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Michael Rosemann
Queensland University of Technology

Roy Chan
Queensland University of Technology

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Structuring and Modeling Knowledge
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Michael Rosemann, Roy Chan
Information Systems Management Research Center
Queensland University of Technology
Brisbane, Australia
{m.rosemann|rw.chan}@qut.edu.au

Abstract

Enterprise Resource Planning (ERP) systems are comprehensive business operating systems that weave together all the data within the organizations' business processes and associated functional areas. Selecting, implementing, using and continuously changing ERP systems requires a great amount of knowledge and experience. The lack of in-house ERP knowledge and the high cost of engaging experienced implementation consultants have led companies to realize the need to better organize their knowledge resources. Different kinds of knowledge are required during different points in time in the ERP lifecycle. This paper proposes a structure for different types of knowledge required to manage Enterprise Resource Planning software. This framework is applicable to organizations seeking to identify the relevant ERP knowledge and to manage their knowledge resources. Based on the proposed framework, a suggestion for how to model knowledge in the ERP context is made in order to relate precisely knowledge to ERP transactions.

Keywords
Knowledge Management, Enterprise Resource Planning, Process Modeling

1. Introduction

Enterprise Resource Planning (ERP) systems like SAP R/3 and mySAP.com, BaanERP, Oracle Applications, PeopleSoft or OneWorld (J.D. Edwards) can be defined as customizable business application systems for the core business processes and the main administrative areas of companies within various industries (Rosemann, 1999). The money spent over the last eight years on ERP projects and the forecast for the ERP market (AMR Research, 1998) including second wave applications like Supply Chain Management and Customer Relationship Management emphasizes the importance of ERP systems and their stake in the information technology and business world.

The GartnerGroup (GartnerGroup, 1999) forecasts that the Enterprise Systems (ES) market will be greater than $ 20 billion by 2002 (with a probability of 80 %). More than 50 % of this will be ES service revenue, while the total ES license revenue will cover approximately $ 9 billion. They estimate that more than 90 percent of Fortune 500 enterprises have purchased a module or a set of modules from an ES vendor. While 50 percent have made a commitment to one vendor, only less than 20 percent went actually 'live'. It is also estimate that the SME market is the main customer group as more than 50 % of these enterprises still haven't selected a next-generation ERP. For the year 2000 (2001, 2002) the GartnerGroup anticipates a market growth of 22 % (25 %, 28 %). ES software accounts for more than half of the software licenses and maintenance revenues. In Western Europe, the top-tier ES vendors account for 64 percent of ES market revenue (see AMR Research Inc., Boston 1998, in

'Electronic Buyer'). These figures show that ERP-initiatives are among the biggest investments enterprises are currently conducting.

Managing ERP systems is a knowledge-intensive task as it requires a great amount of experience from a wide range of people such as representatives from business departments, the IT department and project managers within the organization to external business and implementation consultants. Recognizing this, Knowledge Management seeks to deal with the problem of leveraging knowledge resources in an organization. Activities in Knowledge Management include the tasks of identifying, creating, transferring, storing, (re)using and unlearning knowledge.

There is strong motivation for better leveraging ERP-related knowledge and making this knowledge available to those involved in the ongoing management of the ERP system. "Having made costly errors by disregarding the importance of knowledge, many firms are now struggling to gain a better understanding of what they know, what they need to know, and what to do about it" (Davenport, 1998).

The interrelation between Knowledge Management and Enterprise Resource Planning has two facets.

- On the one side, implemented ERP systems can serve as a main source of knowledge for a companies' Knowledge Management strategy. As ERP systems often support various areas of a company like procurement, manufacturing, warehousing, sales, distribution, accountancy, an analysis of the runtime data (transactions, involved organizational units) can provide the knowledge manager cost-effectively with useful data about the current process performance or further organizational performance indicators. This perspective can be described as *"ERP for Knowledge Management"*.

- On the other side, the management and especially the implementation of an ERP solution requires a substantial amount of knowledge and expertise. Thus, a separated ERP-related Knowledge Management can be identified that covers the entire management of knowledge in an ERP project. This perspective can be characterized as *"Knowledge Management for ERP"*. This is the focus of this paper.

