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Information Systems 30 (2005) 423–443
www.elsevier.com/locate/infosys

A methodology and tool support for managing business rules in organisations ☆

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Received 3 May 2001; received in revised form 14 April 2004; accepted 26 May 2004

Abstract

Business rules are evidently important for organisations as they describe how they are doing business. Their value has also been recognised within the information system (IS) domain, mostly because of their ability to make applications flexible and amenable to change. In this paper, we propose a methodology that helps business people and developers to keep business rules at the business level inline with the rules that are implemented at the system level. In contrast to several existing approaches that primarily focus on business rules in the scope of an application, our methodology addresses the entire IS of an organisation. The paper also describes requirements for a tool support that would be appropriate to support the methodology.

Keywords: Business rule; Business rule management; Enterprise modeling

1. Introduction

In the last decades, business rules have become popular in the information system (IS) community mostly because of their ability to make applications flexible and amenable to change (e.g. [1-7]). Both, researchers and practitioners are convinced that since business rules are very sensitive to business changes they require explicit treatment during IS development to ensure the IS agility. Otherwise many problems may occur. For example

- Since not acquired systematically and completely, business rules do not reflect real conditions of the business environment. Consequently, applications are developed that do not meet business needs.
- There is a lack of documentation on business rules.
- Business rules are buried into program code. It is not clear, what kind of rules govern an application, when the rules are triggered and how they are implemented.

☆ Recommended by P. Loucopoulos

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doi:10.1016/j.is.2004.05.003

- Business logic is hard to maintain as rules are distributed across the application logic.
- Business rules are hard to control, since there is no common and single purpose store for them.

The aforementioned problems have initiated a lot of research in academia and industry. As a result, a variety of tools and approaches can be found today that provide IS developers with facilities for managing business rules in IS development [8-12]. Business rules, however, do not pertain to IS or to its application software. Business rules are set and owned by the business and have to be therefore managed by the business.

In the paper, we emphasise that business rules may not just serve as a mechanism for making applications flexible, but could also be used as a bridge that helps to keep the entire IS of an organisation aligned with its business. As the main contribution, we propose a methodology and requirements for a tool support that facilitates business people and developers with a support for keeping business rules at the business level inline with rules at the system level. The methodology defines all the necessary activities that have to be performed within IS development in order to establish the link between an implementation of a business rule (e.g. *trigger* in database, *method* in program code, etc.) and its sources in business environment. When changes occur at the business level, the methodology and tool assist in finding the applications and their components (no matter what kind of technology they use) that are influenced by the changes.

The paper is organised as follows. Section 2 gives a brief history of business rule related research, discussing contributions from different research areas. In Section 3, we provide a motivation for business rule management in enterprises and give a brief explanation of our research approach. Section 4 proceeds with the discussion on the business rule management process, examining the activities that are required to manage business rules for an overall organisation. In Section 5, the requirements for building an appropriate tool support for the business rule management process are discussed. Finally, a discussion is provided on related work.

2. Background

The roots of business rules come from the Artificial Intelligence community, where they have been successfully applied as a way of representing knowledge. In the *knowledge-based systems*, the knowledge and reasoning of a human expert can be captured and stored in a form of complex networks of rules. The rules are typically described using declarative languages that do not imply order or flow of control. The rules are stored in a *Rule base* and processed in a special component, called *Inference engine*. The inference engine evaluates the conditions of the rules and at any point in time determines which ones are eligible to fire.

Extensive business rule related research could also be found within the Database research community. As a result of this effort *active databases* have emerged [13-17], which, as opposed to passive databases, employ active components such as *triggers* and *database procedures* to perform their own data integrity functions. Another database related research on rules includes *deductive databases* [2,18,19]. While traditional database systems only manage *extensional knowledge* that is embedded in facts and instances, deductive databases add *intentional knowledge*, which is beyond the factual contents of the database. This kind of knowledge can be fully specified with rules and is stored in a rule base before the database is established [20].

Once the idea of implementing business rules in database systems emerged, substantial effort was put into discovering a robust and powerful method for representation of business rules in data models [6,17,21–23]. As opposed to static business rules that can be expressed in Entity-Relationship-Models (ERM), dynamic business rules are not supported, as ERMs do not allow an explicit representation of events, conditions or actions. Consequently, several extensions to the ERM have been proposed (e.g. ER-RM [24] or BIER [25]) as well as other techniques and methods (e.g. ELH of SSADM [26] or the Ross Method [6]). A comparison of selected methods can be found in [21].

As interest in business rules grew, advocates of the approach became aware that an explicit manipulation of business rules was required in

order to support the entire business rule life cycle. As a result, numerous research projects have been carried out in support of business rule discovery, analysis, modelling, classification, articulation, formalisation and documentation (cf. [5-6,8,27–30]). Significant contributions regarding the rule-based paradigm have been received from ESPRIT-projects RUBRIC, TEMPORA and *From Fuzzy to Formal* (F3) (see Section 6).

Business rules also appeared in the object-oriented community. While it seems that proponents of the object-oriented approaches share the opinion that business rules deserve attention, they still disagree on where to put them in object-oriented models [9,31]. Some believe that since objects are responsible for their own data and behaviour, business rules should be modelled in the object/class models as properties of classes. Others are trying to achieve the synergy by merging numerous paradigms, including business rules. In [32], Nilsson points out that the fact that rules are spread and converted into methods is one of the weakest points in object orientation. Although the recently standardized *Unified Modelling Language* (UML) offers elaborative metamodel, it does not provide much guidance for modelling business rules. The only usable element for expressing business rules is a constraint element, which can be attached to any other element. The *Object Constraint Language* (OCL), which is provided for detailed specifications of constraints, seems useful at a design level; however it does not prove that well in systems requirements analysis when working directly with business people [33].

3. BRM—the motivation

This section provides motivation for keeping information on how business rules evolve from their origin in business environment to their implementation in IS.

3.1. Capturing the rational behind business rules

From an enterprise perspective, rules can be defined as assertions that constrain patterns of the enterprise behaviour [34]. They exist in all kinds of forms, ranging from simple to very complex and dynamic. According to their source, business rules can be either internally or externally driven. Internal rules are defined within the organisation and are often derived from *strategic elements*[1] that present the motivation for their existence. External rules, on the other hand, come from the outside world. They include government regulations and laws that govern behaviour in a given industry, or rules that derive from professional practice, e.g. rules that result from standards within the profession itself.

Depending on their information contents, business rules can be based on either *explicit* or *tacit* knowledge. Explicit knowledge is formalised knowledge that is easy to express in form of *principles*, *procedures*, *facts*, *figures*, *rules*, formulas, etc. Contrariwise, tacit knowledge is not easily expressed and visible (see [35]). But when information contents of a business rule correspond to sufficiently routinized behaviour, the rule takes the form of explicit knowledge. Such are, for example, rules that govern important operations, for instance *customer credit approval* in a bank, *damage declaration* in an insurance organisation, or *billing*, *payroll*, and other similar operations that can be found in almost every organisation. In IS development, transformation of rules that apply to such operations (into requirements) is almost straightforward, since specifications of the rules are already present in *documents*, *procedures*, *policies*, *regulations*, *user manuals*, etc.

