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Systems Development of Organizational Memory: A Literature Survey

Dov Te'eni
New York University, teeni@post.tau.ac.il

Hadas Weinberger
Bar-Ilan University, Ramat Gan, weinbeh@mail.biu.ac.il

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Dov Te'eni
New York University
44 W. 4th St., 9-77
New York, NY 10012
Teeni@mail.biu.ac.il

Hadas Weinberger
Bar-Ilan University
Ramat-Gan
Israel, 52900
weinbeh@mail.biu.ac.il

Abstract

Currently, there is no commonly accepted methodology for developing organizational memory systems (OM) that is comprehensive in the sense that it guides the development process from beginning to end and is in sufficient detail to be implemented successfully. Using the ideas of memory metaphor and the user's perspective, we review recent work on OM through two dimensions: the stages of developing OM and the architecture of OM. We then examine the implications of this review on for the OM systems development life cycle and the components of its architecture. This work should therefore prove useful to anyone considering the development of OM.

1. Introduction

The development of organizational memory information systems (OM) is a new craft and certainly less formalized than what appears to be in the various methodologies of systems development. In fact, there is no commonly accepted methodology for developing OM that is comprehensive in the sense that it guides the development process from beginning to end and is in sufficient detail to be implemented successfully like, say, the systems development life cycle methodology [1]. The need for such a methodology is obvious, particularly in face of industry's current interest in knowledge management. One direction for developing such a methodology may be to adapt a more general systems development methodology or, at the very least, learn from it in order to tailor-make an OM development methodology. A second direction may be to integrate several piecemeal approaches into one comprehensive methodology. This paper takes a step in both directions by reviewing recent work on OM through a two dimensional framework and then examining the resulting review in light of established systems development approaches. This work should therefore prove useful in the development of OM.

The memory metaphor has two connotations, each of which prescribes a different type of OM definition. One definition concerns the architecture of memory. For example, an OM "consists of an organization's (semi-formal) knowledge base and a (formal) set of meta-knowledge that can be applied to that knowledge base" [2]. A second type of definition concerns the function of memory. For example, "Knowledge is the key asset of the knowledge organization. OM extends and amplifies this asset by capturing, organizing, disseminating and reusing the knowledge created by its employees" [3]. Indeed, the memory metaphor has suggested useful directions in structure and functionality, some of which have become evident only recently, e.g., the role of OM as short term memory and the idea of OM being composed of multiple individual memories [4].

Understandably though, the memory metaphor says little about the process of developing such a system. The need to engineer an information system that supports but does not replace decision makers and is embedded in a particular organizational setting makes it necessary to complement the OM metaphor with experience in software engineering. In comparison to traditional transaction processing systems, for which the classical systems development life cycle was conceptualized, an OM would be considered highly unstructured. In comparison to decision support systems for which several comprehensive methodologies exist, OM lacks the decision focus that frames the development of the system [5]. Hence, these established methodologies cannot easily be applied to the design of OM. But, the general consensus in these methodologies, that one must begin with the user's perspective, can and should be carried over to OM. Casting the functional definition of OM, which is the system's perspective, into the user's perspective produces a list of functions for which the user can expect support. OM can support the user: 1) as a working memory in processing solutions, 2) as an accessible source of know how, 3) as a directory to other sources of know how (and human experts), 4) as a means of sharing knowledge, 5) as an aid to learning, 6) and as a general device for remembering, and sometimes, forgetting. This rather broad characterization of using OM must govern each stage of the development process.

The framework for this review has, therefore, two dimensions: the development process of an OM (equivalent to a systems development life cycle) and its architecture driven by the required functionality. The following two sections, respectively, describe the process and the components in brief. The studies reviewed are then mapped into this framework (section 4). Finally, section 5 discusses the implications of this review for developing a comprehensive methodology.

