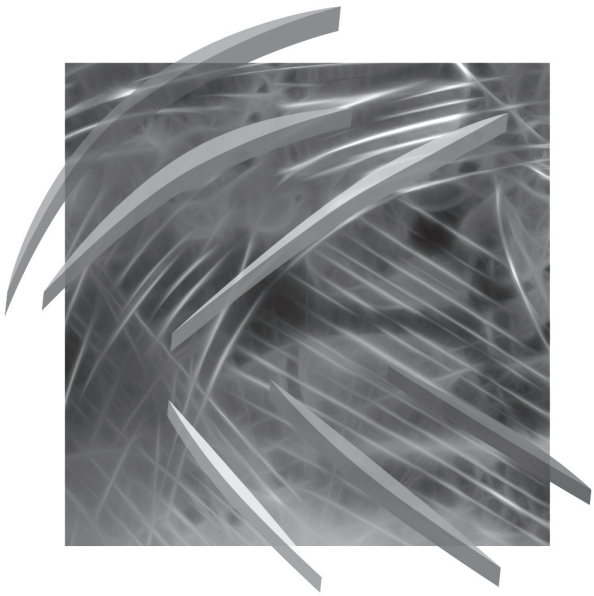
INFORMATYKA EKONOMICZNA
BUSINESS INFORMATICS

21 • 2011



Publishing House of Wrocław University of Economics
Wrocław 2011

Copy-editing: Agnieszka Flasińska, Elżbieta Macauley, Tim Macauley,

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Information of submitting and reviewing papers is available on the Publishing House's website www.wydawnictwo.ue.wroc.pl

ISSN 1507-3858 (Business Informatics)
ISSN 1899-3192 (Research Papers of Wrocław University of Economics)

The original version: printed

Printing: Printing House TOTEM
Print run: 200 copies

Contents

Streszczenia

INFORMATYKA EKONOMICZNA BUSINESS INFORMATICS 21 • 2011

ISSN 1507-3858

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TOWARDS A SEMANTIC REPRESENTATION OF MATURITY MODELS

Abstract: Implementing a business process improvement program is a difficult project, which requires large organizational effort and the presence of knowledge. To facilitate this task, we try to support it with IT. This can be achieved by using an approach to business process improvement based on maturity models and converting the original content into a database and knowledge base form. Representing maturity model as a database opens up new possibilities of computer processing of its content. It allows to join maturity models with a diagnostic knowledge base to build an application that will help managers to evaluate and improve the maturity of their business processes. The aim of this paper is to present the possibilities of formal semantic computer representation of maturity models, as a database, and as a knowledge base and to show the benefits of such representation.

Key words: semantic representation, maturity model, knowledge base form.

1. Difficulties in implementing business process improvement programs

Good processes do not arise accidentally but they are the result of conscious organizational activities. As an aid in the process of improvement, many approaches can be used such as TQM, ISO, Lean Six Sigma or maturity models among them. They all refer to the process paradigm and are often identified with the improvement of business processes. However, implementation of these initiatives is a tough task and no matter what program we choose – it is always combined with great organizational effort of creating working teams, setting goals, assigning resources, preparing schedules, etc. Organizations undertaking the task of implementing the pro-quality program often hire outside experts to assist them in going through the program, for others, unfortunately, the cost of such a team is not acceptable.

Some of the difficulties of introducing quality programs can be located on the side of the organization, among them: lack of support from company management, staff resistance to changes, too high expectations, waiting for quick effects, etc. But some problems arise from the construction of the programs themselves. These include high costs, difficulties in understanding principles of the model or problems

with implementation and documentation. The high costs are a result of difficulties in project management: the assignment of work, monitoring, tracking all tasks and coordination of the entire project. Unfortunately, the nature of initiatives is not conducive to lowering these barriers. TQM and ISO are descriptive in form and do not show how they should be organized. This knowledge remains the domain of expert teams.