It has to be emphasised, however, that explicit business rules are only manifestation of typically richer knowledge. In every organisation, operation procedures can be found that are standardised as a result of experience and feedback from their use. Business rules that are derived from the routinized operations can be documented and translated into explicit business rules and further automated within an IS. In this way, they become available to those who lack the knowledge of the operation. However, in order to understand why a certain

[1] With the term "*strategic element*" we denote elements such as *business vision*, *mission*, *goal*, *problem*, *critical success factor*, etc.

explicit rule exists, and what kind of motivation is behind it, one must first comprehend the knowledge on which the explicit rule is developed.

3.2. Establishing the link between business and IS

Changes in an organisation's business environment almost never happen spontaneously, without any reason, but are typically driven either from internal decisions of the organisation's management or from external forces, such as government laws and regulations. Such changes very often lead to adaptation of existing business processes and frequently require new or modified systems support. What usually changes in the business processes and in the supporting systems are business rules and their implementations, which are re-examined and modified according to the new objectives, goals and policies. This requires the changes to be coordinated at the enterprise level, as the business rules are spread across the entire organisation and its supporting systems. In practice, business rules are either assigned to actors that have certain responsibilities in conducting business processes, or they are implemented and automatically executed in specific subsystems of the organisation's IS. A particular business rule may be involved in several business processes, and supported by several subsystems. Furthermore, in a particular subsystem, each rule may be implemented in a number of different ways (e.g. as a *database trigger*, *stored procedure*, *middletire component*, etc.). In order to be able to keep supporting systems consistent with the business requirements, it has to be documented how business rules evolve from their origin to their implementation. In this way, it is easier to determine what are or what could be the implications of business changes for the supporting systems. Managing information about the business rules evolution and coordinating their changes is basically what we call a *business rule management* (BRM).

The need for establishing an explicit link between a business and an IS has been recognised before [3,31,36–40]. If such a link was established, then it would be much easier to maintain IS in a condition that really reflects the organisation's requirements. Since business rules represent elements that are most often influenced by the changes in business environment, it seems reasonable to use them as a means through which the link is established. This again requires business rules to be managed centrally for the entire organisation.

3.3. Research approach

This section briefly explains the approach taken in our research (BRME).[2] BRME has been motivated by the experiences acquired while working at several strategy planning projects for medium and large organisations, and through the examination of related work. It was discovered in several organisations that there was a lack of information on how their business policies were enforced within supporting ISs. This was presenting problems for organisations, particularly for large ones, where several IT systems were in use to support business processes. To offer greater business agility this kind of information was found crucial.

Evaluation of the existing research has revealed that business rules had extensive support for IS development on one hand (e.g. [1-6]), and for business modelling on the other (e.g. [8,29,32,41]). However, we have not found any evidence, within the existing research, that there is an approach for managing business rules in a way as it is described in this paper.

After the evaluation of the existing work, we designed a BRM process together with a prototype for its support. The process was determined as a scenario identifying all the necessary activities to manage business rules from the business perspective. Both, the scenario and the prototype, were tested on two cases. The experiences acquired have helped to refine the process. An overview on the case studies is provided in Section 4.4.

Based on the experiences with the prototype we have identified the most important requirements for an appropriate tool support. The tool development is sponsored by *Kapitalska družba, Inc*.

[2]The research project BRME—"Business Rule Management in Enterprises" was partially sponsored by the Slovenian Ministry of Information Society and the Slovenian Ministry of Education and Sport. Development of the tool support is sponsored by Kapitalska druzba, Inc.

4. BRM—the process

In order to manage business rules for an entire organisation and to establish and keep the link between its business and supporting IS several activities are required. Besides the activities that are dedicated to managing rules during IS development, there are also activities that have to be performed at the business level. As a part of the BRME project, an investigation was carried out with an aim to identify these activities. Various business rule-based approaches have been studied from academia and non-academia. Special focus was given to the business perspective.

At the business level, the most important activity that is required for BRM is to identify and document the elements that may act as a source, motivation, or explanation for business rules. There are several such elements: *business goals*, *problems*, *policy*, *regulations*, *business processes*, etc. Of course, it is not reasonable to expect these elements will be formalised solely to support business rule acquisition. In the BRME project, enterprise modelling (EM) was identified as a promising technique that may lead into formalisation of business environment to the extent required for BRM.

To find out how business rules integrate into enterprise models, extensive examination of the relationships that bind business rules to a number of concepts modelled in EM was conducted. The next two sections give an overview on the findings. Detailed information can be found in [42].

4.1. Modelling business rules within enterprise models

EM is an activity that is used to create abstractions (models) of different aspects of an enterprise, typically with a purpose to understand and share the knowledge of how the enterprise is structured and how it operates. EM is applicable in a variety of contexts, e.g. *business process reengineering*, *strategy planning*, *enterprise integration* and *IS development* [43].[3]

[3]Some of the most common driving factors for EM are discussed in [44,45]. More interesting thoughts and practical results of expanding EM to cover enterprise knowledge management can be found in [29,46–48].

There is a number of ways how to adequately represent enterprise aspects. For the needs of the BRME project, three different approaches have been studied: the Nilsson's *generic modelling perspectives* [32], the *Enterprise Knowledge Development approach* (EKD) [41] and the *Business modelling language* of Eriksson and Penker [44]. This gave us a good understanding of the position of business rules within other enterprise perspectives.

One of the possible ways for an adequate representation of business architecture, based on EKD [41], is illustrated in Fig. 1. The approach recognises five sub-models, the Business rule model being one of them

- *Business vision model*: Describes an overall strategy of the business, focusing on goal structure and problems that must be solved in order to achieve those goals.
- *Business process model*: Describes the processes that are set to achieve the enterprise goals. The business process model describes how the enterprise processes interact, and clarifies the processes inputs and outputs.
- *Business rule model*: Defines and maintains explicitly formulated business rules as well as some of the rules that are implicit in other models.
- *Business actors and resource model*: Focuses on the structures of resources and their relationships with actors, processes, goals and other components of the enterprise model.
- *Business concepts model*: Establishes a common vocabulary for all the concepts that comprise the business environment (e.g. products, services, information resources, etc.). It helps to avoid misunderstandings and different interpretations of terms used in the business.

