An Enterprise Reference Scheme for Integrating Model Based Knowledge Engineering and Enterprise Modelling[1]

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1 Introduction

In recent years the demand on business process modelling (BPM) became apparent in many different communities, e.g. information systems engineering, requirements engineering [KiB94], software engineering and knowledge engineering (e.g. [BrV94], [SWH+94]). This suggests to aim at a unifying view on business process modelling in all these disciplines. To achieve the business goals some problems which obstruct these goals must be solved. This can be done either by restructuring the business process, by application of standard software, or by developing individual software components such as knowledge based systems (KBSs). To be able to model business goals and to analyse problems occurring during the business processes these processes including organisational structures and activities have to be modelled. This is also true when building a KBS in an enterprise environment. Because the KBS is only a small part of the whole business organisation, it must be embedded into or at least linked to all relevant business processes, i.e. it should not be a stand-alone solution. For this purpose we extend the MIKE approach [AFS96] in the BMBF project WORKS (**W**ork **Or**iented Design of **K**nowledge **S**ystems) by offering business models for modelling relevant aspects of an enterprise. To be able to define an integrated framework with other possibilties to improve an enterprise (e.g. information systems engineering) we determine the standard views of an enterprise. Next we define the views, that are necessary for developing a KBS.

2 Enterprise Modelling

2.1 Notation

It is generally accepted that for an operational description of a system three view are sufficient (see Fig.1) [RaV95]. These three perspectives have a more principal relationship to modelling: they are generally used to describe the kind of the modelled information (static vs. dynamic), there is not necessarily a relation to the modelled information itself and therefore they can not be used to identify useful views of an enterprise. For example dynamics can be viewed in several parts of an enterprise and therefore also in several views (e.g. in the business processes and in the

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processes, that are executed in a software system). Although the level of abstraction is different and they are probably modelled in different layers of an enterprise model, the same notation can be used for both.

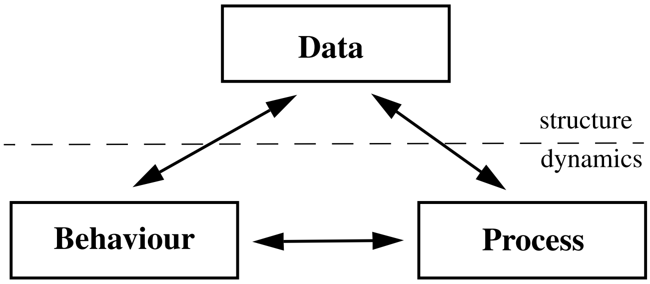

Fig. 1 Modell perspectives

A notation for modelling an enterprise should fulfil the following objectives: it should be understandable and widely accepted, it should be useful for different types of software systems (e.g. information systems and knowledge based systems) and powerful enough to model all relevant aspects. At last it should bridge the gap between the user world and the developers world. OMT (Object Modelling Technique) (see [RBP+91]) has proved its usefulness in several areas: software system design, design of knowledge based systems [ScW93] and enterprise modelling ([BKM94], [KKM95]). For these reasons we use OMT in our integration approach. The data constituent in Figure 1 corresponds to the static object model of OMT, the behaviour constituent corresponds to the dynamic model and the process constituent corresponds to the functional model. So state charts are used for the behaviour constituent and DFDs (data flow diagrams) are used for the process constituent.

2.2 Views

2.2.1 Introduction to the Views

Models mostly have the objective to simplify complex realities by representing only aspects relevant for decisions or actions. Depending on the ensemble of aspects or objects of the reality which are observed, different views reflected by a model are distinguished. In the WORKS approach, nine different views are introduced. The selection and definition is on the one hand determined by the example of well-known views (e.g. in business administration) and on the other hand by the special aims and questions considered in WORKS.

For organisation modelling, business administration's distinction between *organisation structure* and *organisation processes* is useful. In addition, for a work examination, the people working in the organisation (*staff view*) and their working tools (*working tool view*) are relevant. The *data view* is a standard view of organisations, when the development of information systems is concerned. So to speak, data are working objects of information processing activities. Communication and cooperation play a special role under criteria of task design (e.g. task splitting between human and computer [Dan93]) and are therefore treated as a particular view (*communication and cooperation view*).

