# Towards an Enterprise Reference Scheme for Building
# Knowledge Management Systems[1]

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## Abstract

The value of the knowledge incorporated in an enterprise is more and more recognized and enterprises are defining knowledge management strategies to capitalize this assets. But up to now there is little methodological support for building, maintaining and using knowledge management systems (KMS). To remedy this we propose an enterprise reference scheme, that can be used to elicitate the requirements for building a KMS, to model parts of the KMS, and to study the impact of a KMS on an organization.

## 1 Introduction

The value of the knowledge incorporated in an enterprise is more and more recognized (cf. [Cha97] for a survey). As global competition based on knowledge-intensive products/services rapidly increases, an increasing demand on business strategies, tools and techniques for performing Knowledge Management can be observed. This directly creates a need for methodologies for building knowledge management systems (KMS). Because Knowledge Management is aiming at the improvement of knowledge work processes (cf. [Dav96]), methodologies, that aim at building KMS have to examine the business processes of an enterprise. However, Knowledge Management Systems usually don't fall into the categories of systems, for that specialized development methodologies exist, e.g. CommonKADS [SWH+94] for knowledge-based systems, ARIS [Sch94] for information systems, INCOME [Jae96] for workflow systems. Instead, a knowledge management system is a mixture of several tools and techniques (cf. [KüA97] for an overview about Corporate Memory approaches) e.g. CSCW (cf. [AcM90][AcD96]) or hypertext and database resp. document management systems (cf. [DDD+97][Euz96][Sku97]), which are adapted to an enterprise's business processes. But a common point in the former cited methodologies is a focus on enterprise modeling. Therefore one focus for a methodology for building knowledge management systems is surely enterprise modeling. For building such a model guidance is needed, see e.g [Dav93][2]. Furthermore, as building the enterprise model according to an appropriate *knowledge structure* is surely knowledge intensive *wicked* problem (see e.g. [Buc97]), and also important to improve the *self-awareness* of an enterprise. So the enterprise model is often useful as a content of an corporate memory, enabling continous process improvements. It is recognized, that enterprise models serve for three purposes: first for the requirements-elicitation phase through modeling business processes [KiB94], second to foresee and to study the impact of a system on an organization [HBM+96], and third to model the system itself [Jae96][DES96]. A reference scheme (knowledge structure), that supports these tasks for knowledge management systems, should fulfil the following requirements:

- provide a clear graphical language, that can serve as a communication basis between developer and user.

- allow the integrated modeling of several aspects of knowledge management systems, e.g. knowledge-based systems, CSCW, document bases, workflow systems.

- allow the modeling of employees, their needs and knowledge, because they are mainly the knowledge assets of an enterprise. From the modeling the creation of a knowledge maps should be possible, that point people to knowledge resources in an enterprise.

- to react and plan on missing knowledge, the modeling of work processes must be possible in sufficient detail.

In the following we briefly discuss two approaches: ARIS [Sch94] and the Organization Model of CommonKADS [HBM+96]. When introducing our reference scheme we will point to shortcomings in these approaches. This is not aimed

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2. "*Because there are so many relationships that can exist between items under analysis and so many levels of possible detail, analysts need [...] a knowledge structure, which is just a structured collection of concepts and their interrelationships.*"[Dav93]

to be a representative overview, there are many other approaches, however, ARIS is one of the most prominent business process reengineering approaches and CommonKADS is the most popular approach for building knowledge-based systems.