For the purpose of the BRME project, each particular view was studied individually, concentrating on the relationships between the business rule model components and components from the other models. The most important relationships are enlisted below

- *Business rule—Business vision model*
  - A business rule supports the achievement of a business goal

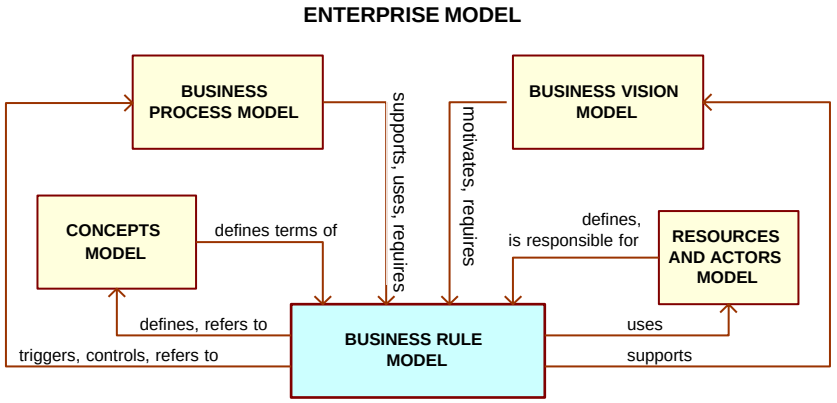

Fig. 1. Enterprise model and its sub-models.

- A business rule hinders the achievement of a business goal

- *Business rule—Business process model*
  - A business rule triggers a process or activity.
  - A business rule restricts the execution of a process or activity.
  - A business rule defines an *ECA structure* (event, condition, activity) with the following meaning: if the *event* happens and the *conditions* are met, then execute the *activity*. Each business process can be described as a composition of ECA structures [8].
  - A business process executes (or uses) a business rule.
- *Business rule—Business concepts model*
  - A business rule description consists of business terms. Each business rule is written in some syntax and is based on some vocabulary. In EM, the most important part of such a vocabulary is defined within the concepts model.
  - A business rule defines a business concept. Rules that define business concepts are typically inherent in concepts models (e.g. as concepts or associations).
- *Business rule—Business actors and resources model*
  - A business rule is in relationship with an actor. E.g.: the actor is responsible for the business rule execution, the actor has defined the business rule, the actor has requested the business rule, etc.
  - A business rule is in a relationship with a resource. E.g.: a business rule is executed in an *organisation unit*, a business rule is a part of a *business function*, a *business role* is responsible for execution of a business rule, etc.

4.2. The evolution of business rules through EM and IS development

The previous section has shown that a lot of information on business rules can be deduced directly from enterprise models. This makes EM a suitable technique for business rule modelling. There are several arguments supporting this idea:

- The enterprise model captures knowledge, which explains the motivation for the existence of rules.
- In enterprises, several different systems are typically developed to provide all the necessary information that is essential for establishing a productive and efficient working environment. In practice, these systems are never developed all at once but it usually takes more than a few projects to develop them. Instead of discovering business rules for each particular system individually, the enterprise model can serve as a useful starting point.
- The enterprise model has to reflect the real business environment; otherwise it cannot serve its purpose. Enterprise models are therefore

continuously adapted and maintained. Thus focusing on business rules as a part of EM assures that the rules are up-to-date.

- EM addresses strategic elements of the enterprise. These elements very often present direct or indirect motivations for business rules. In IS development, on the other hand, the enterprise strategic perspective is often neglected.
- There are many business rules that are already inherent in enterprise models.

On the other hand, there are also arguments that put in question the idea of modelling business rules within EM. As discussed before, EM can be applied in various contexts, not all of which are always appropriate for business rule modelling. Often, business rules present information at the level of abstraction, which is not in balance with the level with which elements from the other perspectives are addressed. In our practice, we have developed over ten strategy plans for different enterprises, where EM was employed to represent the enterprise current state and its vision for the future. In many cases, especially when large enterprises were modelled, business rules were not captured at all, since they were found as too detailed piece of information to be modelled at the business level. In some other cases, for example, when business processes were reengineered, the observation was more detailed, and the identification and acquisition of rules more appropriate.

Fig. 2 illustrates how information on business rules may be captured into business rule model, taking into account the dilemma discussed above.

From the business perspective, business rules can be acquired within EM. Depending on the purpose EM is applied, rules may be elaborated in more or less detail or not at all. What is important is that if acquired, rules are described in a business language understandable to business people and that they are not presented as isolated elements, but are linked to other elements comprising the enterprise model.

In IS development, the observation is deeper. Business rules form an important source in requirements acquisition and need to be elaborated in more detail. This additional information supplements the business rule model. At this level, it is important that rules are presented in an unambiguous form, as they are to be implemented in the IS. Note that in case when business rules are not captured within EM, the business information

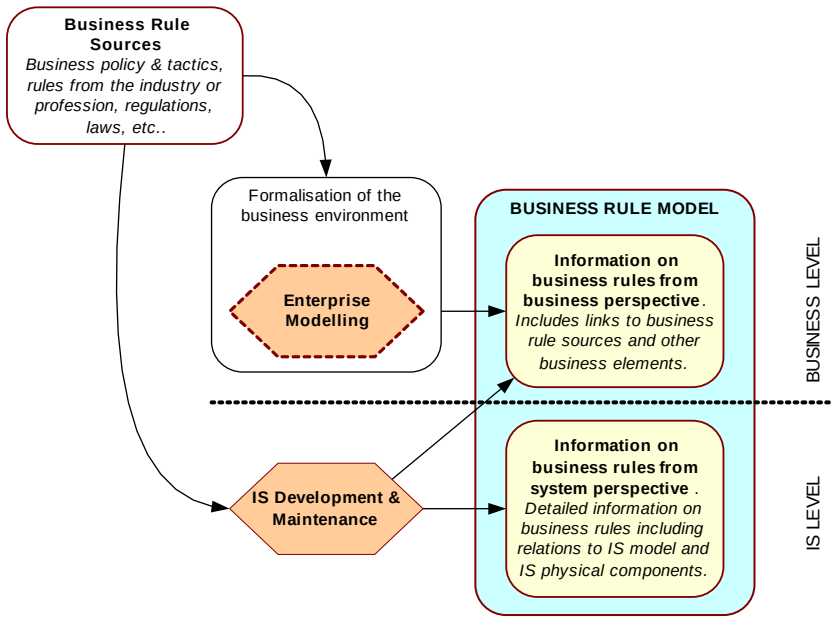

Fig. 2. The evolution of business rule model.

related to business rules has to be acquired during IS development. This information is essential if we want to track business rules from their source to their implementation.

The meta-model in Fig. 3 illustrates the most important information, which is worth tracking on business rules. As stated above, this information is captured through the entire life cycle of the business system and its supporting IS.

The meta-model is divided into two sections, one that comprises business level elements and the other representing concepts interesting at the IS level. At the business level, each business rule is described in business language (*Business Description*) that is understandable to business people. Among business rules there are many relationships, for example, a business rule *supports* another business rule, a business rule is in *conflict* with another, etc. (*Rule Impact*).

Each rule has a history (*Rule History*) that tells when the rule was put into operation and how it has changed over time. The concept *Current status* tells the current position of the rule (e.g. *suggested*, *accepted*, *put into operation*, *declined*, etc.).

As argued before, it is important to keep information about sources that explain the reason or motivation for the rule existence. The sources, such as policy, regulations, or some other administrative acts are often documented (*Document*). A source of a business rule may also be an element modelled in enterprise models, such as a business goal, business process, etc. (*Enterprise Model Element*) (for details see e.g. [8]).

