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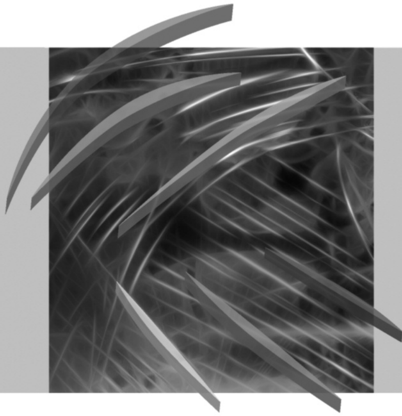

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Intelligent Technologies and Applications

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KNOWLEDGE-BASED SYSTEM FOR BUSINESS-ICT ALIGNMENT

Abstract: One of the approaches to solve the problem of business-ICT alignment is a heuristic approach. It involves the use of external sources of knowledge and teams of experts. On the basis of a thorough diagnosis of the business needs and knowledge about available ICT products, they recommend appropriate solutions. But it is relatively expensive solution that requires access to the group of experts. As an alternative approach we propose using the knowledge stored in models of business goals and processes and a rule-based expert system for reasoning about matching specific ICT with them. The article describes a framework using knowledge base based on maturity models that allows the realization of this task as well as supporting improvement of business processes.

Keywords: business-ICT alignment, maturity models, rule-based systems.

1. Introduction

Achieving a business-ICT alignment is a difficult task. There is growing pressure from business that wants to make sure that investments in ICT are necessary, cost effective and will benefit in supporting the company's strategic objectives. On the other hand, IT projects managers often face the problems arising from the lack of clear business objectives, fast changes in functional requirements and competition between business owners of applications [Khadra, Zuriekat, Alramhi 2009]. The greatest obstacles to good cooperation between business and ICT are problems of mutual understanding of the needs, requirements and limitations of both communities [Luftman, Papp, Brier 1999]. Business people would like ICT professionals to recognize their needs required by the company's strategy and arising during implementation of business processes and to propose appropriate systems, while ICT department expects detailed instructions and formulates expectations that business side is not able to understand.

The agreement would be much easier if both parties could speak the same language using familiar tools that could help to understand problems lie on both sides

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and particularly on the border between business and ICT, and could help to formulate common proposals. The main idea of the proposed solution is combining the knowledge contained in maturity models with the knowledge about possibilities of using ICT to improve processes and using an expert system to diagnose the organization in the scope designated by the content of maturity model. The idea of using artificial intelligence tools to support tasks related to the achievement of degrees of maturity is not new, although it appeared recently (see [Xirogiannis, Glykas 2007;Andrade et al. 2010; Chabik, Orłowski, Sitek 2010]). The novelty of proposed approach is the connection of business processes improvement problems with the problem of business-ICT alignment in one framework.

2. Maturity model as a base for business-ICT alignment

Maturity models (MMs) are well-known approach to process improvement in various areas, not just business. In comparison to other approaches, such as TQM and ISO, MMs are much more detailed in descriptions and have structured construction. In MMs the achievement of specific business goals is directly connected with the set of specific activities (practices). MMs show in detail what actions and in what order should be taken to make the transition from weak or even unorganized processes, toward better ones (Figure 1). This makes MMs very useful in business-ICT alignment. Detailed descriptions make possible to replace vague claims like “we want IT to be cheaper and more useful” (directed from business to IT departments) or “tell us what you want and we will do it” (directed form IT to business), with a set of concrete business goals and practices, which can be linked with particular IT technologies and functionalities.

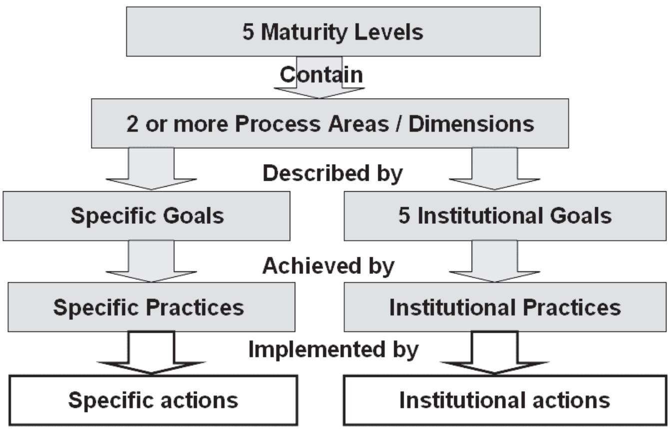

Figure 1. Typical structure of MM

Source: adapted from [Object Management Group 2008].