IT can and should help in overcoming these difficulties. On one hand, there are many applications that offer assistance in particular actions such as process mapping tools, cause-effect diagrams, Pareto charts or histograms, Six Sigma and FMEA calculators, SPC measurement and charts, ready-to-use documents for companies implementing ISO, etc. On the other hand there are many applications for scheduling and resources allocation, but they are designed for common use and they do not offer knowledge specific for business process improvement programs. Notable is the lack of tools that offer comprehensive and holistic support for pro-quality initiatives. To build such a tool, we need a new representation of knowledge stored in improvement programs – other than documents. An old, traditional representation causes that a large part of the knowledge about the model and its use remains hidden in the minds of experts who know details of documentation and have gained the necessary experience.

One of the few proposals for a comprehensive support of quality initiative is Quality Companion application created by Minitab Company [Minitab 2010]. It provides a broad assistance for Lean Six Sigma projects. It allows to manage all items related to Six Sigma projects, and additionally, at each stage of the project Quality Companion offers expert explanations and advice. However, there is no similar support for more complex programs, which are broader in scope. As mentioned earlier, one of the reasons is their traditional form which makes knowledge about them unavailable for computers.

2. Outline of maturity models

Quality models have to play several roles: descriptive – as a tool to assess the existing state (as-is model), prescriptive – as a tool for describing the target state (to-be model), and indicative – as a guide explaining the differences between existing and desired state and showing the way of reaching this state (to-do model). Maturity models are the result of the work of domain experts, practitioners and process management experts. So they are a repository of knowledge about:

– how good processes should look like,
– what criteria should be used in the process assessment,
– what should be done to improve processes.

Fortunately, they also have (contrary to other improvement approaches) construction and structure that allow to think about converting them to the form of database and knowledge base. Further investigations are based on the Business

Process Maturity Model (BPMM) described in detail in [Object Management Group 2008], but they can be generalized to many other – similarly constructed – maturity models.

The BPMM gathers experiences from many successful and unsuccessful implementations of improvement plans. The BPMM is intended for anyone interested or involved in improving an organization's business process related to their products and services – whether the products and services are for internal or external use. The main strength of the BPMM is the direct impact of the best practices from many disciplines into a set of actions changing the company. Each action of the model removes a specific obstacle that hinders or prevents real and lasting improvements, and incorporated specific actions in the culture of the organization. The BPMM is closest to the concept of *Continuous Process Improvement* based on small but continuous changes and progressive implementation of an innovation. It also provides guidance to the organization of these changes and their measurement. Managers use the BPMM to identify the most critical processes to refine and understand the steps necessary to start and sustain improvement processes in their organization. Assessment groups use the BPMM to characterize the maturity of existing processes and to identify their strengths and weaknesses. The model is also used to identify risks associated with implementing new solutions and in the evaluation and selection of qualified business partners.

Table 1. Synthetic characteristics of process maturity levels according to the BPMM

Maturity level	1 – initial	2 – managed	3 – standardized	4 – quantitatively managed	5 – optimized
Characteristic	inconsistent and unstable results of processes	management at the department, improving local efficiency	well-defined processes across the company, standardization, best practices	management by indicators, evaluation based on quantitative measurement	innovative management, change management, agile organization
Level of management	firefighting, just-in-case management, culture of heroes, a simple means of monitoring and control	repeatability, stability, standardization, specialization	cooperation, collaboration, monitoring, documentation of quality management	process management, KPI	organizational culture
Objectives	motivating employees to overcome the problems and performing tasks	introducing fundamental rules of management in work of units and between them	building environment for process management across the company	measurement processes, to predict system load and results	continuous improvement processes at all levels of an organization

Source: based on [Harmon 2007; Object Management Group 2008]

According to the BPMM, an organization can be classified in one of the five successive levels of process maturity. They are described in many publications (see for instance [McCormack et al. 2009; Rosemann, de Bruin 2005; Curtis, Alden 2007]) and their synthetic characteristics are included in Table 1.