An additional but desired piece of information is rule efficiency (*Rule Efficiency*). It tells how efficient the rule is, in terms of achieving its goals. The efficiency is typically measured regarding the elements that the rule constrains or triggers.

At the IS level, rules need to be atomic in a sense that they cannot be decomposed further without losing their meaning (*Atomic Business Rule*). Since descriptions of rules have to be more rigorous at

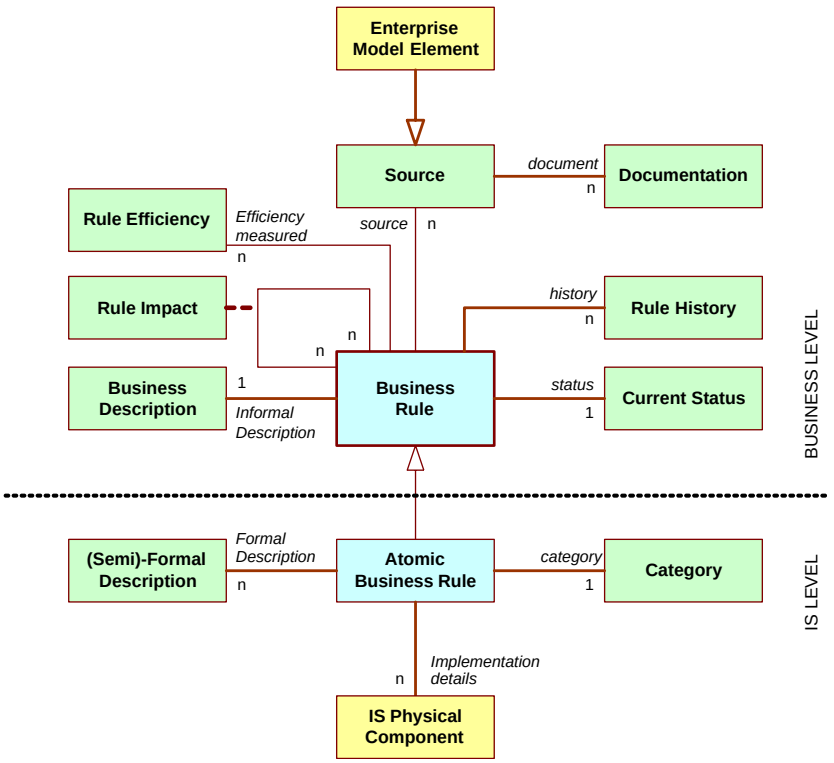

Fig. 3. Components of the business rule model.

this level formal languages have to be employed (*Formal Description*). To simplify rule formalisation and to support rule implementation, the rules should be categorised (*Category*). There are a number of different business rule taxonomies, proposed by many authors (see e.g. [9]).

Finally, each rule at the system level links to one or several *IS physical components*. This is an essential piece of information, as it tells where and how the rule is implemented.

4.3. BRM Scenario

Based on the findings, which were discussed in the previous section, a scenario was designed, defining the main activities and roles required to manage business rules for an entire organisation. Besides the activities dedicated to rule management at business and IS level, the scenario determines the activities responsible for rule maintenance and monitoring. The BRM scenario is illustrated in Fig. 4.

4.3.1. Activities performed at the business level

The most important activity at the business level is *formalisation of the business environment*. The goal of this activity is to capture business elements that may act as a source for business rules. For example, *business goals*, *problems*, *business processes*, *business functions*, *organisational units*, and *business concepts* defining the business terminology. Additional information that has to be captured at this stage is IS software and hardware architecture. These elements are elaborated and

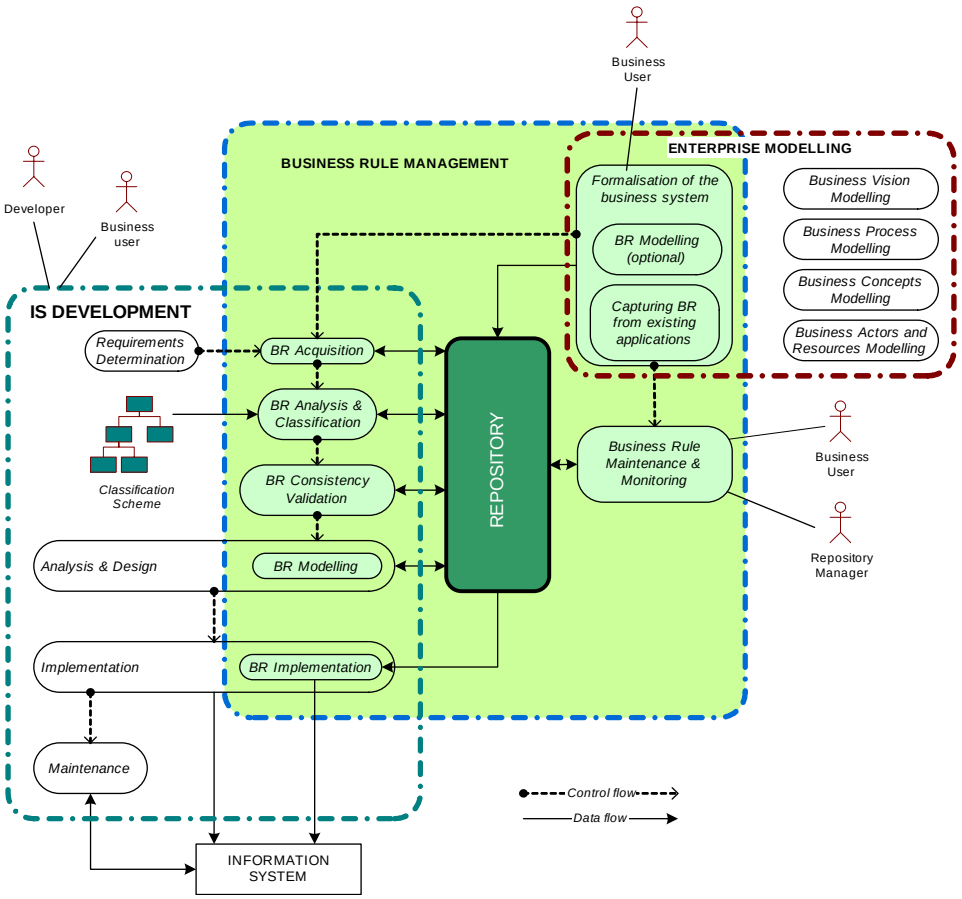

Fig. 4. The BRM scenario.

stored into *repository*, which represents a physical store for the business rule model elements discussed in Section 4.2.

A responsibility of this activity is also to take care of the existing applications, capturing their rules into the repository. This may require extensive work, especially in large organisations with many IT systems. Nevertheless, the acquisition of the rules from the existing applications has to be done, as it is crucial for the establishment of the BRM environment.