Since MMs have proved their effectiveness in practice, hundreds of different models in different fields have been already built. They are used by both business managers and ICT professionals. Every group on its own uses them to improve selected areas of activity. So, as a tool, MMs are well known, which is an additional argument for their application to build a basis for a common agreement.

MMs are based on best practices and are result of the work of teams of practitioners, theorists and management specialists in different fields. They are the instantiation of their expertise and form a kind of knowledge base about processes in the area in which they operate. Moreover, hierarchical structure of models allows translating them to the formal knowledge base almost directly. At the same time, MMs by the content of successive practices could create fixed dictionary of terms that are understandable both for managers and for IT professionals. But, although MMs say much about “what to do”, they say nothing about “how to do”, let alone anything about “what tools to use”. Users of the model have to find on their own a proper way and tools to implement practices described in the model. We can deliver missing knowledge about tools to users by linking maturity model with the knowledge about what ICT tools can be used to implement practices, and help ensure conditions for their optimal use.

3. Functioning and architecture of the framework

The functioning of the proposed framework is based on the assumption that it is possible to:

– use maturity models to obtain knowledge about business goals that an organization needs to achieve and what to do, to have good processes that enable the achievement of these goals and to express that knowledge in the form of rules,
– acquire knowledge about relationships between business processes, business objectives and ICT and to express that knowledge in the form of rules,
– express the state of a specific organization as a set of facts and refer it to this knowledge.

This accumulated knowledge will enable reasoning about the correctness of the activities of the organization and matching business goals with concrete ICTs, according to the procedure:

– transform maturity model into the rule base,
– refer ICTs to the content of the model and transform this knowledge into the rule base,
– gather the facts describing the state of the organization in relation to the maturity model,
– you can infer about comparing the state of the organization with the recommendations of the model,
– you can infer about current and potential use of ICT available in the organization to implement the recommendations of the model and achieve business goals.

To implement this procedure we need to prepare proper environment and design the form of knowledge base needed for inference engine. The proposed solution is inspired by the ontology of facts introduced by T. Halpin [2000] and based on the rule-based expert knowledge representation. Proposed architecture includes (Figure 2): 2 fact bases, 4 rule bases, additional rules, inference engine, reporting and visualization tools, and supporting applications.