This paper proposes a three-dimensional framework to identify and structure the knowledge, which is required to manage an ERP system. This framework focuses on the identification of different types of knowledge and the management of knowledge throughout the ERP lifecycle. While most existing ERP literature have focused on the types of knowledge, methodologies and critical factors required for the implementation of ERP software (Bancroft, 1996; Clemons, 1999; Kirchmer, 1999; Mahrer, 1999; Parr and Shanks, 1999; Scott, 1999; Slooten and Yap 1999; Sumner, 1999), it is noticed that they have often lacked in a knowledge-specific framework. As ERP implementations are knowledge-intensive, knowledge resources can be better managed by having the transparency about what knowledge is required at which point in time during the implementation phase and where the knowledge resides. With this knowledge at hand, managers and implementation consultants can more effectively implement the system. In addition to a theoretical framework, this paper will prescribe a practical working framework on how ERP-specific reference models can be extended in order to explicitly describe the required knowledge.

The structure of this paper is arranged as follows. The next (second) section motivates the development of a framework for ERP knowledge. The third section explains the three dimensions of this framework, namely the stages of the knowledge lifecycle, the phases of the ERP lifecycle and the types of knowledge required for the ERP management. The fourth section proposes an approach for the explicit specification of ERP knowledge using extended ERP reference process models. The paper summates with a brief outlook.

2. Motivation for the Development of a Framework of ERP Knowledge

Without a proper framework and a model for managing the knowledge through all the phases of the ERP lifecycle, managers may not able to successfully tide their system further to the future maintenance and upgrade phases of an ERP system. From the case studies espoused (Bancroft, 1996; Clemons, 1999; Kirchmer, 1999; Mahrer, 1999; Scott, 1999; Slooten and Yap, 1999; Sumner, 1999), this need for cohesion and organization of this flux of different kinds of knowledge are of critical influence for the entire success of the project. In order to structure the knowledge, which is necessary within an ERP project, a three-dimensional matrix is suggested. Knowledge required for an ERP project can be classified along these three dimensions. The dimensions of this framework are:

- The stages of the *knowledge lifecycle*: identifying, creating, transferring, storing, (re)using and unlearning knowledge,
- the phases of the *ERP lifecycle*: selecting, implementing, using, and changing the ERP system, and
- the types of knowledge required (the *knowledge content*): business, technical, product, company and project knowledge

Figure 1 shows the principal design of this framework with the three independent dimensions.
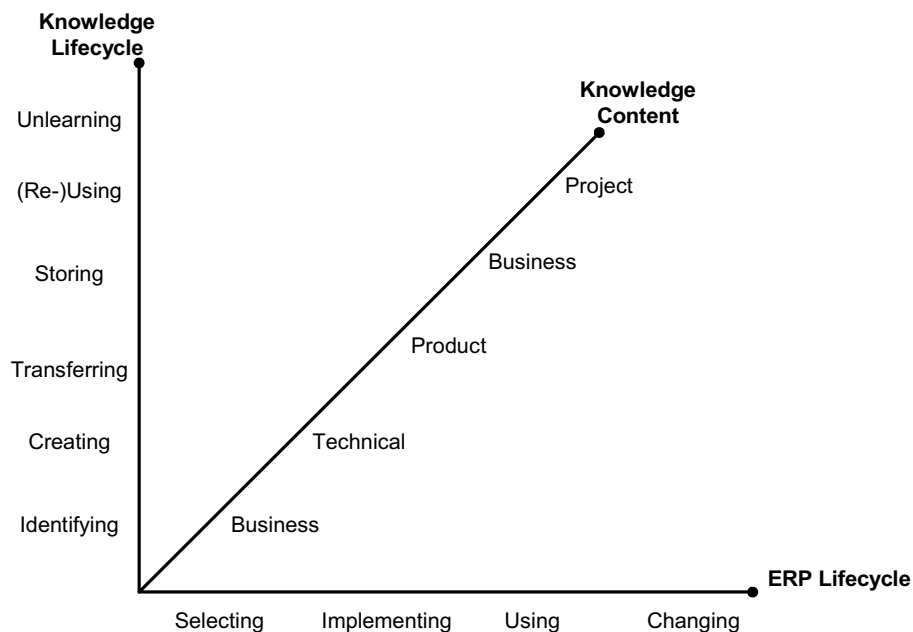