A major advantage of the BPMM is its highly defined hierarchical structure (Figure 1). Thanks to that, each level of maturity is a well-defined set of states, which should be achieved and which lead the organization closer to the full maturity in a sustainable way. Subsequent levels, based on previous ones, bring more advanced processes and build them into the culture of the organization, up to continuous self--improvement.

Figure 1. Structure of the BPMM

Source: adopted from [Object Management Group 2008].

Each maturity level is determined by the *Key Process Areas*, identifying the main directions in which the organization should be developed. Each process area in turn is determined by the *Specific (Business) Goals*. Moreover, the BPMM suggests reaching five *Institutional Goals* concerned with each Key Process Area. Good processes cannot cease after the end of improvement work, so institutionalization of the process is needed to build an adequate infrastructure, appropriate culture and overall organizational support, without which improved processes have no chance to survive. Thus, process maturity means not only the degree of organizing processes themselves, but also the degree of organizational support for processes and how processes are rooted in workers' minds and in the culture of the organization. Therefore, to achieve specific goals, the organization must implement *Specific Practices* described in the model and to achieve institutional goals must implement *Institutionalization Practice*. All practices consist of more actions and possibly sub-actions with complementary descriptions.

Table 2. A part of BPMM

Level 2: *Managed* Process area: ***Work Unit Monitoring and Control***
This process area contains 3 Specific Goals (SG): **SG 1 – Work Assignments Are Managed:** *Work assignments and work activities for a work unit are managed against its requirements, estimates, plans, and commitments*. **SG 2 – Performance and Results Are Tracked:** *The actual performance and results of a work unit are monitored against its requirements, estimates, plans, and commitments*. **SG 3 – Corrective Actions Are Performed:** *Corrective actions are performed when the performance or results of a work unit deviate significantly from its requirements, plans, or commitments*.
The Specific Goal SG 3 tied 5 Specific Practices (SP): SP 11 – Address Significant Deviations SP 12 – Address Deviation Causes SP 13 – Communicate Progress SP 14 – Revise Plans SP 15 – Apply Lessons Learned
The Specific Practice SP 13 tied 4 Sub-practices: 1. Obtain and verify the inputs needed to present the progress, accomplishments, issues, and risks with relevant stakeholders. 2. Conduct reviews at points in time that are meaningful to the work unit and the reviewers. 3. Identify and document action items and track them to closure. 4. Document issues and risks identified in the review.

Source: [Object Management Group 2008].

Table 2 shows a small part of the BPMM describing one of the nine areas of the second level of process maturity (*Managed*). The fulfilment of the requirements of Process Area *Monitoring and Control Unit* consists of achieving the three *Specific Goals*. Table 2 shows five specific practices (SP11–SP15) that should be implemented to achieve the third specific goal – *Corrective Actions Are Performed*, and four sub-practices related to Specific Practice 13 – *Communicate Progress*. To assess the degree of process maturity, managers should reasonably and honestly answer the question whether actions carried out in the company correspond to the activities described in the model. As you can see, BPMM is a very detailed and very comprehensive model and achieving the next levels of maturity is always a project that requires support for itself.

3. Representation of the maturity model as a database

Saving data about business processes into a database is an idea known for a long time. The proposed database and knowledgebase is an attempt to go one step further and write in these bases knowledge of how processes can be improved. Databases are well-known representation of reality, easy in processing by computers and widely

accepted by users. Compared to the traditional version of the model, (as a document) database representation has several important advantages:

– replacing the linear structure of the document with database interconnections gives an easy and fast access to the content of the model and search capabilities,
– a possibility of obtaining current state (as-is model) by plain SQL queries,
– a possibility of finding a difference between the current state and the target state (to-do model), by recursive SQL queries,
– an easy finding gaps in the improvement program (list of practices omitted on particular maturity levels).

Figure 2 shows the database schema that stores the BPMM components with additional information about resources and specific tasks. Strict hierarchical structure enabled storing of the whole model in one table with the inner recursive relationship (maturity-model table).