## 2 Existing Approaches

### 2.1 ARIS

A modeling approach (including tool support) for business process reengineering and description of information systems is ARIS ("Architecture of Integrated Information Systems" [Sch94]). The architecture or basic orientation frame of ARIS is given by two dimensions orthogonal to each other (figure 1). In one dimension *views* on the object worlds to be modeled are distinguished. Another dimension is *level of implementation* in ARIS, e.g. requirements definition level, design specification level, and implementation description level. For modeling several diagram notions are proposed: e.g. EPC (event-driven process chain) for modeling processes, ER for data modeling. Shortcomings of ARIS for building knowledge management systems are e.g.: ARIS has no notion of *explicit* or *tacit knowledge*, so it is not possible to identify knowledge assets and knowledge gaps during business processes, that are needed to perfrom knowledge intensive tasks. Furthermore, the distribution of tasks between human and computer cannot be modeled explicitly. The methodology behind ARIS does not support a clear development strategy leading from (informal) documents to the semiformal graphical notation used by ARIS and to the implemented systems, so a explicit tracabilty of design decisions for the implemented system is not possible.
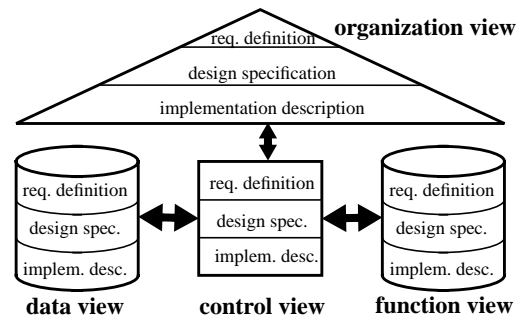


**Fig. 1 .** The "ARIS house"

### 2.2 CommonKADS Organization Model

The CommonKADS Organization Model (figure 2) is developed to serve three main purposes:

- identification of promising areas for knowledge-based systems applications.

- help if identify the impacts of knowledge-based system on the organization.

- help the knowledge engineer to develop a feeling for the organization.

The Organization Model consists of several constituents, e.g. "function", "knowledge", and "process". However, for the single constituents no internal structure is defined (but see [KGL97] for an extension). In modeling tools supporting the CommonKADS methodology the constituents of the Organization Model are represented through plain text parts. Furthermore, "*the model is definitely not meant as a general model that can be used for organizational analysis [..]. Features that would normally be part of such a general model, but are most of the time irrelevant for KBS projects, are therefore missing*"[HBM+96]. However, a corporate memory consists only partly out of KBSs. Other parts are e.g. databases, document bases, intranet services etc. A definite elicitation process from informal documents (e.g. protocols) to semi-formal models is also not defined.
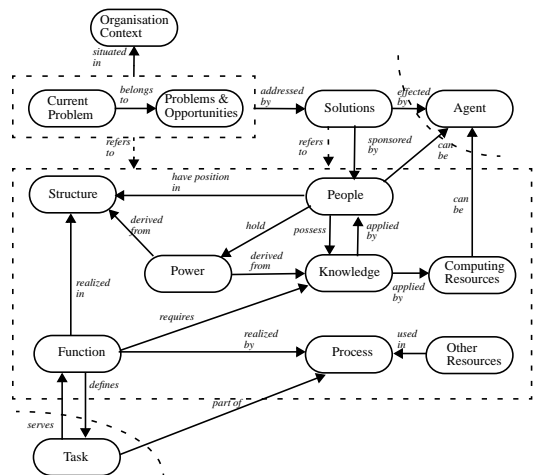


**Fig. 2 .** The CommonKADS Organization Model

## 3 Towards a KM Reference Scheme

### 3.1 Notation

At first we have to determine an appropriate modeling language. It is generally accepted that for an operational description of a system three views are sufficient (see figure 3 taken from [RaV95]). These three perspectives have a more principal relationship to modeling: they are generally used to describe the kind of the modeled information (structure vs. dynamics). Dynamics can be identified in several parts of an enterprise (e.g. in the business processes and in the processes, that are executed in a software system). Although the level of abstraction is different in these two processes and they are probably modeled in different layers of an enterprise
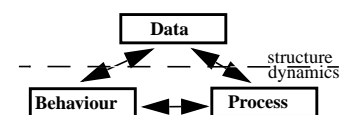


**Fig. 3 .** Model Perspectives

model, the same notation can be used for both. Furthermore notation for modeling an enterprise should widely accepted, 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, so that models are usable for software development or adaptation. OMT (Object Modeling Technique) (cf. [RBP+91]) has proved its usefulness in several areas: software system design, design of knowledge-based systems [ScW93a] and enterprise modeling ([BKM94], [KKM95]). For these reasons we use OMT in our approach. The data constituent in figure 3 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 statecharts are used for the behaviour constituent and DFDs (dataflow diagrams) are used for the process constituent. However, we have to admit that OMT is not an ideal communication basis between knowledge engineer and the user. For this purpose we propose to exchange abstract class boxes through less abstract pictograms, visualising instances of the reference model.