Fig. 1. A framework to structure ERP-related knowledge

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The demand for ERP-related knowledge and support resources is high and the lack of expertise has resulted in the turnover and poaching of ERP-knowledgeable staff (Gable et al., 1997). The loss of employees with ERP-specific knowledge often hurts an organization in poorly equipped post-implementation knowledge and thus being unable to further evolve their business processes.

The proposed framework can be used by managers to provide specific knowledge resources as needed throughout the ERP lifecycle. ERP providers might be motivated in the future to deliver their solutions with a similar classification of the required knowledge. In general, the framework allows managing an ERP system from the knowledge viewpoint and supports to differentiate precisely between different types of knowledge.

In dealing simultaneously with knowledge and ERP management, managers and consultants may often find difficulty in managing areas of knowledge through the various project teams at different times. Managers may also risk losing the ability to implement certain procedures and tasks in the midst of an ERP implementation project. In such a situation, losing the ability to implement certain procedures and tasks may contribute to the failure of the implementation project. The proposed framework may help to overcome the information/knowledge overload as encountered by many ERP clients as it helps to organize the involved types of knowledge.
The contributing factors for a need to better knowledge resources often reside from the lack of knowledgeable personnel and resources and the fast-paced business industry pushing for speed and efficiency. The lack of experienced personnel and the risk that organizations are unwillingly to take in training new personnel have restricted the market to employees with at least two years experience in ERP implementation or on completion of at least one project lifecycle. Although such resources exist, the time taken for these experienced personnel to enter the market results in a lag time. Despite the calm transition over to the new millennium in the beginning of this year and that the Y2K occurrence has been substantially blown over, organizations are now putting into effect more of their resources into bettering knowledge resources.

The dimensions for the Knowledge Management framework should be viewed as a coherent, single unit. One dimension inadvertently affects another and the attributes in each dimension are also related to one another. They impact the (know-what) declarative knowledge, i.e. meta-knowledge, (know-how) procedural knowledge and (know-why) usual knowledge (Zack, 1999a; Zack, 1999b; Zack, 1999c) in the organization.

The flow of the knowledge in this framework requires tight coupling from one attribute to another. Each attribute indirectly/directly influences another. The three dimensions must be embraced as a holistic approach to the entire ERP management and not to be treated separately. This framework is by no means the comprehensive and final one. Changes may be made to the implementation process when it is mid-way through the installation process. However, any changes to the implementation plan will mean that the factors from the Knowledge Management attributes have to be reviewed and catered for.

The main function of this knowledge repository is to store the knowledge identified in the three dimensions so that it can be reused during the relevant ERP lifecycle stage. The knowledge repository is henceforth used to capture the critical knowledge imminent and use it for other phases in the lifecycle, such as re-using the knowledge or creating new knowledge without 'reinventing the wheel'.

Within the temporal factors, knowledge is a process of reuse, review and renewal. The renewal of knowledge occurs relative to time; knowledge captured may be valid during the implementation time (*t*) but may not be as useful post-implementation (the process of *unlearning* along this perspective allows old/obsolete knowledge to be dis-selected as the next process enhances knowledge by increasing the value of it). Therefore, it is required that additional value is added to the existing knowledge and create new knowledge that can be used during (*t*+1). The process of knowledge renewal is a continuous one (*t*+*n*).

The proposed framework serves as a starting point to analyze and structure the required and the available knowledge. A knowledge manager will be responsible for the knowledge lifecycle dimension and information systems that allow the related tasks to be carried out. An ERP manager will extend his or her focus to knowledge management in the four tasks of selecting, implementing, using and changing ERP software. Finally, along the knowledge content dimension the different types of knowledge become obvious. It will be possible to document, who possesses what knowledge, where it is located, in which phase of the ERP lifecycle it will be needed and what knowledge is obsolete (unlearning). The three dimensions of this framework are discussed in further detail in the following chapter.