An optional activity in this phase is *Business rule acquisition*. Whether this activity is performed or not depends on the context, in which EM is applied. If performed, the following sub-activities are suggested (not shown in the figure):

- *Identification of high-level business rules*: In this activity, *high-level business rules* are identified typically with respect to the goals that define the enterprise's vision. The high-level business rules are seen as statements that describe how the business has chosen to achieve its goals and how the most important business policies will be implemented.
- *Identification of externally imposed rules*: Besides the rules that specify how an enterprise implements its business tactics, there are also rules coming from outside of the organisation. Such rules may include *government laws*, *regulations*, *industry*- or *profession-specific* rules, etc. External rules should be carefully studied as they can set important business restrictions, affecting the enterprise from several aspects. The most common way of determining externally exposed rules is to examine the business vision model and to identify constraints that come from the outside world.
- *Refinement of the high-level business rules*: Once the high-level business rules are captured, it is often necessary to refine them and decompose into more clear and unambiguous specifications. This is done through close examination of the business process model. Business rules that are accepted as a way of achieving a certain goal are executed in business processes that support that goal. Such rules may decompose into more detailed rules, governing specific business process activities or even further into rules that control operations inside these activities. Several business rules may also derive from the business concepts model. In particular rules that define relationships and constraints, can contribute to more complete set of business rules. It is recommended that all *non-trivial* rules specifying relationships and constraints are captured.
- *Identification of the business rule resources and actors*: In this activity, the responsibility is to re-examine business rules and to supplement the business rule model with information about the resources the rules are using, and in particular about the actors that play any role regarding the business rules. For example, an actor may be the one who has defined the business rule, the one who is responsible for the rule execution, etc. Most of the information can be derived directly from the business actors and resources model, which describes relationships between actors, resources and other business components.
- *Business rule consistency and conflict validation*: Once we have captured all the rules that are essential for the enterprise, we must recheck the rule consistency and see if there are any conflicts. This can happen quickly as there are often differences in how organisation units interpret and perform the enterprise's business policy.

4.3.2. Activities performed within IS development

Important activities dedicated to managing information about business rules are performed during IS development. These activities include

- *Business Rule Acquisition*: One of the most important activities in IS development is determination of the requirements for a desired system. Since business rules represent an important subset of requirements, they are typically acquired together with other requirements. The purpose of having a special activity for business rule acquisition it to make the acquisition process more systematic as to ensure all the rules are acquired. Note however, that the business rule model itself presents an important source for business rules. The rules that have

been captured within EM or within previous IS developments are stored in the repository and are available to developers for further and detailed analysis.

- *Business rule analysis and classification*: The purpose of this activity is to make sure each rule is *atomic*, it belongs to exactly one *category*, and is *formally* or *semi-formally* described using a predefined *rule language*.[4] The classification of rules is not compulsory but is recommended as it simplifies the rule formalisation and ensures higher clarity and consistency of the rule descriptions. It is recommended also that for each rule category an appropriate *rule template* is defined. A rule template can be seen as a sentence pattern that tells how to describe the rules that belong to a particular category. An example of a rule classification scheme supported with rule templates can be found in [51].
- *Business rule consistency and conflict validation*: For the overall organisation, this activity is done already during EM. Here it is performed again for the systems problem domain to ensure that the complete set of business rules includes only the rules that are consistent and do not conflict among themselves. There is no special way how to perform this activity. A possible way is to group the rules by the objects they constrain or actions they trigger and to check if there are any conflicts.
- *Business rule modelling*: The purpose of this activity is to provide business rules with graphical representations that help developers to understand the rules. The technique depends on the type of the system being developed, the development approach, the rule category, etc. and can vary from simple to complex graphical representations, including *decision trees*, *activity diagrams*, etc. In the scenario, modelling of the rules is not mandatory, due to two reasons: firstly, there are many rules that are simple and do not need additional graphical representations and secondly, there are many rules that are already modelled within other perspectives (e.g. within *data models*). The objective in this activity is to identify the rules that are complex (e.g. having many relationships with other modelling elements) and to provide them with graphical representations, which will make them more clear and understandable to developers. A special focus in this activity should be given to the rules that influence among each other. Graphical representations of rules should be captured in the repository.
- *Business rule implementation*: The last BRM activity performed within IS development is the business rule implementation. There are a number of different technologies and supporting tools available to support business rules implementation and maintenance [52]. They range from database-oriented tools that enforce rules using database mechanisms, such as *triggers* and *stored procedures*, to rule oriented systems that offer declarative rule specification languages and special mechanisms to take care of the rule execution. Which technology will be or should be used depends on several factors, but particularly on the type of the system being developed. For example, in a typical knowledge-based application, rules will be captured and stored into a *rule base* and executed by a *rule engine*. In a typical workflow system, business rules will be integrated in the *workflow definition*, which will be used by a *workflow engine* to run the workflow [53]. Furthermore, in a typically database oriented system, business rules will be probably spread across the entire application. While it is desirable that rules are physically stored in one place and that they are executed centrally, this is not always possible. The ultimate responsibility of this activity is to ensure that the information on where and how the rules are implemented is captured.

4.3.3. Business rule maintenance and monitoring

Apart from the activities that are performed during EM and IS development, the BRM scenario prescribes additional tasks that take care of the business rule changes through their lifecycle.

[4] Natural languages are not appropriate for describing rules at this level. More appropriate are semi-formal languages, such as *structured English*, or specially designed rule languages, such as *External rule language* [49] *Object Constrain Language* [50], *RossMethod* [6], etc.

These activities can be performed at the business or IS level. They include

- *Change control:* The purpose of this activity is to coordinate business rule changes. In general, the motive for business rule changes always arises from the enterprise business environment and consequently from modifications of the enterprise model. If it seems that a business rule has changed because of some technical issue or because of some new IS requirement, and that from the business perspective there is no need for the change, then this is not really a business rule. Business rules are *owned* by the business and are always tightly connected with the business environment. Accordingly, for every change in the business rule model there must be an explanation at the business level, describing why the change is necessary. Furthermore, to be able to control changes, information has to be managed about who has requested changes, who has approved them, when they will be implemented, etc.
- *Version control*: Due to their dynamic nature, business rules can have several versions over time. In some cases it may even happen that there will be several versions of the same business rule in use in an enterprise's IS. For example, one version of the rule will be used in one subsystem, while other subsystems will be using a different version. In order to know which version is in use in which system as to be able to perform assessments for different rule versions, the business rules history has to be tracked.
- *Impact control:* Business rules are rarely independent, which means that a change to a particular rule may cause several other rules to change. To manage changes, all dependencies between rules and other components have to be tracked. Before a business rule is changed, the impact analysis must be done to find out if there are any obstacles in changing the rule.

In this section, the activities were discussed that are required to establish and preserve the link between an organisation's business and its supporting IS. It was emphasised that activities are necessary at both, business and IS level. At the business level, the organisation's business policy has to be captured together with its context that explains a rational behind the policy. As it was shown, EM methods are very useful for this purpose. Furthermore, it has to be taken into account that business rules, which derive from business policies, evolve through the entire IS lifecycle. In order to keep business logic that controls IT systems in an organisation aligned with the organisation's business policy, it is essential that the information is kept on how business policy has evolved through the IS lifecycle, including the information on how it was implemented in supporting IT systems.