2. Organizational Memory Development Processes

OM development processes are discussed in academic and applied journals in a piecemeal fashion [6]. The processes commonly referred to include knowledge acquisition, problem identification, OM development and knowledge storage, knowledge classification, representation, dissemination and utilization [7], [8], [9], [10], and [11]. A more systematic description of these processes is depicted in Figure 1 as a cycle of stages in the development process. It is meant to resemble a standard systems-development life cycle. Each of these stages is described below and associated with some of the researchers who have used or explored these processes.

1. *Problem recognition and goal definition* begins by identifying a problem that needs to be solved (e.g., inefficient use of mechanical expertise in tools repairs). In OM development this stage is often governed by management's perspective of OM goals. Roughly speaking, OM goals are oriented towards the entire enterprise or towards a specific task. Enterprise related goals are either externally driven (e.g., gaining competitive advantage [7][12]) or internally driven (e.g., enhance organizational learning [13]). Task oriented goals of OM are the support of certain types of tasks (e.g., using an expert's experience in forecasting [14]). Given a certain orientation, problem recognition (or opportunity seeking) identifies a problem and determines whether it warrants further development.
2. In *knowledge acquisition* existing and potential knowledge resources are identified and captured in an accessible form, (e.g., [7] and [10]).
3. *Knowledge analysis* is the organization and mapping of knowledge, often using formal structures such classification schemes, knowledge maps and semantic networks (e.g., task oriented typologies [14], [15]).
4. *Design of representation and human-computer interface* is the detailed design of both the knowledge representation and the way it is presented to the user. It includes such activities as ontology design [7] and the design of knowledge model [16] or architectures [17], on the one hand, and visualization of knowledge [18], on the other hand.
5. *Construction* turns the design into a functional OM From the user's perspective this is the stage that produces the tangible 'products', which are the retrievable knowledge items such as best practice databases, lesson learned archives experts guides etc. [7],[18],[19].
6. *Implementation and use* involves the deployment of the system [19] and its integration into the work stream [10].
7. *Evolution* includes the maintenance, growth and adaptation of the OM.
8. *Evaluation* assesses whether the OM meets its goals. For example, in a task support orientation, a measure of retrieval effectiveness may indicate the quality of the OM [20].

Figure 1 summarizes these stages graphically. The lifecycle shown in the figure emphasizes the iterative and cyclical nature of the capture, analyze, design and construct activities but also the adaptive nature of any developmental process needed to support systems that evolve.