3. The Dimensions of the Framework

3.1 The Knowledge Lifecycle

Since advents in information technology and data processing, the information age has been gradually turning into a 'knowledge society' (Drucker, 1989). The emphasis is now on managing an organization's knowledge resources as the key to the organization's growth. The definition of Knowledge Management to date remains pervasive. While the terms data, information and knowledge have been used similarly, knowledge is neither data nor information (Davenport, 1998). Although knowledge is related to data and information, management of these entities occurs on different levels and these varied levels have different degrees of complexity. Management of data often occurs on a technical level (such as data from raw test results or details of an employee). The management of information requires the data to encapsulate a meaningful message to the receiver. In order to understand what Knowledge Management is, a distinction between the terms data, information and knowledge has to be made. Davenport (1998) describes them as:

- *Data* is a set of discrete, objective facts about events. In an organizational context, data is most usefully described as structured records of transactions.
- *Information* is data endowed with relevance and purpose. It is a message with a sender and a receiver. Information is meant to change the way the receiver perceives something, to have an impact on his judgement and behavior, it must "inform" him or her.
- *Knowledge* is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. In organizations, it often becomes embedded not only in documents and repositories but also in organizational routines, processes, practices, and norms.

The philosophical inquiry of knowledge, known as "epistemology", reveals that knowledge has its theoretical foundations in philosophy (Nonaka and Takeuchi, 1995). The theory of knowledge creation distinguishes between tacit and explicit knowledge. *Tacit* knowledge is

difficult to articulate and encode, and consequently difficult to transfer (Nonaka, 1991). *Explicit* (documented) knowledge on the other hand can be communicated or expressed in a formal language.

Another dimension of organizational knowledge creation (Figure 2) is the ontological dimension which emphasizes on developing the 'communities of interaction' to develop new knowledge. Information is flow of messages, which might add to, restructure or change knowledge, while knowledge is created and organized by the flow of information. The fundamental of organization knowledge creation is focusing the attention on active and subjective nature of knowledge such as 'belief and commitment'.
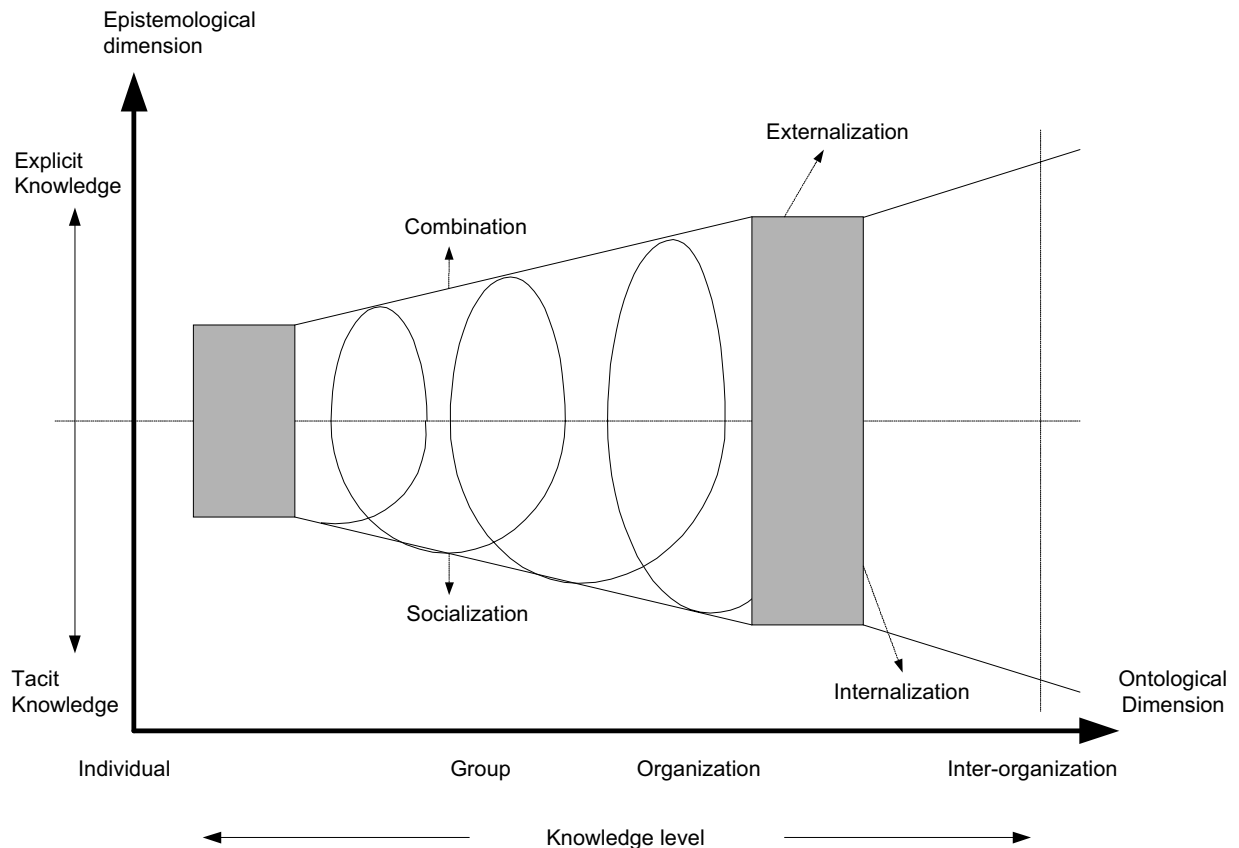