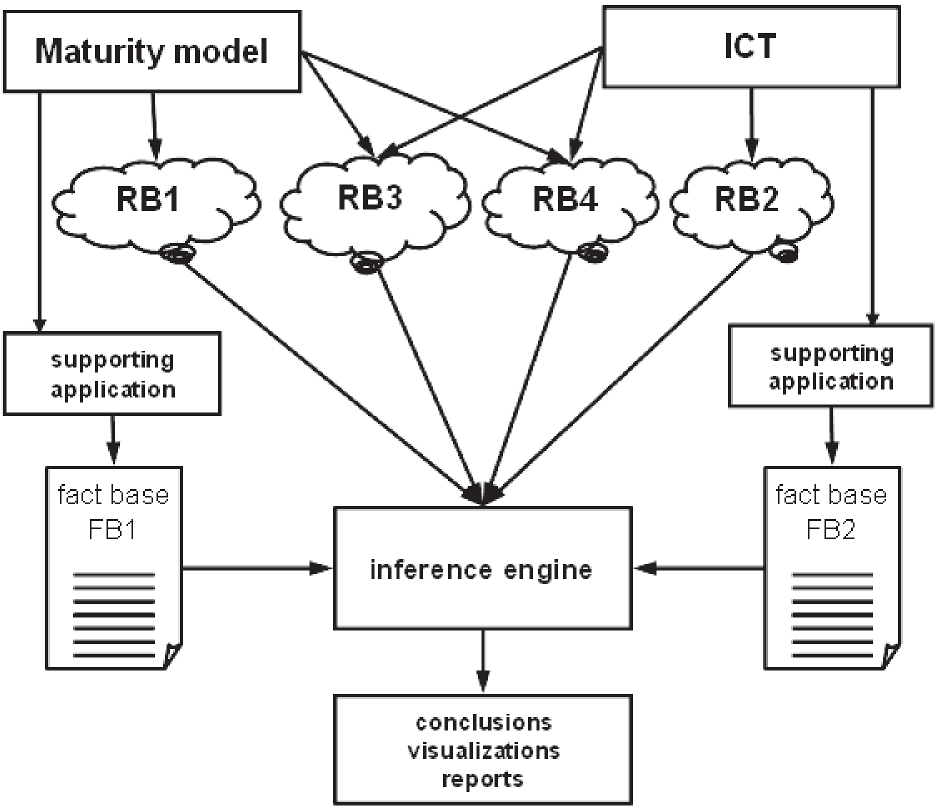

Figure 2. Architecture of the framework (signs used in figure are described in the text)

The components of the framework are described in detail further.

3.1. Fact bases

To diagnose the organization it is necessary to get its description. It is presented in the form of the two fact bases:

FB1 – collects facts about practices from selected MM implemented in the organization:

```
[practice n implemented] = [True | False]
```

FB2 – gathers facts about using ICT in the organization, and is of the form:

`[ICT used n] = [True | False]`

Both fact bases are created by users in a particular organization. In the case of larger models a number of practices may reach hundreds and even thousands of items. However, gathering facts can be relatively easy supported by simple specialized database or spreadsheet applications (supporting applications in Figure 2).

3.2. Rule bases

Proposed framework contains four base rules which describe, respectively:

RB1 – maturity model used in the framework (maturity levels, business goals, processes, practices, etc.),

RB2 – relationships between ICTs themselves,

RB3 – practices from MM that should be implemented to take full advantage of ICT,

RB4 – links between ICTs and practices that may be supported by the specific ICT.

We proposed separate rule bases, because different inferences need different rule bases (see Table 1 in Section 2.4.), and the rules can be built independently by different teams of experts. However, to ensure proper inference, notation and a set of concepts of all components should be compatible (all bases should share the same ontology). For example, a user cannot apply the term “database” if in the other rule base the term “DBMS” is used. Thanks to that, the next advantage of the framework in addition to the possibility of using expert system is introducing a common conceptual platform provided by MM, where business and ICT specialists can talk.

RB1 – knowledge contained in the maturity model

For a demonstration, we use a small part of e-learning Maturity Model (eMM) [Marshall 2007] designated for improving e-learning processes and a few ICTs, to show how to write down the knowledge in the rule bases. One of the dimensions (**Dim**) in eMM is: *Processes surrounding the support and operational management of e-learning*, and one of the business processes in that dimension is (**BP**) *Student inquiries, questions and complaints are formally managed and collected*. To achieve fourth level of maturity in this process, the author proposes three obligatory practices:

PR1 – Information on the type and resolution of student complaints and concerns is monitored regularly.

PR2 – Feedback from students regularly collected regarding the effectiveness of the collecting and resolution of student complaints and concerns.

PR3 – Feedback from staff regularly collected regarding the effectiveness of the collecting and resolution of student complaints and concerns.

At this point we would like to emphasize that:

– presented example covers only a very small part of the model which consists entirely of several dimensions and hundreds of practices,
– knowledge about ICTs can be written at different levels of detail (from the whole technology – as in this example, to the individual features of specific software products).

Rules relevant to this maturity model structure have the form:

```
[level p of model completed]          if
[level p-1 of model completed]        and
[level p in dimension 1 achieved]     and
…                                     and
[level p in dimension m achieved]
```

// to complete level p we need to complete lower level and achieve level p in all dimensions defined in the model,

where: p is the level of maturity, m is the number of dimensions in the model.