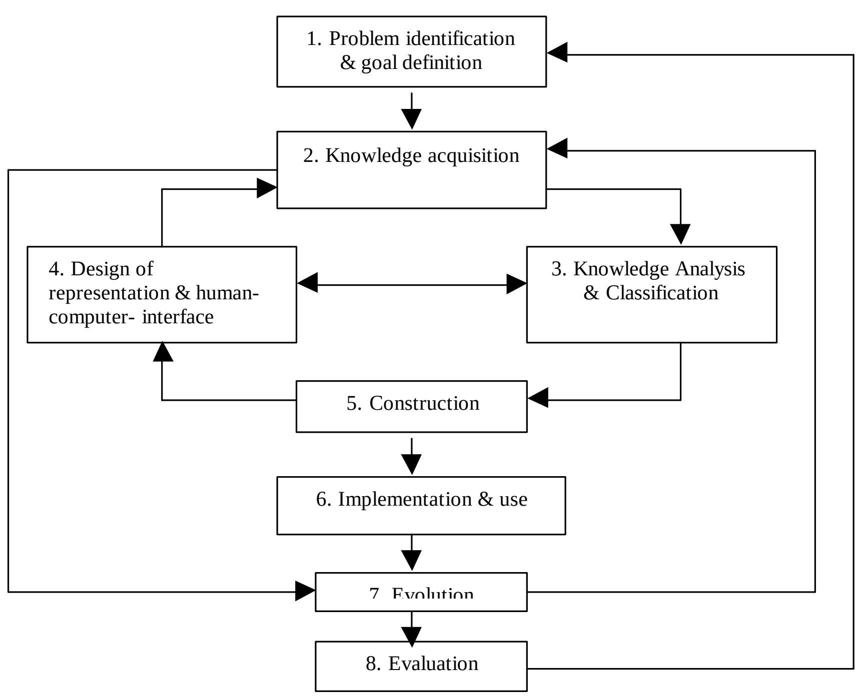

Figure 1: Organizational Memory Development Processes

3. Organizational Memory Architecture

Any architecture of OM should include both the design of knowledge items as well as the design of the overall context of the knowledge and its use. These two levels have numerous names in the literature; here they are called knowledge items and meta-knowledge respectively. A third component of OM is the enabling information technology. This classification of OM components is based on Wijnhoven [10] who identified two inter-related aspects of OM: content (knowledge and information) and means (processes and media). Each of these three types is summarized briefly.

3.1 OM component: Meta- Knowledge

Meta-knowledge should link knowledge items with their environment (e.g., who is the knowledge item contributor and in which task it is used). Examples of meta-knowledge in information science applications are classification schemes, thesauri [21], [22], and collection management systems. Many of these techniques have been used in the design of digital libraries to 1. Facilitate access to controlled collections of information objects [23], [24], and 2. Incorporate user needs assessments and evaluation [25].

Turning back to the OM development processes, the meta-knowledge component is directly associated with the stages of knowledge analysis and representation design. It would seem, however, that meta-knowledge that builds on user characteristics (e.g., user profiling [2]) should build more closely on an analysis of the user, which seems absent from most of the work on the stage of knowledge analysis. Many of the research projects conducted in information science and computer science about meta-knowledge are beginning to have implications for OM design. See in particular templates for describing documents [26], [27], and [24], which can be used in knowledge acquisition.

3.2 OM component: Knowledge items

Knowledge items are the basic components of the OM available to the users, corresponding to the functionality from the user's perspective (see above). The most common aspect is the know how: 1. Best practices (from past experiences), 2. Lessons learned (case studies showing problem-solving expertise), 3. Experts guides ("yellow pages") and 4. Repositories of FAQ (frequently asked questions). Sharing facilities include 1. Discussion groups and 2. Knowledge markets [7], [11]. Memory's more general functions of remembering and forgetting, and indeed, learning, are usually excluded from practical accounts of OM. Nevertheless, repositories of notes (on a public board or initially on private notebooks) or newsletters that may later be contextualized may prove to be an important part of OM. Finally, the use of memory as a short-term memory has been reported in only a couple of papers, e.g., using display systems [3].

3.3 Organizational Memory Enabling Technology

Obviously, our primary interest is in computer-based OM and we therefore consider the enabling technology as a major OM component. The types of IT correspond to Conklin's functional definition cited above: capture, organize, disseminate, reuse, and learn. The last item is added to reflect an evolving OM, which ideally would have some kind of learning capability. With small differences, these functions have been used in several other frameworks of OM and knowledge management (see [28], [29], [30]).

4. A review of studies within the framework

Using the two dimensions (the OM development process and the OM components), we provide a comprehensive framework to review extant research. These two dimensions are organized, respectively, in Tables 1A and 1B. One immediate result is an indication of areas that are lacking in research effort. To this end we use these tables to map recent studies of OM into the appropriate cell in each table. In Table 1A, we place each reviewed study at the development stage it emphasizes (when it covers several stages in depth, it is noted in all the appropriate cells). This presents the overall picture of which stages in the development process have received more, or less attention. Furthermore, each of the studies is indicated as conceptual (C) or empirical (E), which refers to case studies or a description of developing prototypes. This is done to show the nature of recent efforts and perhaps explain part of our findings. It should be clear that we review only studies about OM development but do not include any of the vast body of literature on knowledge management techniques that are potentially relevant to OM (this body is accessible through the reviews mentioned above). Similarly, in Table 1B, we associated each study with the OM component on which it concentrates.