4.4. Testing the BRM scenario and prototype—case studies

As a part of the BRME project, a prototype has been developed that partially supports the activities of the described BRM scenario. The prototype provided simple user interface for capturing information on business rules into a repository. The user interface was developed in Delphi and the repository in Oracle RDBMS. The prototype supported no visualisation of the repository contents, or any service to support rule implementation and deployment.

To test the scenario and the prototype two case studies have been carried out. An overview is given in the next two subsections.

4.4.1. Testing the BRM scenario and the prototype for suitability at the business level

The aim of the first case study was to test the BRM scenario, in particular to examine if business rules can be effectively captured within EM, together with their relationships to other business elements. Furthermore, BRM prototype was tested for suitability at business level. The study was based on a real project, aimed at developing an IT/IS strategy plan for the University of Ljubljana (UL) [54].

UL is the largest university in Slovenia. It encompasses 27 member institutions (UL members) and counts about 60,000 students and 1300 administrative staff. Due to expected changes in legislation that impact on the university's structure

and operation, the university initiated a project with a purpose to develop an IT/IS strategy plan. The project was started in August 2001 and successfully finished five months later.

The strategy plan was developed according to the *Unified IS development methodology* (EMRIS), which is used in several Slovenian government and non-government organisations [55]. EMRIS covers *strategy planning*, *IS development* (structured and object oriented) and the *development of workflow management systems*. At the time the plan for the university was developed, the methodology did not provide any tool support. Acquisition of information on the university business and IS was conducted using a combination of interviews and questioners. The data was captured using the BRM prototype.

The study has confirmed that EM can be successfully applied to acquire various pieces of business information that help to put business rules in context. EM was performed according to EMRIS and included *business vision modelling* (goals, problems, and critical success factors), *business process modelling* (key business process, activities) and *business structure modelling* (organizational and functional structure). The information on the university IS software and hardware architecture was captured during the analysis of the existing IS. The data was captured in the repository provided by the prototype. The number of elements captured is shown in Table 1.

Table 1
Number of elements captured within the strategy planning

Business goals	45
Business problems	33
CSF—critical success factors	21
Organisational units	28
Functional units	51
Key business processes	13
Business activities	152
Business concepts	62
IS SW and HW architecture	15
Business rules	32

While it is desirable to examine business rules during EM, the study has confirmed that detailed acquisition of rules at business level might not always be appropriate. In our case, the purpose of EM was to represent the current state of the university and its vision for the future. EM was thus applied rather superficially, giving more focus on business vision and structure and less on business processes and concepts. Accordingly, business rules were only discussed within modelling the goals, problems, and critical success factors of the university. Examples of rules that were discovered within business vision modelling are represented below.

One of the goals of the university was *to adopt the ECTS-compatible credit accumulation system*, which is required according to the *Bologna declaration* to foster the desired convergence and transparency in qualification structures in Europe. There were several business rules that were derived from that goal. For example

- The courses, the examination requirements, and the successful completion of the curricula must use the *system of credit points*.
- Curricula may include courses delivered at any faculty or university department inside or outside the university.
- Courses on the curricula and the individual parts of the examinations must be each designated a given number of *credit points*.

These are high-level rules, which might be decomposed into more detailed rules if discussed further, e.g. in parallel with business process modelling or business concepts modelling. The reason for not carrying out the detailed acquisition of business rules at business level was the fact that we did not find it appropriate to the context in which EM was applied. The detailed acquisition of business rules would require deeper analysis of the university business system, which was not required for developing the strategy plan. In some other context, e.g. if the purpose of applying EM was to model and optimize business processes of the university, many other business rules could have been captured. To point this out, business rules have been discussed in detail for a sub-process "examination procedure" which is a part of one of the key business process identified within the university.

For the sub-process "examination procedure" 32 rules altogether were identified and captured in the repository. The rules were derived from the *examination regulations* specified in the *statute of the university*. Some of the rules are

- Final examinations begin when the formal lecture period is finished.
- No classes are to be held after the end of the formal lecture period.
- A student can sit for an exam after having attended the class.
- A student can sit for an exam six times at the most.
- A student can sit for an exam three times at the most in one academic year.
- If the student has already passed the exam, he/she cannot register again.

Regarding the prototype, the study confirmed its suitability. The prototype was successfully used to capture information about the business and IS. However, to make it more useful for business people, it required additional facilities, especially for manipulation and representation of the repository data.

Fig. 5 depicts the main window of the prototype for capturing business elements and related business rules. The main window is overlaid by the sub-window, in which business rules associated with business elements can be captured.

4.4.2. *Testing the BRM scenario and the prototype for suitability at the IS level*

The aim of the second study was to test the suitability of the BRM scenario and supporting prototype for the activities performed at the IS level. The study was based on a real project, aimed at renovation of the Student Records IS (SRIS) [56]. According to the strategy plan, developed for the UL, the SRIS represented a critical subsystem of the university IS.

Renovation of SRIS was required because of an obsolete technology that in the old SRIS only supported on-site work. The functionality that was available was purely designed for administration and was thus only available for staff users.

The new SRIS was developed in Oracle Portal (3-tired architecture), using EMRIS as a methodological approach. The developers were asked to use the prototype to manage business rules. The repository already included the data captured within the strategy planning.

Findings of the study were the following: in requirements acquisition, many new rules were discovered and stored in the repository.

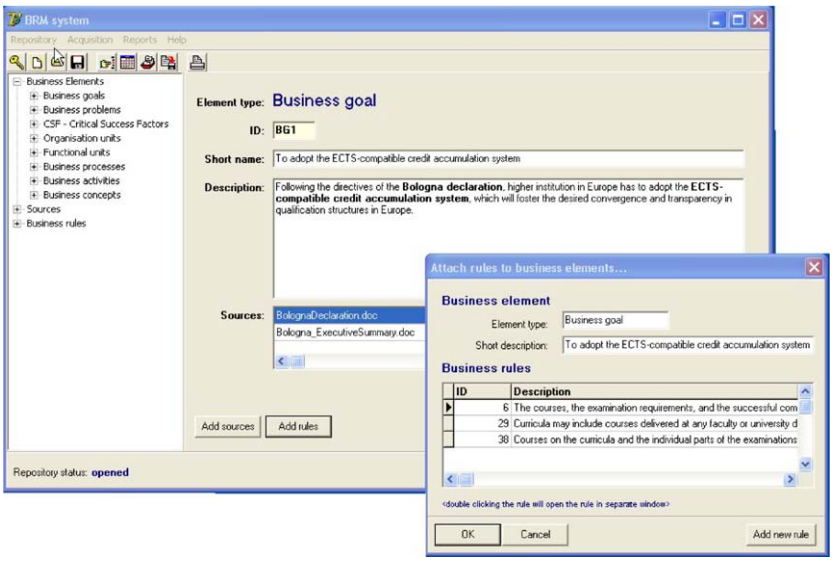

Fig. 5. Capturing business elements and related business rules.