Due to structure of MM, rules in the RB1 are hierarchical, and recursion in the rules' body shows that to reach higher level of maturity, reaching the lower one is needed (one should not skip levels).

```
[level p in dimension m achieved]     if
[level p-1 in dimension m achieved]   and
[level p of process 1 reached]        and
…                                     and
[level p of process k reached]
```

// to achieve level p in dimension m we need to complete lower level and reach level p in all processes defined for this dimension.

where: p is the level of maturity, m is the number of dimensions in the model, k is the number of processes to be implemented at the level m of a dimension.

For our example this rule looks like:

```
[Level 4 of Dim achieved]   if
[Level 3 of Dim achieved]   and
[Level 4 of BP reached]     and
… //other BPs defined in model to reach
```

The last rule is:

```
[Level p of process k reached]   if
```

```
      [level p-1 of process k reached] and
      [practice 1 implemented]         and
      …                                and
      [practice n implemented]
// to reach level p in process k we need to complete
lower level and implement n practices defined for this
process.
```

where p is the number of level of maturity, k is the number of the process to be implemented at the level p of a dimension, n is the number of practices to implement.

Respectively exemplary rule is:

```
[Level 4 of BP reached] if
[Level 3 of BP reached] and [PR1 implemented] and
[PR2 implemented] and [PR3 implemented]
```

Maturity models are constructed in different ways (see [Lahrmann, Marx 2010] for details), but in general, there are only a few different forms of maturity models, so it is not a problem to prepare templates of rules for each of them. The only condition is that a model preserves original concepts: maturity levels, hierarchical structure and practices or sub-practices. RB1 is prepared by an expert familiar with the process management, content and structure of the selected MM. It is also possible to automatically generate a knowledge base, if the entry model is sufficiently structured. RB1 is relatively constant and depends on the state of knowledge related to the field of the MM. RB1 is a removable element of the proposed framework. We can apply various MMs in the framework, depending on the area where we want to increase the maturity, but after such a change, it is necessary to modify RB3 and RB4.

RB2 – ICTs and their mutual relationships

RB2 stores knowledge about ICTs and relationships among them in the forms of rules:

```
      [ICT n may be used]   if
      [ICT 1 used]          and
      …                     and
      [ICT m used]
// to use particular ICT n we should first use m other
ICTs
```

where n is the number of specific ICT, m is the number of ICT, which should be implemented before.

RB2 is created by an ICT expert on the basis of the interactions between particular technologies. The content of this rule base is relatively constant and depends only on the development of information technology. RB2 is a constant part of the framework. Introducing knowledge about new technologies into RB2 involves modifications in RB3 and RB4. A part of the exemplary matrix and one of exemplary rule are presented in Example 1.

Example 1. Part of ICT relations matrix

ICT needed (upper side) to implement other ICT (left side)	Local databases	Data warehouse / KPI	ETL tools	BSC
Local databases	×	×	×	×
Data warehouse /KPI	✓	×	×	×
Workflow and document mgmt	✓	×	✓	×
ETL tools	×	×	×	×
Data mining tools	✓	✓	✓	×

Where each "✓" sign causes generating one condition, so one of the corresponding rules is:

```
[Workflow and document mgmt may be used] if
[local database used] and [ETL tools used]
```

RB3 – business requirements for ICT application

The use of ICT depends not only on technology but also on the maturity level of processes in organization. It reflects well-known truth that high-level information technologies demand well-organized processes. Knowledge about these dependencies is expressed as:

```
[ICT n may be used]          if
[practice 1 implemented]     and
…                            and
[practice k implemented]
```

where n is the number of specific ICT, k is the number of practice in MM.

As before, this knowledge can be saved as a matrix (Example 2).