From an initial examination of Table 1, it seems that in the context of OM, the functionality needed to support reuse and learning has received little attention. Furthermore, learning, which often involves remembering relevant information embedded in a different context, is also one that has not been directly addressed in the enabling technology of OM.

Table 2 shows the same collection of studies from a different perspective - the reference field of the researchers. As we constructed Table 1, we found it intriguing to note the diversity of reference fields in the area of OM and thought that too may explain some of our findings. We add to Table 2 a third column that summarizes the main directions of further research noted in the studies. We took this as an indication of what the researcher sees as a primary concern that should be addressed. Surprisingly, information science has hardly contributed to the design of OM ontology and classification schemes. There is obviously a potential contribution to be made.

We further took the case studies described in the empirical research, and organized them in Table 3. The idea here was to identify any meaningful pattern of the more successful systems, where success was defined as a system being used extensively. As it seems clear from our review that today's bottleneck of OM is knowledge acquisition, we tried to identify the source of knowledge in each case. Although, there is no clear-cut pattern of success, it does seem that systems do not succeed when the source of knowledge is wholly dependent on a group of experts rather than wide participation of human agents in addition to automated agents. In other words, the old philosophy of the expert system that informs the user what to do is not effective. On the contrary, OM will succeed only when it is built to evolve on the basis of user feedback and collaboration between users that produces knowledge as input to the OM.

Table 1A: Recent studies of OM organized by development stage (classified as Empirical or Conceptual)

Development stage	Citation
1 Problem recognition and goal definition 1.1 Enterprise goals 1.2 Task goals	1.1 Enterprise goals: Abecker et al., [7]-E, Drucker [12]-C, Kuhn & Abecker, [31]-E, Nonaka & Takeuchi [32]-E, O' Leary [19]-E, Simon [14]-C, Van Heijst [33]-E, Wiig [34]-E, Zack, [11]-E. Grundstein & Barthes [35]-E 1.2 Task goals: Simon [14]-E, Wijnhoven [36]-E, Fox[37]-C, Uschold et al. [38]-E.
2 Knowledge acquisition	Abecker et al., [7]-E, Dieng [6]-E, Fujihara, et al., [39]-E, Gaines et al., [17]-E, Kuhn & Abecker [31]-E, Mahe et al., [15]-E, Simon, [14]-E, Walsh & Ungson [40]-C, Wijnhoven [10]-E, Zack, [41]-C, Zack [11]-E, Yap [42]-E, Conklin [3]-C, Rosner et al. [43]-C.
3 Knowledge analysis 3.1 Item level 3.2 Collection level	3. 1 Item level: Motta et al., [44]-E. Hollands [26]-E. 3.2 Collection level: Fujihara, et al., [39]-E, Mahe et al., [15]-E, Prasad & Plaza [45]-E, Simon [14]-E, Wijnhoven [10]-E, Zack, [41]-C, Zack, [11]-E.
4 Design of representation and human-computer interface	Abecker et al., [7]-E, Fujihara, et al., [39]-E, O' Leary [9]-C, Otondo, [16]-C, Buckingham Shum [18]-C, Te' eni & Schwartz [2], [E],Zack [41,11]-C.
5 Construction	Ackerman [13]-E, O' Leary [9]-E, Buckingham Shum [18]-C, Wijnhoven [36]-E, Zack [41]-C, Zack, [11]-E, Kuhn & Abecker [31]-E, Euzenat [46]-C.
6 Implementation and use	Ackerman [13], Buckingham Shum [18]-C, Te' eni & Schwartz [2], [C],Zack [41]-C, Zack, [11]-E, Euzenat [46]-C, van Heijst et al. [33]-E.
7 Evolution	Ackerman [13]-E, Kuhn & Abecker, [31]-C, Simon, [14]-E. van Heijst et al. [33]-E.
8 Evaluation	Ackerman [13]-E, Abecker et al.[7]-E, Kuhn & Abecker, [31]-E. Verkasalo & Lappalainen, [20]-E, Durstweitz [47]-C, Ackerman & Havelrson [4]-E.