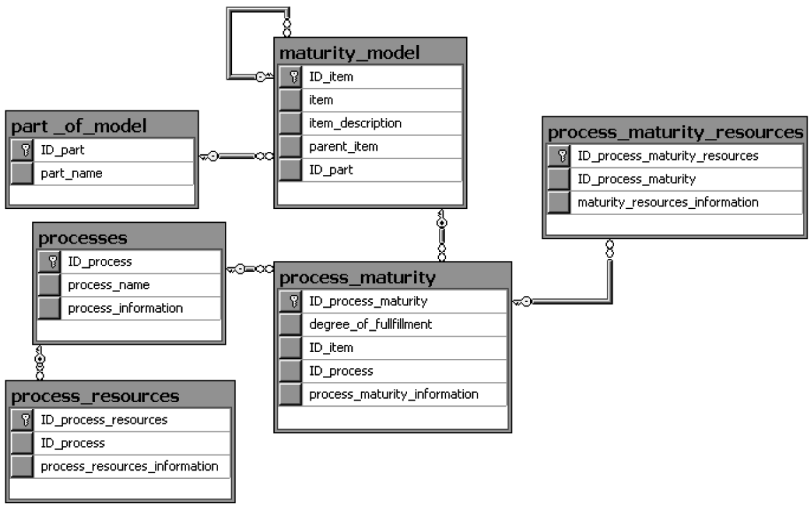

Figure 2. A simplified diagram of the database storing the BPMM data

Source: own elaboration.

The primary objective of the representation model in the form of the database is the ability of building applications that can help participants of the BPMM (business process owners, managers who want to improve their processes) to organize their work. The application can serve as:

– a way to assign specific resources to individual activities and practices and to set priorities, budget and schedules, and to control the proper allocation of resources,
– a tool of monitoring current state and progress of improvement work and implementation of selected measures (KPIs),

– a tool for creating documentation of work related to the achievement of degrees of maturity in accordance with the BPMM,
– a reporting and alerting tool,
– a graphical representation of the hierarchical structure of the BPMM,
– a navigator and a guide on all aspects of the model and as a teaching tool.

Sample screenshots from the application supporting the implementation the BPMM program are shown in Figures 3 and 4.

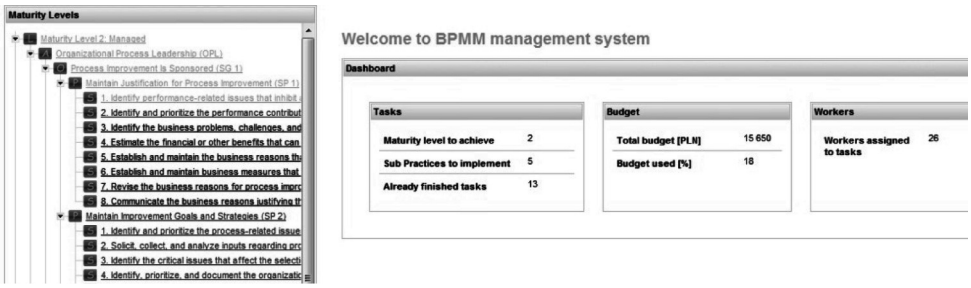

Figure 3. The starting page of application supporting BPMM

Source: own elaboration.