Example 2. Part of the matrix for RB3

Practices we have to introduce to fully implement ICT	Local databases	Data warehouse /KPI	Data mining tools	BSC
PR1	×	×	×	✓
PR2	×	✓	✓	×
PR3	×	✓	✓	×

Where each "✓" sign causes generating one condition, so one of the corresponding rules is:

```
[Data mining tools may be used] if
[PR2 implemented] and [PR3 implemented]
```

RB3 and RB4 together store the most important knowledge from the point of view of business-ICT alignment. RB3 and RB4 are created by managers familiar with MM and ICT experts together. In RB3 rules link every ICT with practices from maturity model to show what practices are necessary for effective implementation of specific ICT. To build this rule base, experts will have to combine the functionality offered by different technologies with specific practices proposed in the MM. It will not be possible if business experts will not explore possibilities offered by the ICT and ICT experts will not indicate practices that must be implemented to make their systems worked. Hence, functionality, capabilities and technological requirements of ICTs will be expressed in terms of business, and business terms linked to specific technologies.

As MMs usually contain a lot of practices (eMM contains over 880 practices) and number of ICTs is also high, to facilitate understanding of mutual relationships and facilitate experts' communication, rather than directly in the forms of rules, knowledge can be collected in the visual form of the matrix. Each row of the matrix corresponds to one practice from the maturity model, and each column corresponds to the specific ICT or application (Example 3). At the intersection of row and column experts point out whether the implementation of specific practices is needed to make full use of ICT. Matrixes can be easily and automatically translate to the set of rules. In the basic version, only the values 1 or 0 (needed/not needed) are used. In the extended version it is possible to enter values from the interval [0, 1] to indicate the degree of certainty that experts consider such a need – which enables uncertain reasoning, offered by some inference engines.

RB4 – ICT supporting specific practices

RB4 is similar to the RB3, but the direction of links is inverted. In opposite to RB3 rules join every practice from maturity model with ICTs to show what ICT can be used for better performance of specific practice:

```
[Practice n can be supported]    if
[ICT 1 may be used]   or
…                     or
[ICT m may be used]
```

where n is the number of specific practice, m is the number of ICT.

As before, knowledge about that is written in the form of matrix and as a set of rules (see Example 3). As mentioned before, in our example, RB2 contains ICTs names, but it may contain more detailed knowledge in the same form. For instance, it can be used to store modules and functionalities of particular ERP system. Respectively, RB3 and RB4 should contain relations between practices and ERP elements. Then, we can conduct reasoning about business-ERP alignment.

Example 3. A part of the matrix for RB4

ICT that could support practices	Local databases	Corporate portal	Social applications	Text mining	Workflow/ document mgmt
PR1	×	×	×	✓	×
PR2	✓	×	✓	×	✓
PR3	✓	✓	×	×	✓

And one of the corresponding rules is:

```
[PR2 can be supported] if
[local databases is implemented] or
[social application is implemented] or
[workflow/document mgmt is implemented]
```

3.3. Additional Rules

Maturity models recommend sustainable development. In practice, it happens, however, that implementation of some of the practices precedes the development of the entire organization. It is not impossible, but generates certain risks. Additional rules that allow reasoning about risks arising from leaving gaps in maturity levels have the following form (rules for dimensions and the whole model are similar):

```
[There is a risk concerned with practice n] if
[practice n implemented]         and
[level p of BP reached]          and
[p < k-1]
```

where n is the number of specific practice, p is achieved level of maturity, k is the level of maturity the particular practice belongs to.

Another rule allows reasoning about insufficient use of ICT, resulting from the omission of certain practices. It has the form (cf. RB3):

```
[ICT n not fully supported] if
[ICT n used]                and not
(
[practice 1 implemented]    and
…                           and
[practice k implemented])
```

where n is the number of specific ICT, k is the number of practices.

For the completeness of consultation, to show ICTs that are used properly (see RB3 and RB4) we can still add a rule:

```
[ICT n properly used] if
[ICT n ]             and
```

```
[ICT n may be used]
```

where n is the number of specific ICT.
All above rules are constant elements of the knowledge base.

3.4. Scope of consultations

The range of stored knowledge and facts enable reasoning about:
R1 – process maturity level achieved in organization in relation to the selected MM,
R2 – gaps in implementation of practices and risks arising from that facts,
R3 – possible next steps in process improving,
R4 – opportunities to support implemented practices with particular ICT,
R5 – ICTs needed on the next levels of process maturity,
R6 – not fully used ICTs,
R7 – risks related with ICT, not properly correlated with organizational maturity,
R8 – practices, and ICT, that should be implemented to effectively use specific ICT.

