideration by the lean concept. The Six-Sigma approach qualifies process success which is described with Critical to Quality Characteristics (CTQs). It also is limited to value creation processes with verifiable lacks displayed within these indicators (Töpfer and Günther, 2009).

Parameters	
Amount	Output, Cash, amount of new clients per day
Time	Cycle time, Mean time between failure (MTBF), Inventory turnover
Quality	Scrap rate, Variance

Table 2. Examples of Parameters for Process Efficiency

Factors for Process Efficiency

Factors for process efficiency rather rate the process success verbally and abstract than evaluating it with a figure. The factors can take shape of either a binary Yes-No decision or a discrete cascade of opinions about the process success. The opinion cascade can be a set of verbally escalating statements or quantized quasi-values that embody a success rate from virtually 0 to 100%.

Performance management in the classical meaning, i.e. tracking the achievement of an employee’s goals is a common way of developing staff in enterprises and a good example for process success factors. They normally form verbal goals that are rated in an opinion cascade as a failure or success. A similar approach is postulated by Zellner (2003) in Customer Relationship Management (CRM). He suggests claiming a success whenever an abstract goal in a certain phase of the CRM has been archived, repeated throughout the whole customer lifecycle.

The European Foundation for Quality Management (EFQM) offers an excellence model for enterprises that rates multiple so-called enablers and results by relevance, performance, approach, application, assessment and improvement (Moll, 2009). A

maximum of one thousand points can be granted for the total of these criteria. So, the EFQM Model also offers a quasi-value for the success of a process (in this case the complete company).

Huth (2007) offers a six-stage assessment model in his work about the comparison of Lean and Six Sigma principles that also can be used to rate all other processes' success. He suggests using various criteria in the categories Strategy, Approach, Methods, Culture (Implementation) and Impact that can be subject to an either-or decision or certain weighting.

Factors	Yes-No-Decision	Opinion Cascade
Marketing	Kept customer base Started further negotiation	Customer satisfaction (0-100%)
Human Resources	Implemented talent development program Participated in graduate fair	Incentive system implemented (rudimental, partly, fully)
Research & Development	Expanded alliances with key suppliers Market-readiness for new product finished	Perceived technical renommé (0 to 5 Points)

Table 3. Examples for Factors for Process Efficiency

Parameters for Process Effectiveness

Processes can be reduced to their basic building blocks and immanent parameters which describe them in detail as a system with the function to execute a certain task. This reveals the existence of many collective numeric indicators which are independent of complexity or maturity and are able to assess a process in total or its pieces. They can be quantitative like instances, dwell and departments or qualitative like granularity or necessary knowledge. Though, most of the commonly used models to disclose process effectiveness or outcome in industry show characteristics of maturity models.

A simple five-stage set of values is being proposed by Rummler and Brache (1995) in their Process Maturity Model and Process Performance Index. By far more complex is the Capability Maturity Model Integration (CMMI) methodology that originally has been proposed for IT projects (Kneuper, 2003). It breaks down the scope of the assessment into process areas and rates their maturity in 5 levels. In addition, it suggests the use of metrics and indicators in certain process areas, which again emphasizes the problem that terms as well as content of definitions like Process, Project and their success and outcome must be clearly separated and not be mixed up.

Harmon's (2003) work is about an assessment model called SCOR for processes in supply chain management. He recommends the use of various common metrics in a framework called plan, source, make, deliver and return as well as a final benchmarking with the industry. The approach of formulating goals and their optimum parameters in a specific language (Goal Driven Language, GDL) to automatically optimize business processes in a Business Process Execution Language (BPEL) algorithm is proposed by Kramberg (2008).

Hammer's (2007) Process and Enterprise Maturity Model (PEM) is a radical enterprise-independent process reengineering approach for practitioners and managers and has advanced to a certain state-of-the-art-model over time. He assesses the maturity of a company by claiming a success for specific factors of a verbally escalating four-level opinion cascade, both for the areas of process determinates and enterprise competencies.

Parameter	Quantitative	Qualitative
Amount	Steps (Instances), Documents	Granularity of data to be processed Amount of various scenarios
Time	Cycle time, Deadline	Man hours in full time equivalents Response time
Relevance	Departments involved, Stakeholders	Severity of task to be processed, Maturity

Table 4. Examples of Parameters for Process Effectiveness

Factors for Process Effectiveness

Another possibility to describe processes of any kind are ontologies. In information science, they embody formal specifications of a concept (Gruber, 1993). In business, they are used often in the context of knowledge management and expert systems but not very frequently to describe what a business is doing. They're able to classify and describe a concept's (in this case processes') instances, properties and relations. Suitable analyzing programs (so-called reasoners) allow users to

ask qualified questions to an ontology. The answers will not contain crude data like a database extract but may be a meaningful statement on the same semantic level as the question, either as binary Yes-No statement or as an open description. The answers to a question to an ontology can hence be considered as a description of the result and outcome of the Process. In addition to that, the answer can be rated as more or less meaningful and sufficient as a solution for a problem. Thus, qualified questions to Ontologies can be interpreted as Success Factors for the detection of process effectiveness to some extent, and in this respect, rated answers from Ontologies can be taken into consideration to be their actual indicators, factors for process effectiveness.