## 3.2 Views

Analysing existing approaches to enterprise modeling, a result is that certain views on an enterprise are similar in various approaches. Thus any enterprise reference model should et least support this minimal set of views. A reference scheme aiming at supporting the development of KMS have to provide more views, directed to certain knowledge management techniques. Which views are really modeled in an application is case dependent: sometimes only very limited modeling is necessary (e.g. if the requirements of the knowledge management system is very clear). Due to the lack of space the views are only described very sketchy, e.g. in contrast to e.g. CommonKADS the views have an internal structure which is described in [DDE+97].

- The *Data View* is very common in enterprise modeling. It allows the modeling of documents, database schemata etc. used in an enterprise and in its business processes. CommonKADS does not explicitly model this view, but it can be catched by the "Other Resources" constituent (figure 2). ARIS allows certain modeling languages for this approach. Our suggestion is to use the static OMT model for modeling this view.

- The *Process View* is another very common view on enterprises. In this view certain business processes are modeled using primitives defined for this view, e.g. ARIS uses EPC (event-driven process chain), which are claimed to be a kind of petri nets. In CommonKADS no further modeling primitives are suggested for this view (but see e.g. [KGL97]). In our approach we suggest the following modeling primitives for this view: we distinguish between business goals and processes. For each business goal a task decomposition is expressed through the static OMT model. For the dynamic aspects (control flow and dataflow) we use the dynamic and functional model of OMT. Furthermore we distinguish between three level of detail in processes: business level, job level and job part level. This leads to a better overview for large processes.

- The *Organizational Structure View* is intended to capture the static organizational aspects of an enterprise, e.g. the structure of the organisational units. ARIS supports this view through organizational charts, CommonKADS suggests "a tree-like diagramm" for the structure constituent. We propose the static OMT model for modeling this view.

- The *Staff View* allows us to incorporate a human centric view into the enterprise model. ARIS subsumes this view into the Organization View of ARIS, whereas CommonKADS has a "people" constituent, but without any structure. We see this as a separate view, because in KM the staff of an enterprise is the most important knowledge asset. We propose the use the OMT static model notation as the modeling language for this view.

- The *Working Tool View* allows to model dependencies between a task and a tool that is needed to perform it. ARIS captures this view in the different stages of the "ARIS house" (figure 1 ). However, KM depends heavily on the tools and techniques for building, maintaining, and using Knowledge. Therefore we introduced an own view. CommonKADS has an "Computing Resource" constituent, but defines no internal structure for that. We propose the use the OMT static model notation as the modeling language for this view. For further aspects of the working tool view see [DDE+97], whre also some attributes of this view are defined.

- The *Communication/Cooperation View* describes necessary communication and cooperation, that occurs in a business process. ARIS has no own communication view, instead, this is regarded as part of the business processes. This has the drawback, that communication, that occurs aside of business processes can not be modeled. CommonKADS has an own model for this view, the "Communication Model" [WHK+93], that is primary intended to capture the interaction between the staff and a knowledge based system. As a notation we propose either the static OMT model, or (equivalently) interaction diagrams.

These are the views that we regard as universally usable for several typs of systems. Because Knowledge Management is regarded as a very diverse field, other views on an enterprise may be important for different techniques used to implement

knowledge management. In the following we propose views important for building knowledge based systems as part of a general knowledge management strategy.

- The *Source View* is intended to model relevant sources for the knowledge elicitation process for building knowledge based systems. Therefore, we distinguish between sources of the knowledge and the knowledge itself. This allows the identification of experts and knowledge fields, that are important for the knowledge elicitation process. When building a corporate memory ARIS does not support the notion of knowledge. We propose the use the OMT static model notation as the modeling language for this view.