The *expertise view* is founded on the special focus of the WORKS approach on knowledge-based systems. It is the adoption of a standard modelling concept (CommonKADS [SWH+94]). In connection with this, the usable knowledge sources (*source view*) are interesting for the purpose of knowledge acquisition. In the next section some of the views are introduced.

2.2.2 The Data View

The data view is essentially a meta model of OMT. In applications a much more enriched reference scheme may be required, but it is straightforward to construct one out of the following modelling primitives.

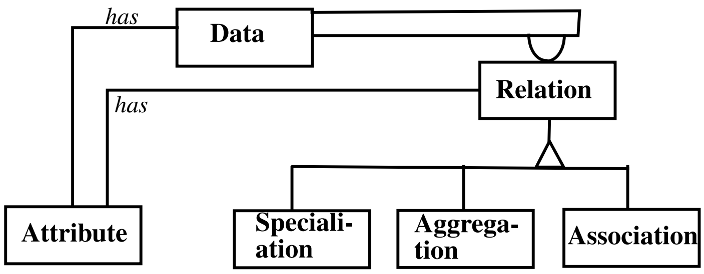

Fig. 2 Data View

2.2.3 The Process View

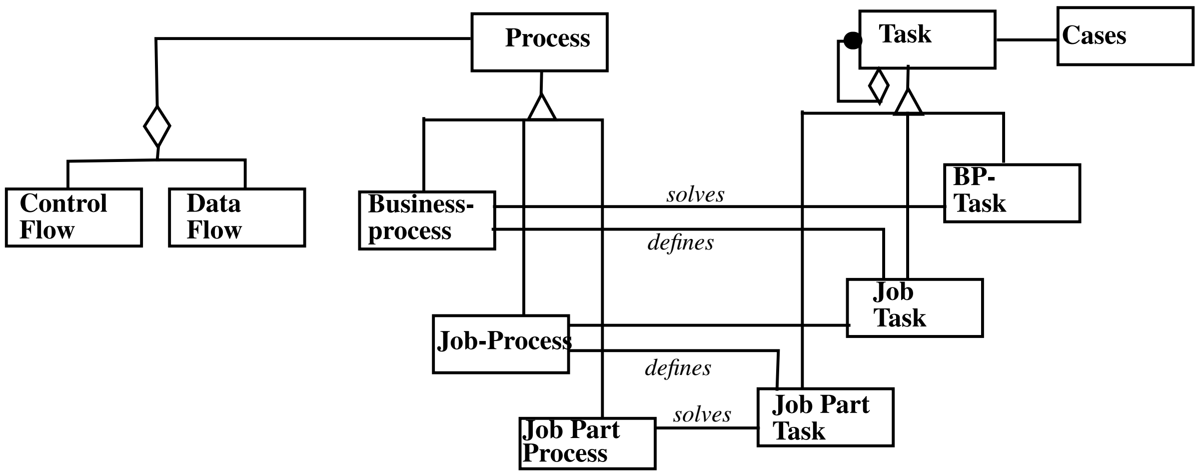

Fig. 3 process view

The process view describes the dynamic aspects of an organisation with the main constituents (see figure 3): "process" and "task". The following connections exist between them: a task can be decomposed in its subtasks The control flow and the data flow between subtasks defines a process to solve the task [SWH+94]. Here the process-task hierarchy has a depth of three, but this defines just special process types that we distinguish. In reality there may be several task-process decomposition in each layer of the shown hierarchy (on the other hand side the process view of an enterprise should not be too detailed, but focus on relevant aspects.) To achieve an integrated modelling technique we use the dynamic and the functional model notation of OMT to describe the data flow and the control flow of a process, e.g. DFDs (data flow diagrams) and state charts. By this we adopted the approach of [BKM94]: by an abuse of notation the "process classes" of the process view (described by the static model notation of OMT) are used as processes in the dynamic model description (the control flow).