Apostolou, Stojanovic, Lobo and Thoenssen (2005) propose a software prototype and ontologies for eGovernment in four equal parts: domain knowledge, used services, lifecycle and orchestration of all. The approach of Gehre, Katranuschkov and Scherer (2007) (Project Intelligrid) is mainly the same, offering a catalog of a business process-(domain knowledge), service, organizational- and software resources ontologies for the use in virtual, distributed workgroups like in project management.

Jenz (2003) recommends a three-stage ontology model for business processes, namely a basic business process management ontology (BPMO), an industry-specific- as well as an organisation specific ontology. He proposes to combine them into a single business ontology and technical representations, e.g. an IT-ontology. This historical approach of describing and somehow condensing a domain into a hierarchy of several ontologies was extended in recent research. Based on the approach of a Service Oriented Architecture (SOA) in which context ontologies can be seen as independent services to be coordinated, the specific ontologies with domain knowledge are supported by choreographic ontologies which contain the interfaces and translating elements.

Samires, Momotko and Ruggaber (2006) (Team NESSI) offer the development of a BPM software for cross-domain modeling of processes. It is designed to use already existing elements of object- or workflow-oriented programs and semantic frameworks (ontologies). It also differentiates between domain specific and choreographic concepts.

Qualified Questions	Yes-No-Question	Open Question
Production	Is the continuous production endangered in case the Shift Manager is sick?	In which Machine Family training efforts are lowest?
Finance	Does the new law affect our product costs?	What cost impact has it to drop a certain Process step?
Human Ressources	Do I have to hire extra staff for the new process?	What minimal qualification is necessary for the processor at this task?

Table 5. Examples for Factors for Process Effectiveness

Findings

The following table combines the domains, models and indicators of the previously assessed models and finally embodies the RMC of Models for Business Process Analysis. For clarity reasons and in contrary to the categorization in the Investigation Course, the RMC discloses the indicators as the relevant distinctive feature in the access part and displays the models' domains as basic categorization.

All in all, the RMC displays to what extent models are applicable in a certain domain as well as for the assessment of a specific process performance problem, either fully (X) or partly (O). Stakeholders may want to pick a domain in the classification part and an indicator for the performance problem of interest in the access part and can read out if a model exists and can be applied.

Classification		Main Part		Access Part			
				Process Success / Efficiency		Process Outcome / Effectiveness	
Domain	Subdomain	No	Model	Parameters	Factor	Parameters	Factor
Production Processes	Processes with Quality Problems	1	Six Sigma	X	O		
	no restriction	2	Lean Manufacturing	X			
		3	Lean Six Sigma		O	X	
Support Processes	Human Resources	4	Performance Management		X		
	Customer Relationship	5	CRM		X		O
	IT-Projects	6	CMMI	O		X	
	Supply Chain Management	7	SCOR			X	
	Administration	8	eGovernment				X
All Processes	Domain specific	9	BPMO				X
	Virtual organisations	10	Intelligrid				X
	no restriction	11	EFQM		X		O
		12	Process Maturity Model/Process Performance Index			X	
		13	Goal Driven Language			X	O
		14	PEM			O	X
15	NESSI					X	

Table 6. RMC of Models for Business Process Analysis

CONCLUSION AND OUTLOOK

Models for business process analysis can be categorized into four process performance systems according to the occurrence and applicability of an individual indicator. Each indicator tries to disclose process performance in order to solve a performance problem. The models can be combined into a RMC which enables stakeholders to quickly overview and select a suitable model for a certain scope.

Nevertheless, a critical acclaim of the RMC setup must be done. This instrument emphasizes that not exactly one model exists for every single problem. But in principle a range of models is available and usable (Fettke et al., 2001). In this respect, the RMC is not final, but a snapshot of the current state of the art and should be reviewed from time to time.

According to the claim of the relevant theories, a business and therefore its processes have to be transparent and comparable irrespective of their domain. From that point of view it can be stated that the models and the RMC allows enhancing the transparency of the business processes via the analysis of suitable indicators. The feature of comparability of processes is still underrepresented because the models and indicators are mostly exclusive to a performance system or domain and so, results cannot easily be exchanged and shared.

Picking up that point, the design of the RMC also reveals that there are voids in the representation of models for more than one isolated performance problem. If an enterprise wants to thoroughly reengineer its processes, it should be able to evaluate their efficiency and to rate their effectiveness in any given Business process without restriction to a specific process domain or performance system. It should not be forced to use many different and isolated models. By now, the existence of a multitude of models and ecosystems and lack of a certain comprehensive approach leads to the suggestion that an super ordinate or integrated model concerning at least the basic approaches of all of four performance systems to cover the

performance systems' problems today is lacking and should be deployed. This is subject of further research by use of the presented RMC as a blueprint for designing an combined or integrated reference model as presented in the overall research scope. Up to now, the proposed artifact already facilitates the search for appropriate models by practioners and researchers.

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