- The *Expertise View* is oriented towards the structure model of MIKE [AFS96] and the model of expertise in Common-KADS [SWH+94]: A task is solved by a problem solving method, which needs domain knowledge. The problem solving method defines a task decomposition ("divide and conquer") of the original task and the data -resp. the control flow of these subtasks. The expertise view is a special view: it is the only one, which contains all different model views (cf. figure 3). This is due to the fact, that it represents a complete description of a knowledge based system. The main goal when building this view is the modelling of *tacit knowledge* and thus obtaining as a result *explict knowledge* (see e.g. [Non95]). ARIS does not have the notion of knowledge based systems. As in the Process View, all OMT modells have to be used.

For other areas of Knowledge Management more views on enterprises must be defined, that enable the building of more and more advanced KMSs, e.g. for CSCW or hypertext and database resp. document management systems.

Several connections exist between these views: most of them are standard, 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, the expertise view and the data 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 a closed task, where mainly his knowledge determines how to solve the task. This is the point, where a knowledge based system may come into the game. The tasks performed by problem solving methods are just subtasks of the task the employee perfoms.

## 4 Usage

The proposed reference scheme has been developed and evaluated in the BMBF project WORKS (Work Oriented Design of Knowledge Systems). The aim of the project is to build the knowledge system ERBUS ("Ergonomie-Beratungs und Unterstützungs-System") to support industrial designers concerning ergonomic questions. In the course of the project the documents, that were produced during the design process and the process itself was modeled. The built views helped to identify two tasks, that can be supported by knowledge based systems and several other possibilities to support the design task. Furthermore, it helped to connect the documents created during the design process to the problem solving methods of the knowledge based system. For a more elaborated report see [DDD+97].

## 5 Conclusion and Future Work

Starting from ARIS and CommonKADS we developed an enterprise reference scheme for building KMSs. We proposed concrete structures and graphical notations for this model [DDE+97]. This was exemplified for an Knowledge Management System for designers [DDD+97]. Future work include the utilization of already defined and definitions of new views regarding other aspects of Knowledge Management, e.g. CSCW (cf. [AcM90][AcD96]) or hypertext and database resp. document management systems (cf. [Euz96][Sku97]). We are currently realizing tool support of modeling enterprises based on our MIKE [AFS96] approach.

## 6 References

[AcM90] M. S. Ackerman, T. W. Malone: Answer Garden: A Tool for Growing Organizational Memory. In ACM Conference on Office Information Systems (Cambridge, MA, April, 1990), pp. 31-39.

[AcD96] M. S. Ackerman, D. W. McDonald: Answer Garden 2: Merging Organizational Memory with Collaborative Help. In: Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'96), pp. 97y-105.

[AFS96] J. Angele, D. Fensel, and R. Studer: Domain and Task Modeling in MIKE. In: Proceedings of the IFIP WG 8.1/13.2 Joint Working Conference, Domain Knowledge for Interactive System Design, Geneva, May 1996.

[Buc97] S. Buckingham Shum: Negotiating the Construction and Reconstruction of Organisational Memories. In: Journal of Universal Computer Science. Vol. 3, No. 8, Special Issue on Information Technology for Knowledge Management, Springer Science Online, August 1997.

[BKM94] B.M. Bauer, C. Kohl, H.C. Mayr, J. Wassermann: Enterprise Modeling using OOA Techniques, In: Proceedings Connectivity '94: Workflow Management - Challenges, Paradigms and Products. München: R. Oldenbourg-Verlag, 1994, pp. 96-111.

[Cha97] R. L. Chase, Creating the Knowledge-Based Organization, URL: http://benchdb.com/kmssurvey/report.htm.

[DDD+97] M. Daniel et.al. ERBUS - Towards a Knowledge Management System for Designers. In: Proceedings Workshop "Knowledge Based Systems for Knowledge Management in Enterprises", 1997, URL: http://www.dfki.uni-kl.de/km/ws-ki-97.html

[Dav96] T. Davenport: Some Principles of Knowledge Management, URL:http://www.bus.utexas.edu/kman/kmprin.htm, 1996

[Dav93] A.M. Davis: Software requirements: objects, functions, and states, Prentice Hall, 1993

[DDE+97] S. Decker, M. Daniel, M. Erdmann, and R. Studer. An Enterprise Reference Scheme for Integrating Model Based Knowledge Engineering and Enterprise Modelling . In: Proceedings of the 10th European Workshop on Knowledge Acqusition, Modeling and Management (EKAW 97), Sant Feiu de Guixols, Catalonia, Spain, October 1997, Springer Verlag, LNAI 1319

[DES96] S. Decker, M. Erdmann, R. Studer: A Unifying View on Business Process Modelling and Knowledge Engineering. In: Proceedings of the 10th Knowledge Aquisition Workshop (KAW 96), Banff, Canada, November 1996.