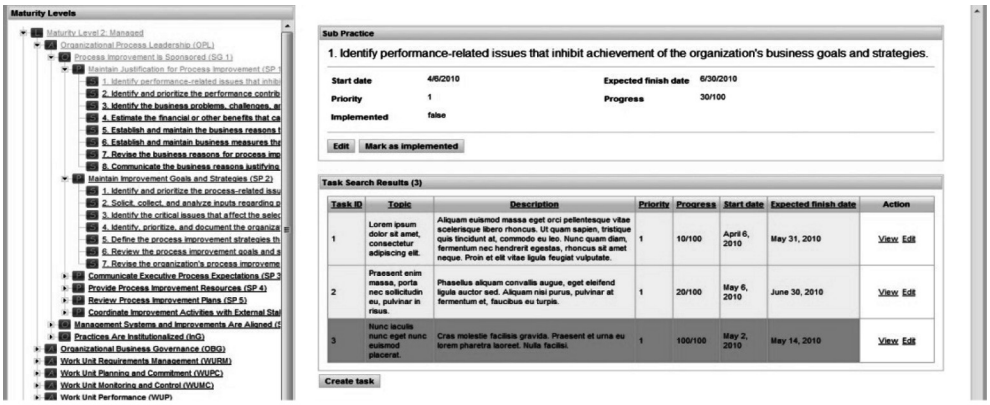

Figure 4. A sample report of the BPMM tasks provided by the application

Source: own elaboration.

The application was described in detail in [Kania, Bacewicz 2010].

4. Using maturity model as a knowledge base

A database representation resolves some problems associated with using the model but not all. To use the database, users still must have their own knowledge about

using maturity models. Moreover, to undertake the proper action and get full use of the model it is necessary to find an interpretation of the obtained picture of the organization and to answer at least the following questions:

– Have the tasks already performed been completed as specified by the model?
– How to assess the current state?
– Does the current state need to be improved and where is it most urgent?
– What improvement actions should be taken?

If we want computers to support introducing the BPMM and answering these questions it is necessary to extend the system with a knowledge base. The model contained in the database can be connected to further data and knowledge sets. Information gathered during the implementation improvement program can be treated as a collection of facts that create a picture of the state of the organization which requires interpretation, evaluation (diagnosis) and propositions of the best way to proceed. A diagnostic knowledge, necessary to make such an assessment can be written as a set of rules - and therefore as a knowledge base. Linking them together with an inference engine gives an opportunity to use an expert system as an assistant in the achievement of process maturity (Figure 5). An expert system can be used:

– in the assessment of the degree of the maturity of process organization,
– in detecting the gaps between the process maturity of processes at different levels of maturity.
– as an advisor in establishing the order and the risk of taking concrete healing action within the organization on the way to achieve higher level of maturity.

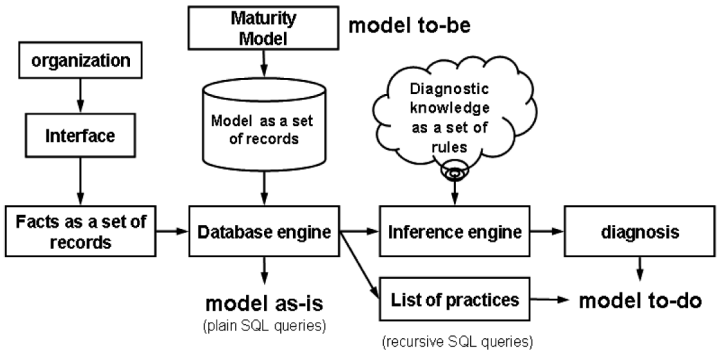

Figure 5. Database enhanced with a diagnostic expert system

Source: own elaboration.

Another possibility is to treat the maturity model itself as a ready-to-use knowledge base, and its descriptions as a set of rules. In the simplest case, each record of the maturity model can be treated as a rule, for example (compare Table 2):

Work Unit Monitoring and Control (PA2) **if**
Work assignments are managed (SG 1) and
Performance and results are tracked (SG 2) and
Corrective actions are performed (SG 3)

Corrective Actions Are Performed (SG 3) **if**
Significant deviations are addressed (SP 11) and
Deviation causes are addressed (SP 12) and
Progress is communicated (SP 13) and
Plans are revised (SP 14) and
Lessons learned are applied (SP 15)

In this case, just using an expert system gives the advantage of providing an inference mechanism. This enables separating knowledge from the mechanisms of its use, focusing on the representation and replacing complex SQL queries with inference mechanism contained in the expert system. Moreover, knowledge base holding the model content can be easily enhanced by an expert with a set of rules that eliminate some of the questions of the model to shorten the way for the evaluation, simplify the assessment and indicate the likely level of maturity. That knowledge can be incorporated into the knowledge base much simpler than into the database. In addition, an inference engine offers built-in explanation mechanisms with additional descriptions and examples.