Altogether, there were 159 rules captured. For each new business rule, the developers were obliged to establish the connection to business elements that were already in the repository. As discussed in Section 3, the objective of having business rules associated with pieces of business information is two-fold

- To have a track from business rule origin to its implementation. This may help business people to determine the implications of changes that occur or may occur in business.
- To capture the rational behind the rules. Sometimes it is difficult to explain why a particular rule is implemented in some application. In such cases, it is useful to know the reason for the rule existence.

In our case study, we had an opportunity to investigate how important it is to know the origin of business rules. An important source for the rule acquisition was the old system. Inspecting its program code and documentation, many rules were found and captured in the repository. The problem was, however, that there were 27 instances of SRIS (one for each UL member). Since UL members had different business rules in operation, it was difficult to discover which of the rules derive from the university statute and which were implemented by the UL members. We had to study the statute in details and discuss with the UL members the rules that we did not find in the statute. Interestingly, the UL members were not familiar with the motivation for all the rules. There were few rules that made them wondering why exactly they were implemented. There were even few rules that were abolished once they were discussed within the UL members. The information about the rational behind those rules was clearly missing. In our case study, the developers captured this information by connecting each business rule they discovered to its sources.

Through the process of adopting the credit accumulation system, several changes are expected at the university business level. Using the data captured with the prototype it should be easier to find the applications and their components that will have to be changed accordingly.

Within the case study, the prototype was found useful. However, to make it more valuable and motivating for developers, it required additional functionality, such as a support for rule design,

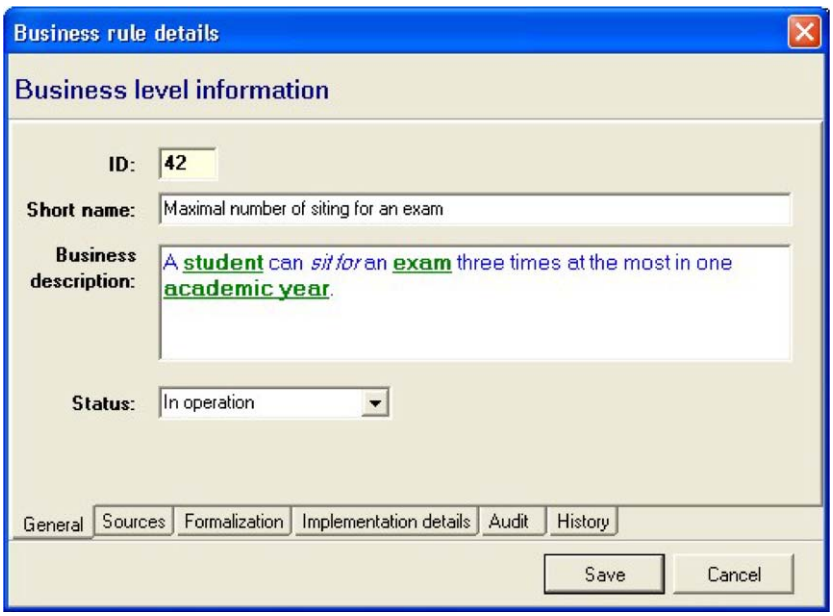

Fig. 6. Capturing business rule details—business level information.

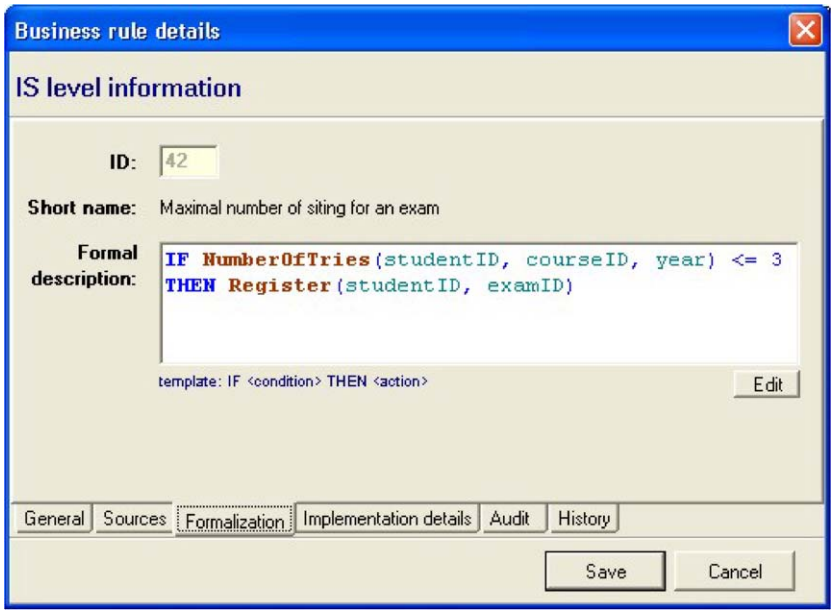

Fig. 7. Capturing business rule details—IS level information.

including various types of rule representation (e.g. decision tables, decision trees, rule flows, etc.), the implementation of rules (code generation), the visual representation of rule interrelationships, etc.

Figs. 6 and 7 show two screenshots from the prototype, depicting the main parts of the window for capturing business rule details.

5. BRM—the tool support

The BRM process clearly cannot be performed without an appropriate tool support. Since there are many tools on the market that offer various features related to business rule acquisition and management (BR tools), we have performed an evaluation to examine how these tools support the functionality required by the BRM process. This section represents a summary of our findings. Details can be found in [57].

5.1. The evaluation of existing BR tools

We have examined several BR tools that are available in the market. Where demo versions were available, the tools were tested in practice. The examination of the other tools was based mostly on the available sources, which we believe are reliable.

According to the functionality that is required for the support of the BRM process, BR tools can be classified into three groups, each of which provides some of the features, required for the BRM process. The groups are named according to the purpose of the tools they comprise.

- Group A: BR tools for rule-based IS development.
- Group B: BR tools for the development of knowledge-based applications.
- Group C: BR tools for enterprise-wide business rule management.

The tools from the first group (Group A) are aimed at rule-based application development. They offer various features for business rule *acquisition*, *formalisation*, *modelling*, and specifically for business rule *implementation*. They are primarily intended for developers. Most often, they do not provide any support for business people (e.g. acquisition of rules in business

language, acquisition of various business rule sources, etc.). Many tools on the market belong to this group. For example, *Usoft* (Ness Technologies, Inc.), *Versata Logic* (Versata, Inc.), *CDM RuleFrame* in conjunction with *Oracle Designer* (Oracle corporation), etc.