[Euz96] J. Euzenat: Corporate Memory through Cooperative Creation of Knowledge Bases and Hyper-documents. In: Proceedings of the 10th Knowledge Aquisition Workshop (KAW 96), Banff, Canada, November 1996.

[HBM+96] R. de Hoog, B. Benus, M. Vogler, C. Metselaar: The CommonKADS Organisation Model: Content, Usage and Computer Support. In: Journal of Expert Systems with Applications, Vol.11, No. 1, pp.29-40, 1996

[Jae96] P. Jaeschke: Geschäftsprozeßmodellierung mit INCOME, In: G. Vossen, J. Becker: Geschäftsprozeßmodellierung und Workflowmanagement, Thomson Publishing, 1996

[KJO+95] H. Kangassalo, H. Jaakkola, S. Ohsuga, B. Wangler (eds): Information Modelling and Knowledge Bases VI, IOS Press, 1995

[KKM95] R. Kaschek, C. Kohl, H. C. Mayr: Cooperations - An Abstraction Concept Suitable for Business Process Re-Engineering. In: J. Györkös, M. Krisper, H.C. Mayr (eds.): ReTIS'95 - Re-Technologies for Information Systems. OCG Lecture Notes 80, Oldenbourg, 1995.

[KGL97] J. Kingston, A. Griffith, T. Lydiard: Multi-Perspective Modelling of the Air Campaign Planning process. In: Proceedings of the Fifteenth International Joint Conference on Artificial Intelligence, Japan, August 1997

[KiB94] M. Kirikova and J.A. Bubenko: Software Requirements Acquisition through Enterprise Modeling. In: Proc. 6th Int. Conf. on Software Engineering and Knowledge Engineering (SEKE´94), Jurmala, 1994.

[KüA97] O. Kühn and A. Abecker: Corporate Memories for Knowledge Management in Industrial Practice: Prospects and Challenges. Journal of Universal Computer Science. Vol. 3, No. 8, Special Issue on Information Technology for Knowledge Management, Springer Science Online, August 1997.

[Non95] I. Nonaka and H. Takeuchi: The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press, 1995.

[RaV95] G.J. Ramackers, A.A. Verrijn-Stuart: Conceptual Model Requirements for Integrated Business and Information System Development. In:[KJO+95], pp.: 197-213

[RBP+91] J. Rumbaugh, M. Blaha, W. Premerlani, F. Eddy, W. Lorensen: Object-Oriented Modeling and Design. Prentice Hall, Englewood Cliffs 1991.

[Sch94] A.-W. Scheer: Business Process Engineering: Reference Models for Industrial Enterprises, Springer, 2nd ed. 1994.

[ScW93a] G. Schreiber, B.J. Wielinga: KADS and Conventional Software Engineering. In: KADS - A Principled Approach To Knowledge Based System Development, Academic Press, 1993

[SWH+94] A.Th. Schreiber, B.J. Wielinga, R. de Hoog, H. Akkermans, and W. van de Velde: CommonKADS: A Comprehensive Methodology for KBS Development. In: IEEE Expert, December 1994, 28-37.

[Sku97] D. Skuce: Hybrid KM: Integrating Documents, Knowledge Bases, Databases, and the Web. In: Proceedings of AAAI Spring Symposium on Artificial Intelligence in Knowledge Management, 1997. URL: http://ksi.cpsc.ucalgary.ca/AIKM97/AIKM97Proc.html

[WHK+93] A Waern, K. Hook, R. Gustavsson, and P. Holm: The CommonKADS communication model. Technical report ESPRIT Project 5248 KADS-II/M3/TR/SICS/006/2.0, Swedish Institute of Computer Science and ERITEL, December 1993. URL: http://swi.psy.uva.nl/projects/CommonKADS/abstracts/CK-SICS-06.html