An even further-reaching proposal is to use more than one knowledge base. This second knowledge base could store, for instance, knowledge about specific information technologies. Each of them has its own requirements and capabilities, and synchronizing the development of the organization with the available information technology is a separate and important issue. Using an advising engine would also be a significant help in implementing the maturity model because the BPMM shows in detail actions to be taken to improve a process, but says nothing about how to do that. Depending on available technologies, the implementation of specific actions could be carried out in various ways (for example, in one organization a specific measure must be calculated manually, while in the other it could by calculated as a data warehouse KPI), and the tasks contained in the model could be related to solutions and practices of the company (Figure 6).

Cooperation maturity model with an additional knowledge base will enable:

– reasoning about ICTs needed to achieve subsequent maturity levels, not fully used ICTs, risks related with ICTs, not properly correlated with organizational maturity,
– making recommendations how to use appropriate ICT tools in processes improvement,
– identifying technologies that are ahead of the maturity of organizational processes or inhibit the achievement of it (indicating the gap between business and IT),
– better synchronization between the business solutions used in the organization and information technology.

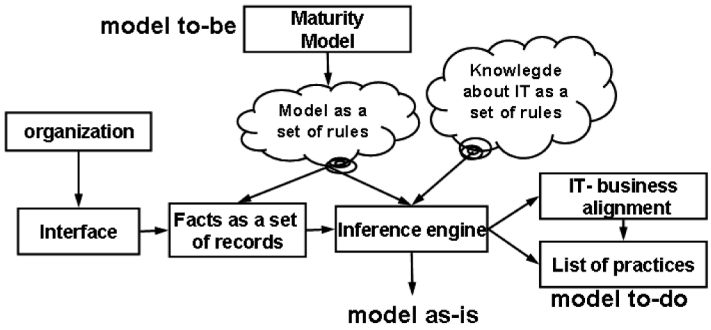

Figure 6. System enhanced with additional knowledge base

Source: own elaboration.

An expert system will help to solve the problem of business-IT alignment and thus to reduce barriers of using maturity models in practice.

5. Conclusions and further research

Conversion of the content of maturity models into database and knowledge base opens up new possibilities to process the knowledge contained in the business process improvement programs. After transformation it will be much easier to use that knowledge in applications supporting the implementation of process improvement programs. Solutions presented in the article have been partially verified in practice and the next step of research will be the construction of a knowledge base using BPMM. A promising way is also representing maturity models in RDF or OWL notation. That will allow using any ontology processing language.

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W KIERUNKU SEMANTYCZNEJ REPREZENTACJI MODELI DOJRZAŁOŚCI

Streszczenie: Wdrożenie programu poprawiającego proces biznesowy jest zawsze trudnym projektem, wymaga złożonych akcji, dużego wysiłku organizacyjnego i często wiedzy grupy ekspertów. Aby ułatwić to zadanie, poszukujemy możliwości wspomagania za pośrednictwem IT. Może to być osiągnięte przez zastosowanie dobrze znanych podejść doskonalenia procesów z wykorzystaniem modeli dojrzałości i przekształceniem oryginalnej postaci takiego modelu do formy bazy danych i bazy wiedzy. Reprezentacja modelu dojrzałości jako bazy danych otwiera nowe możliwości przetwarzania i jego dołączenie do innych danych firmy. Pozwala to na połączenie modeli dojrzałości z diagnostyczną bazą danych i zbudowanie aplikacji, która pomaga menedżerom oceniać i doskonalić procesy biznesowe firmy. Celami artykułu są zaprezentowanie możliwości formalnej reprezentacji semantycznej modeli dojrzałości, takich jak baza danych oraz baza wiedzy, i pokazanie korzyści takiej reprezentacji.

Słowa kluczowe: reprezentacja semantyczna, model dojrzałości, forma bazy wiedzy.