The tools from the second group (Group B) support knowledge-based application development. They facilitate the development of intelligent applications based on the acquisition of knowledge. These tools follow the paradigm of expert systems. They are often based on results of a rich heritage of expert system technology. For processing rules, they employ special mechanisms, called *inference engines*. They are typically versatile tools offering a wide variety of features for business rule management at business and IS level. According to Gartner Group, their prospects for the future are more than promising. In conjunction with *business process management* technology [10], which is pervading many markets today, their success is expected to continue [58]. Many BR tools fall into this group. For example, *ILOG Business Rules* (Ilog, Inc.), *Blaze Advisor* (Fair Isaac Corporation), *CleverPath Aion Business Rule* (Computer Associates International, Inc.), *Visual Rule Studio* (RuleMachines Corporation), etc.

The last group (Group C) comprises BR tools that are intended for the management of business rules from the business perspective, independently of particular implementation environments. The tools from this group specialise for business rule acquisition including the acquisition of various pieces of business information that help to put business rules in context. There are not many tools of this kind on the market. Their biggest disadvantage is that they do not support rule implementation. A typical representative of this group is *BRS RuleTrack* (BR Solutions LLC).

5.2. Discussion

As it was expected, the evaluation has confirmed there are many tools on the market that support business rule acquisition and management. Some of them are very sophisticated and powerful, offering a variety of interesting features. However, there are few obstacles that hinder their use for the purpose of the BRM process. Most importantly:

- Existing BR tools offer only limited support for EM. In fact, the evaluation has shown a great majority of BR tools do not support EM at all. Even though it is expected BR tools with inference engines (Group B) will be used in conjunction with business modelling, currently this is not so. At the most, they offer support for business process modelling to handle rule flows in decision processes. There is no or very little support for the other enterprise perspectives.
- The purpose of the BRM process is to manage business rules for an overall IS, and not just for parts of it. Even though there are BR tools on the market that offer enterprise-wide repositories for business rule management, their use for the support of the BRM process is hindered, as they rely on specific technologies. For example, BR tools from Group B use inference engines to process rules. If one of such tools was used to manage business rules for an overall enterprise, this would require all the applications that comprise the enterprise's IS to be developed using that particular technology. Exceptions are tools from Group C, which are technology independent. However, they are rare on the market and lack support for the rule implementation.
- The BR tools that are available on the market are often very expensive. This makes them unaffordable for many organisations.

The purpose of a tool that would be appropriate for the BRM process is not to provide an integrated IS development environment. Its purpose is rather to provide a central store (an enterprise-wide repository with corresponding services), which would be used by all, policy makers, business analysts and developers to capture information on how the business policy that controls their business is connected to business logic that controls their IT systems. Our conclusion is that for the purpose of the BRM process, it is better that such tool provides less

Table 2
Most important requirements for the BRM tool support

Business level functionality	IS level functionality
BR acquisition • BR acquisition using informal languages (ability to capture BR in languages understandable to business people) • Acquisition of business modelling elements (ability to capture elements comprising BR environment) • Acquisition of documentation on BR • Acquisition of IS software and hardware architecture • Mapping BR to business modelling elements (ability to attach BR to the elements comprising BR environment)	*BR acquisition* • BR reusability (ability to map BR from the enterprise repository to the application domain) • BR detailed acquisition (ability to add new rules) • Mapping BR to business modelling elements (ability to attach newly discovered rules to the elements comprising BR environment) • Business rule classification and formalisation (ability to describe rules in formal languages and techniques including graphical representations)
BR management • Enterprise-wide BR repository • BR consistency and conflict validation • BR maintenance (ability to maintain BR at business level) • BR history and change control • Monitoring BR efficiency • Change impact analysis (ability to simulate changes at business level observing implications at IS level)	*BR implementation* • Business rule implementation (ability to generate programme code for various platforms) • Business rule deployment (ability to deploy rules into their environment – this feature is desired but not crucial for the BRM process) • Capturing implementation details *BR management* • Consistency and conflict validation

functionality (comparing it with the tools available on the market) but it supports the following:

- It can be used independently of the IS development approach or technology
- It supports management of enterprise knowledge to the extent that is required to put business rules in context (preferably by using EM methods).
- It is easy to use.
- It offers features that stimulate business users and developers to use it (it should support business rule implementation for various platforms).
- It is affordable for majority of organisations.

Table 2 presents the requirements that we believe are the most important for the support of the BRM process. The requirements are based on the experiences, which we have acquired while using the prototype (see Section 4.4). Some of the requirements were discovered during the evaluation of existing BR tools.

6. Related work

With respect to the literature, the contribution of this paper is in synthesis of traditional and special activities that deal with business rules explicitly within an enterprise modelling, IS development and further through the entire business rule lifecycle. The scenario and tool support described in the paper support the business rule management process, providing a means to keep the organisation's IS aligned with the business environment. While it has been recognised before that it is important to establish explicit links between business objectives and strategies and IS development [3,31,36,37,38,39,40], it has not been shown how business rules can be used in this regard, or any scenario that would explain how this could be achieved. The works which we briefly

describe below are related projects that directly or indirectly support our approach.

Important research work concerning rule-oriented systems development has been done under ESPRIT projects: RUBRIC [1] and TEMPORA [11]. RUBRIC (Rule Based Representation of Information-systems Constructs) developed a rule based paradigm for specifying a business IS. The project was based on integration of conceptual modelling, object-oriented development and declarative rule based specification of all aspect of ISs. The work was later applied and extended through TEMPORA project, which developed methods and tools for systems development, integrating database technology, rule-based systems, and temporal reasoning.

Another important research field that indirectly supports our approach is integration of enterprise (knowledge) modelling and requirements engineering. One of the first attempts in this regard is ESPRIT project F3 [59]. F3 was aimed in developing a coherent methodology and requirements engineering workbench including a broad range of acquisition and validation techniques, supporting the transition process from an informal requirements description to a formal specification. One of the approaches taken by the F3 was in the direction of employing extensive knowledge acquisition to eliminate problems that emerge because of inconsistent, vague and ambiguous requirements. The enterprise modelling method later evolved through other projects and is currently known as EKD—Enterprise Knowledge Development [41]. EKD suggests to identify business rules that limit or operationalize business goals and to formulate them using explicit statements.

The need for embedding business rules into their context has been also well discussed in the work of Herbst [8]. Herbs has defined business rules as a main component of systems analysis and presented a meta-model for business rules.

7. Conclusions and outlook

We have presented an approach for business rule management in organisations, which presents another attempt towards greater business agility. The key concept of the approach is that there must be an explicit link between each business rule instance as exists in business environment and its implementations in one or several application systems. If such a link is established, then it is much easier to maintain IS in a condition that really reflects the organisation's requirements.

In the paper, we have described a scenario that comprises the activities essential for the *business rule management process*. The experiences which we have acquired while using the scenario and supporting prototype in practice have helped us to improve the process and to define the requirements of an appropriate tool support. The development of a tool support, which is in progress, is part of a real project aimed at establishing the continuous business rule management environment.

We are aware that the establishment of an environment in which business rules at IS level are connected to their sources at business level requires extensive work, for which organisations may not have enough motivation. In our future work we will address this issue by examination of how the activities from the scenario can be performed in conjunction with the processes that deal with business analysis, such as *strategy planning*, *business process reengineering*, *IS renovation*, etc.

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