Table 1B: Recent studies on Organizational Memory organized by components

OM component	Techniques / tools	Citation
Knowledge items	Working memory: display systems Know how: best practices, lessons learned, expert guidance, FAQ Sharing facilities: discussion groups, distribution lists, records of exchanges Directory to knowledge sources: Yellow pages, maps of expertise, catalogs of external sources Learning, remembering and forgetting: private and public postings	Conklin [3] Abecker et al., [7], Ackerman, [13], Davenport [8], Kuhn & Abecker, [31], O' Leary [19],Satzinger et al. [48], Zack, [41].
Meta knowledge	Ontology Thesaurus Classification schemes Concept maps Modeling languages	Abecker et al., [7],[49], Motta, et al., [44], O' Leary [9], Buckingham Shum [18], Te'eni & Schwartz [2], Farquhar et al. [50] Davenport [8]. Ackerman [13], Abecker et al. [7], Otondo, [16]. Gaines et al. [17], Buckingham Shum, [18]. Hollands et al. [26].
Enabling IT	Capture: automated extraction, interfaces with other systems Organize: Catalog, ontology and executive systems Disseminate: Information retrieval, bulletin boards, Email, CSCW, Web-sites, search engines Reuse: information retrieval systems, real-time applications, e.g., chat, calendars, instant messaging Learn: support systems to improve and update OM	Gaines et al. [17], Simon [14] Abecker et al. [7], Kuhn & Abecker, [31], Fujihara et al. [39], O'Leary [9] Buckingham Shum [18], Te'eni & Schwartz [2], Ackerman [13]. Yap [42]. Buckingham Shum [18],

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Table 2: Reference Discipline of Recent OM Research

Reference discipline/ Citation	Focal point	Further Research Directions
1. *Computer science- AI*		
Abecker et al. [7]	Overview of required intelligent system for OM.	Knowledge description.
Abecker et la. [49]	Prototype realization for several of OM system principles.	Business-process oriented methodology.
Kuhn & Abecker [31]	Case studies on major OM development stages.	Knowledge representation models. OM integration with business processes.
Van der Vet & Mars [51]	Practical aspects of ontology design	Ontology development.
Computer science- engineering		
Gaines et al. [17]	Knowledge acquisition and knowledge analysis processes.	Intelligent collaboration model.
Mentzas & Apostolou [52]	Case study on a pan-European research on knowledge management (KM) framework.	KM framework & infrastructure
Motta et al. [44]	Ontology design for intelligent retrieval using bottom-up approach.	Applicability of document enrichment approach for KM.
Buckingham Shum [18]	Human issues in incorporating IT for OM.	The need for multi-disciplinary dialogue on knowledge processes.
Verkasalo & Lappalainen [20]	Knowledge acquisition and knowledge evaluation.	Developing applicable methods for the evaluation of OM utilization.
O'Leary [9] [19].	Case studies of OM architecture, enabling IT & ontology design.	OM architecture design.
Van Heijst et al. [33]	Problem recognition & design of representation.	Methodology for structuring knowledge in OM.
MIS		
Ackerman [13]	Case study on OM development.	Investigation of social aspects in computer mediated communication.
Satzinger, Garfield & Nagasundaram [48]	OM system design for fostering creativity.	Creating channels for communicating creativity.
Te'eni & Schwartz [2]	Case study of OM system design, knowledge analysis & design of representation.	Modeling Contextualization strategies.
Information Science		
Smith [23]	OM architecture.	Top-down approach to analysis & presentation.
Van House et al. [25]	Knowledge representation.	Strategy for Design & representation.
Organizational Behavior & Learning		
Nonaka & Takeuchi [32]	Social aspects of OM, knowledge creation, & communication.	Knowledge dissemination and use.
Walsh & Ungson [53]	Reflection on OM accepted definition, structure and processes.	Methodological research for accepted OM concept.