2.2.4 Organisational Structure View

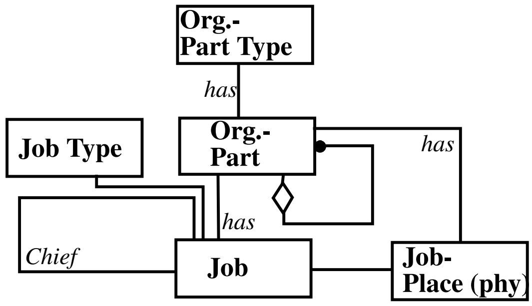

Fig. 4 Organisational Structure View

The organisational structure view is intended to capture the static aspects of an enterprise. The first we want to describe are the organisational units. Therefore we model a decomposition of the organisational unit class. Further we want to differentiate between jobs and job places, because both are important to take into account for human needs. To allow statements about larger enterprises the job place type and organisation unit type class are used.

2.2.5 Expertise View

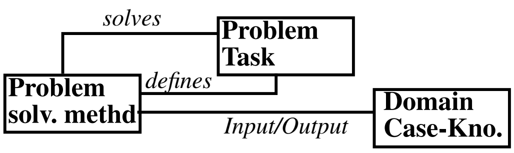

Fig. 5 Expertise View

The expertise view is oriented towards the structure model of MIKE and the model of expertise in CommonKADS [SWH+94]: A task is solved by a problem solving method, which needs domain knowledge. The smallest parts of a problem solving method are again tasks ("devide and conquer"). Process have also a data flow and the control flow. The expertise view is a special view: it is the only one, which contains all different model views (see figure 1). This is due to the fact, that it represents a complete description of a knowledge based system. So all the other views realize only the frame of the expertise view. The expertise view is of course generally much more complicated - however, the integrational approach is very much the same, even in more complicated situations.

2.2.6 Source View

The aim of the source view is to provide a possibility to model relevant sources for the knowledge elicitation process. Therefore it is one of the model constituents, that are necessary for the development of a knowledge based system. This supports the planning of the knowledge elicitation process, where different staff members have to be interviewed.

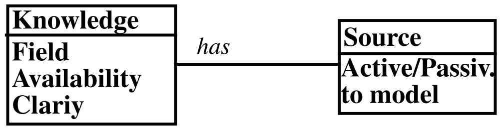

Fig. 6 Source View

2.2.7 Communication/Cooperation View

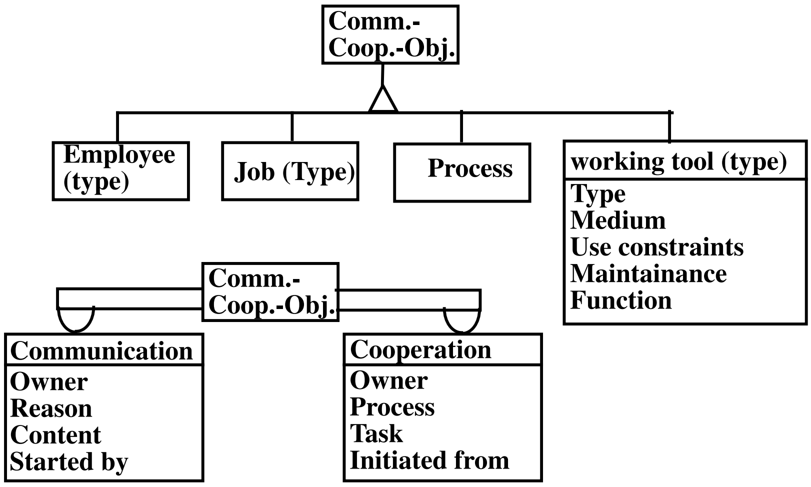

Fig. 7 Communication/Cooperation View

For the development of an information system as well as for a knowledge based system it is important to know, at which point in the work the employee needs additional information to perform his task. The design of the Communication/Cooperation view is similar to known techniques of describing human/computer interaction (interaction diagrams). The communication/cooperation objects can be instances of the classes employee, job, process, working tool, i.e. these are the objects, that can communicate/cooperate with each other. The other diagrams correspond to a simple link between two of these objects: the link is annotated with attributes, which make assertions about the owner, the contents etc. of the communication/cooperation.

2.2.8 Connections between the views

Several connections exist between these views: most of them are standard connections, but a few are important in the context of the development of knowledge based systems. The most important one is the connection between the process view and the expertise view. The point, where a knowledge based system can support an employee is at the job part task level. At this level an employee works on closed task, where mainly his knowledge determines how to solves the task. This is the point, where a knowledge based system may come into the game.