Table 1 shows the relationship between the proposed inferences and components of the framework.

Table 1. Required elements depending on the scope of reasoning

Inference	Elements required	Scope
R1, R2, R3	RB1, FB1	Maturity model, processes
R4	RB4, FB1, FB2	Business-ICT alignment
R5	RB1, RB4, FB1, FB2	
R6	RB1, RB4, FB1	
R7, R8	RB1, RB2, RB3, RB4, FB1, FB2	

Inference is carried out entirely by an expert system. It can also be used to provide detailed explanations to the user. The first group of tasks (R1–R3) is associated with a diagnosis of the processes themselves. R4–R8 tasks focused on the diagnosis of business-ICT alignment, and the better use of ICT available in organization. The effects of reasoning will be used primarily by process managers and IT managers. An expert system can also help in adopting the recommendations by preparing a roadmap – a list of further actions to be implemented. It can be readily determined based on the differences between the current state and the target level defined by the model. Hence, that way an organization can get a procedure for common transition for business and ICT, from the existing state (as-is) to the final one (to-be).

Suppose now that in a specific organization only local databases are used, practices PR1 and PR2 were implemented, but PR3 was not. Based on the knowledge presented in the example, a user can expect the following information from the expert system:

– To achieve fourth level of maturity of this process, it is necessary to implement PR3.

– To support PR2, social applications could be used directly and document management systems after introducing ETL tools.
– To effectively implement a data warehouse, it is necessary to implement PR3, etc.

These conclusions seem trivial, but we should remember that for the full model an assessment would be more comprehensive and obtaining it without the help of expert system – much more difficult.

Consultations may be conducted ad hoc or regularly. Fewer consultations are possible in organizations where sustainable development and a high degree of business-ICT alignment have been diagnosed. The increased frequency of consultations is needed in organizations, where a large number of gaps was detected, as they have to cope with an increased risk of loss of good processes, lowering the levels of maturity in certain areas or even across the organization. In that case, periodic verification of fact bases allows early detection of such troubles and preventing regress. The rule bases content should be periodically updated due to the development of knowledge about organizational processes and the emergence of more developed maturity models and because of the introducing new functionalities that can support these practices, which previously could not be supported.

4. Conclusions and further research

With proposed framework we try to resolve two problems: supporting improving business processes itself by helping in using MM and improving business-ICT alignment by creating common ontological platform and reasoning about risks and possibilities. Besides benefits described earlier, through the proposed framework managers can:
– get self-assessment in relation to selected model and explanation of this evaluation,
– get assessment of how much organization is ready to implement specific actions to improve the process maturity or to introduce concrete ICT,
– lower barriers of pro-quality programs through the use of expert system in place of the experts (better access to the knowledge, cost reduction, etc.).

As first trials confirmed usability of proposed solution, the next step will be building support applications which will allow automatic translation of maturity model to knowledgebase and integration of all blocks and closing them into one framework.

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OPARTY NA WIEDZY SYSTEM DOPASOWANIA BIZNES-ICT

Streszczenie: Jednym z podejść do rozwiązania problemu dopasowania biznes-ICT jest podejście heurystyczne, polegające na wykorzystaniu zewnętrznych źródeł wiedzy i zespołów ekspertów, którzy na podstawie dogłębnej diagnozy potrzeb biznesu i wiedzy o dostępnych produktach ICT rekomendują odpowiednie rozwiązania. Jest to jednak rozwiązanie stosunkowo drogie i wymagające dostępu do grona ekspertów. Alternatywą jest wykorzystanie wiedzy dostępnej w modelach celów i procesów biznesowych oraz wykorzystanie systemu eksperowego do wnioskowania o możliwości dopasowania do nich konkretnych ICT. W artykule przedstawiono propozycję postaci bazy wiedzy opartej o modele dojrzałości umożliwiającą realizację tego zadania oraz usprawnianie procesów biznesowych.

Słowa kluczowe: dopasowanie business-ICT, modele dojrzałości, systemy ekspertowe.