5. Discussion

We started out with the memory metaphor as a guide to the functionality and structure of OM. The memory metaphor can be taken one step further to look at OM from the user's perspective. Indeed, OM can be seen to support things people do with their memory: using their know how to perform, sharing knowledge, determining which expert to consult, temporarily storing information and learning. Using the memory metaphor and the user's perspective, we now discuss our findings on two dimensions: the development and architecture of OM.

5.1 OM development life cycle

Figure 1 depicts the stages of developing the OM. It should be seen as an ideal pattern of activities although, in reality, the development cycle may be incomplete. As we suggested earlier, there is no one methodology that covers all stages of the life cycle. In that respect, we conclude that there is indeed a need for developing such a comprehensive methodology. This call for a methodology is echoed in the high proportion of similar calls for methodologies of OM development in recent papers (see Table 2).

Furthermore, in comparison to the stages of knowledge acquisition and the design of representation, several stages have received only scant attention, particularly, evolution and evaluation. It is especially surprising to see such little attention given to evolution since much of the motivation from management is based on a dynamic view of organizations [32]. One reason for the seemingly piecemeal approach taken in most of these studies is the high rate of empirical studies (see Table 1), particularly descriptions of constructing computer-based tools that require a concentration of effort in one direction. Moreover, looking at

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both Tables 1 and 2, shows clearly the need to engage in interdisciplinary efforts in order to construct an integrative methodology. One way of integrating the different approaches may be to adopt a bottom-up and top-down combination of development methods [51], [26]. This not only ensures a more iterative approach needed in dynamic environments but it also is an easier way for merging different perspectives that are more inclined to prefer one direction rather than another.

The need for a comprehensive methodology goes beyond the obvious need to cover all stages in order to produce a successful system and a smooth transition between these stages [1]. A comprehensive methodology is needed to highlight the interdependencies between stages and the dynamic nature of the development process. The interaction between stages is especially necessary to cope with the relatively very low common structure of the knowledge items. It usually makes little sense to specify knowledge acquisition before an initial classification, and a trial-representation, have been explored. Moreover, the different perspectives of management on the goals of OM produce very different criteria for allocating resources to the development of OM. A comprehensive methodology could stress the need for the required resources along the life cycle to ensure successful OM. Finally, there is also a need for automated tools to support such a lifecycle. Currently, OM tools are dedicated to supporting one or few stages in the development life cycle, far from the state of standard CASE tools [19]. Following are some examples of such tools. KONUS [31] supports engineering design, and KnowMore is a more general task support system [49], both are clearly tied to the stages of knowledge implementation and use. RITA [31] and KnowMore [49] support the design of a representation. KCT [39] supports the knowledge acquisition processes with a compound methodology of a human-computer iterative interview process.

It is not clear, though, that one development life cycle (such as that in Figure 1) would universally fit all instances of OM. In particular, the user's perspective may have to be brought into the process earlier when the OM is new to the organization and uncertainty is high (e.g., [36]). In fact, the higher the uncertainty about how the knowledge will be used, the higher the need to iterate around the stages of capture, analysis, design and construct (see Figure 1). Several researchers suggest, that little be invested in the early stages of the cycle until the OM is actually used (e.g., [3], [31]). But perhaps the most salient conclusion is the need to bring in the user's perspective as early as possible in the life cycle [36]. More specifically in terms of Figure 1, the user's perspective should be included in the stage of defining the OM goals [47]. We believe that as the OM's complexity and uncertainty rise, the user's perspective will become more dominant, and the transitions between one stage and another will become more rapid and less pre-defined. Moreover, as evident from Table 3, it is clear that only a wide involvement of users in the knowledge acquisition and evolvement will enable success.