Another important link is the connection between the data view and the domain class in the expertise view: an employee (the expert) does his job in the context of the enterprise, especially in the context of its data. So the input-output of his problem solving behaviour consists mostly of data elements of the data view. To perform the knowledge elicitation task the links between the working tool view, the staff view, and the source view are important. These deliver the information, which persons have to be interviewed.

3 Knowledge Based Systems and Organisation Modelling

Having developed a framework for modelling business processes in general and for embedding them into an organisational environment the question arises which part of a business process could or should be handled by an assisting KBS and not for instance by an information system. Due to the nature of a KBS there does not exist a complete checklist for answering that question. Nevertheless, a few characteristics may be identified: In our framework (see the process view) part of a job task is amenable to such an assistance by a KBS. I.e. we do not envision that a complete business process is supported by a KBS. Rather, a task which is handled by a single person or few cooperating persons is a candidate task.

If there exists a completely formal model for specifying the task and for computing a corresponding solution, for instance an optimization model as known from operations research, there is typically no need for a KBS approach. Instead, a KBS approach is advised "when we do not have overt domain and problem solving models" [ShG92].

If domain and task specific problem solving knowledge, which "encodes" the experience of an expert, is needed in order to be able to solve the task in an efficient manner, such a task is a candidate task for KBS support. "In simple terms this means analysis is not simply interested in what happens, as in conventional systems, but with how and why" [Bro86]. In other words, expertise is concerned with knowing how to do things [ScB96] and is captured in domain and task specific heuristics.

Typically, candidate tasks represent problems which are at least NP-hard in their general formulation [Neb96]. Therefore, experts use their heuristic knowledge for instance to restrict the original problem, to reformulate it or to provide only an approximate solution.

It should be clear that there does not exist a strict borderline between tasks which are suitable for KBS support and those which are not. Therefore, it is up to the business process analyst to make a final decision. Obviously, such a decision will be influenced by a lot of additional aspects, e.g. whether one has already gained experience in developing assisting KBS.

4 Tool Support for Enterprise Modelling

Our approach stresses the importance of the organisational environment, esp. the primary character of business goals. This organisational environment has to be modelled whether a KBS has to be built, a workflow management system is projected, or the business processes are reorganized in any other way. The construction of the above described views should be supported by an appropriate tool. This claim is realized for example by the ARIS-Toolset [Sch94]. The ARIS model contains slightly different views and concepts and thus the tool set as well. But in principle this tool set can be used to develop an enterprise model which serves as the base for the decision whether to build a KBS or any other means of reorganisation. ARIS is not specifically headed towards building KBSs: it does not support the modelling of the expertise view. We extend our

MIKE-Tool, which then contains mainly two different sets of views. The first subset consists of those views which serve to model the environment, i.e the organisational structure view, the staff view, the working tool view, the communication/cooperation view, the data view and mainly the process view. All these views are interrelated by several relationships (as outlined in figure 8). The second subset consists of the expertise view and the source view which contains the MIKE models (elicitation model, structure model, expertise model). The two sets are connected mainly via the process view. This view describes business processes and tasks and relates them to problem solving methods and tasks of the expertise view.

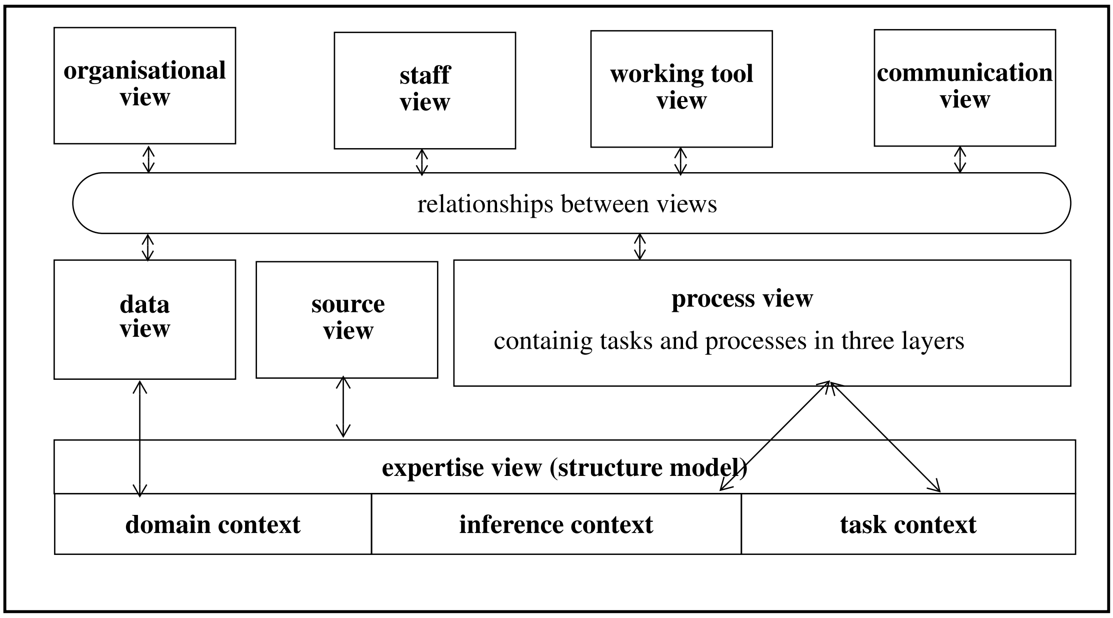

Fig. 8 Architicture of the Views in a Tool

Following MIKE's philosophy of modelling, the first subset of views is elicited by natural language protocols as well as the standard MIKE models. This elicitation may be supported by questionaires (of the knowledge systems analysis) or other informal means, e.g. images or sound files. These informal protocols are structured and interpreted to constitute the different views. By structuring all entities and putting all relevant information into the fitting view(s). These views are linked to one another by defining relationships between related entities. Furthermore a certain kind of link (*elicitation link* [Neu94]) is established automatically between the protocols and the structured information. Thus everything that is modelled can be traced back to the protocols and thus is put into the correct context. By that inconsistencies and failures during modelling can be found and the communication between modeller (knowledge engineer) and information provider (expert) becomes easier.

The business modelling process was started because certain problems arose which obstructed business goals. The areas surrounding these problems and goals should be modelled in more detail than other (possibly less relevant) areas. If a relatively stable state is reached a decision must be made which states how to solve these problems. If the decision is constructing a KBS then the second subset of views becomes relevant. Probably further information must be elicited to model problem solving behaviour, so further protocols are produced which complete the input for the expertise view. Now MIKE's structure model is defined. This is done by identifying entities relevant both in the expertise view and in the business views and linking them. Also all elicited protocols may contain relevant information for defining a problem solving process based on a KBS. Largely this process resembles the regular specification process in MIKE, i.e. informal information (from protocols) is interpreted and structured to yield a semi-formal model. The main difference lies in the fact that also semi-formally modeled information contained in "outside" models (i.e. the business views) has to be considered in the structuring process. In that way the higher level business views are closely connected with the structure model in the expertise view. The next step of modelling in MIKE consists or formalizing the semi formal structure model to constitute the formal model of expertise specified in the language KARL. This specification can be tested because KARL is an operational language so that the KBS may be evaluated by prototyping.

5 Related Work

The importance of capturing the characteristics of the workplace context in which a KBS should be used is stressed in [VaM94]. This approach proposes a so-called workplace ontology to describe among others the organizational embedding of the system, available resources, and expected problems. However, in contrast to our approach, there does not exist an explicit model of the workflow the KBS is embedded in. I.e. the proposal of Vanwelkenhuysen and Mizoguchi is representing static aspects of a workplace, whereas our approach also takes into account the dynamic aspects of a workplace context.

5.1 ARIS

A widespread modelling approach (including tool support) suitable for comparison is ARIS (“Architektur integrierter Informationssysteme”, integrated information systems architecture).

The architecture or basic orientation frame of both approaches is given by two dimensions orthogonal to each other. In one dimension, both approaches differenciate distinct *views* on the object worlds to be modelled. The dimension ‘degree of formalisation’ in WORKS (informal, semiformal, formal) corresponds to the dimension of *levels* in ARIS (application level, data processing concept level, implementation level). Both dimensions refer to increasing formalisation or data processing orientation respectively.