5.2 OM architecture

The memory metaphor produces a long 'shopping list' of functions we may expect of an OM. In that sense it is extremely powerful. The direct implication is the list of knowledge items appearing in Table 1B. Looking, however, at the Table 1B, one can see a paucity of research on the functions of learning, remembering and forgetting. Moreover, looking at the research cited under the stage of evolution in Table 1A, one can see a parallel need to devise new ways of supporting the evolution and reuse of OM. Indeed, the user's function of learning (and for learning, one needs to remember and sometimes forget) relies on an evolving OM and one that is reused. Learning, remembering and forgetting must, on the one hand, integrate the development of the organization with its corresponding OM, and on the other hand make the OM more valid and reusable by improving its content. This conclusion is also supported by our conclusion from the review of the case studies (Table 3), which suggests that there must be a wide spread involvement in acquiring and evolving the knowledge of the OM. This will only come about when users have an incentive to cooperate. The architecture of OM used above (Table 1B) may therefore be inadequate to truly support these functions. Additional components that specifically address knowledge reuse such as critiques of decisions, explanations and recommendations that can articulate the context and analyze changes in context so as to reuse knowledge appropriately. Similarly, as suggested by Khun and Abecker [31], the OM should also include dedicated components that facilitate knowledge evolution, such as finding redundancies and contradictions and improving the set of decision rules.

The memory metaphor can, and should, be taken one step further to simulate the function of group memory before so as to better inform the design of organizational memory. It is well known that group memory suffers from process losses, in which groups loose potentially valuable information when integrating the individual memories [54]. OM must include dedicated components in its architecture that can facilitate work at the individual level, at the group level, and perhaps most importantly, at the transition between individual and group level processing. For example, if users can store information in individually administered memory, decide when to make it public but maintain ownership (e.g., receive credit for it), and if necessary decide to make it private again, users may be more inclined to contribute to shared memory [55].

All in all, using the memory metaphor can indeed improve and expand the current architecture of OM. But the memory metaphor may also be limiting when it comes to designing the enabling technology because the technology may simply be better at doing things another way. For example, technology may be designed to systematically forget and rejuvenate knowledge according to some defined pattern of eliminating unused links and creating new ones on the basis of periodic news. But there again, perhaps it is just dreaming.

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Table 3: A compendium of recent case studies

Organization / citation	Name of system	Task / enterprise goal	Source of knowledge	Success measure / comments
Crankshaft design [31].	KONUS	task	Company expertise	Company did not invest in full system
Quality assurance for vehicle components [31].	RITA	task	Company expertise	Company postponed development indefinitely.
Bid preparation in oil production system [31].	PS-Advisor	task	Company expertise	Company postponed development.
Product processes organization [8].	Knowledge Links	enterprise	internal and external repositories and user's input	Company is using extensively ; emphasis on reuse.
Price Waterhouse, Arthur Anderson, Ernst & Young [9].	International Business Language	enterprise	Internal	Company is using it extensively. Basically, it uses an ontology as part of an intelligent assistant in queries to the knowledge base.
Growing O.M. [13]	Answer Garden	enterprise	Company expertise and user input.	System is operational.
Manufacturing life cycle [17].	Genosis project, Mediator system	enterprise	Consortium of 31 enterprises: coordinating intellectual and managerial processes. Human and automatic agents interact.	Prototype stage.
Metallurgical domain [14].	KBS architecture	task	Company expertise	Prototype is under development.
I.R. strategies and manual K.A. processes. [39]	KCT	enterprise	Company expertise and user input. A combination of AI techniques with human feedback.	Prototype stage. Domain independent semi automated effective tool.
Human issues in KM technologies [18].	Collaborativ e Hypermedia infrastructure	enterprise	Corporate expertise to form ontology as a basis for user collaboration.	Under evaluation. Teams have constructed contextual tools for group collaboration using IT.
Multinational textile company [2].	HyperMail	enterprise	Company expertise to form ontology, which is to evolve by user participation.	*Prototype is under development.* Based on the need to contextualize communication
APV Anhydro Global marketing process [42]	VR &3D	enterprise	Company expertise: Internal technical knowledge.	Operational. Emphasis on enhancing the extraction, presentation, and sharing knowledge.

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