However, ARIS does not consider informal models, so a reference from the semiformal models of the application level to respective primary inquiry informations cannot be realised. On the expert- and data processing concept level we find semiformal models (diagrams) of different notation (among others ER-models for data modelling). On the implementation level, program listings, that is formal models, have to be settled. WORKS does not go that far in the direction of implementation. At best, formal specifications of knowledge based systems are planned (in the formal und executable specification language KARL) in the expertise view.

Relevant modelling aspects for WORKS that are not supported by ARIS are for example the modelling of knowledge (expertise view), qualification profiles of employee groups (staff view), the distribution of tasks (cooperation view), and the communication (communication view) between man and computer. In ARIS, there exists no explicit valuing view like the strong points’-/deficitary points’ view.

5.2 Other Modelling Approaches

Winter and Ebert define in [WiE96] an enterprise reference scheme for enterprise modelling. However, the presented reference scheme is not process oriented: data flow and control flow are the central aspects of the dynamic view, whereas we focus on the process to task mapping, which in our view is a more appropriate reference scheme for modelling and reengineering business processes, because the same task may be solved through different processes. The organisational structure is not modelled, but the relationships between jobs is modelled with more emphasis.

The dynamic part in the reference scheme of [RaV95] is much different: Rammakers focuses on the Task - Action -Activity composition, which seems not very appropriate to capture the notion of a business process. The reference schemes described in [RaV95] and [WiE96] have a quite similar static model part.

In [KiB94] the notion of an Enterprise Model is introduced. Such an Enterprise Model is composed of several submodels: objectives model, activities and usage model, actors model, concept model, and information systems requirements model. In that way, the Enterprise Model aims at capturing all aspects which are relevant when developing an information system in a business context, i.e. it defines a meta-level framework which specifies the type of knowledge which has to be modeled within each of the submodels. We can interpret our approach as a concrete instance of such a meta-model, i.e. as a proposal of how to represent such submodels and their relationships.

A meta-model approach for modeling business processes is described in [JJP+96]. Jarke et al. propose the definition of a language meta model which can be used to describe different views on business processes. Their proposal for a meta language aims at modeling quality-oriented business processes and puts emphasis a.o. on supporting the negotiation process which is needed to achieve coherent views. On the other hand, their approach does not consider the development of a KBS and does not pay much attention to the persons working in an organisation.

The organisation model of CommonKADS [HBM+94] has several drawbacks: at first it is oriented towards knowledge engineering. In the management model of CommonKADS the organisation model is constructed, when it is for sure, that a KBS should be build. The process constituent is not very elaborated: no description method is provided to allow a modelling of business process and to link them explicitly with the model of expertise.

6 Conclusion and Future Work

We defined an enterprise meta model and showed, how it is connected to model based knowledge engineering. As mentioned above by using the MIKE approach to model the business views as well, the modeling of the KBS is tightly connected with business modelling. In that way relevant information can be extracted from according views. It is already structured and serves as a reference because of the links established from the model of expertise through the structure model (both included in the expertise view) to the task and data view and to all the other business views. Thus tracebility of information or requirements is highly supported by this integration of BPM and KBS development.

One possible extension of our approach are scenario descriptions: A common way to elicit knowledge esp. about dynamic behaviour are the so called *Scenarios* or *Use Cases* (cf. [JCP+94], [RBP+91],[Eng96]). These scenarios are widely known in object oriented Software Engineering ([JCP+94]], [RBP+91]) but also in requirements and information systems engineering ([Eng96]). We plan to acquire requirements by scenarios because they help to achieve the common cases of a business process or an expert's task. Scenarios help experts to express their way of working, thus scenarios are useful to increase communicatability of requirements. At first scenarios are instances/examples of what the system should realize or of the current state of an enterprise. These examples serve as a first basis to identify common entities and activities which can afterwards be grouped, classified and put in several relevant relationships.

The generic process model does not state explicitely how solutions to business problems should look like. These solution could consist of a KBS, an information system, a workflow engine or any other means of business functions. In this aspects the MIKE approach can be useful: although it is oriented towards building expert systems, parts of it can be reused when specifying other kinds of software, i.e. MIKE could be viewed as the basis for a general requirements elicitation method.

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