Fig. 2. Knowledge transfer across organization (Nonaka 1991)

Certain 'triggers' that can start the cycle are seen as the formation of a 'team' starts the *socialize* phase. Dialogue between the team initiates the *externalization* phase, 'coordination' and working together trigger the *combination* phase and finally experimentation of different ideas i.e. learning by doing triggers the *internalization* phase (Nonaka, 1991). Tacit knowledge is thus mobilized through dynamic entangling of the different modes of knowledge conversion. The knowledge spiral is upward moving as it starts from an individual reaching to groups departments, inter-departmental level to organization level to inter-organizational level.

While the four modes of knowledge can create new knowledge independently, the central theme hinges on a dynamic interaction between the different modes of knowledge conversion

(Nonaka, 1994). The key for this synergetic expansion of knowledge is joint creation by individuals and organizations.

The concept of Knowledge Management in particular interest to this research is discussed as follows. The core of Knowledge Management is the organization of processes in which new knowledge is developed, distributed to those that need it, made accessible for the future (re-) use and the conscious process of unlearning. Knowledge Management focuses on the competence of organizations, namely the capacity to interpret data and assign it a value. In addition, Knowledge Management focuses on another essential product of knowledge intensive work processes, namely new knowledge.

Based on the literature reviewed on Knowledge Management (Choo, 1998; Davenport, 1998; Dove, 1999; Gable, Scott and Davenport, 1998; Leonard Barton, 1998; Myers, 1996; Nonaka and Takeichi, 1995) the consolidation of this research has derived a Knowledge lifecycle depicted as shown in Figure 3. The activities in the knowledge lifecycle is depicted in a simplified way, as it suggests a strict cycle of identifying → creating → transferring → storing → (re-)using → unlearning knowledge. However and obviously, further links between these different tasks exists, which are not depicted. This is of minor importance as the corresponding dimension in the framework above does not have a direction.

The organization is seen as the key to the Knowledge Management cycle and its people as the source of the knowledge (see knowledge workers, Drucker, 1989). The first phase requires the identification of the *critical knowledge* in the organization. Critical knowledge is defined as knowledge that is both important and essential. The second phase of the cycle requires the creation of new knowledge. Existing knowledge is value-added to transcend the available knowledge. The next phase requires the knowledge to be stored. The medium for this storage may be print or electronic or may even exist in the form of an analogy. The important determinant for the successful transfer of knowledge is that the knowledge is effectively captured and can be easily conveyed upon in a later time. It is then crucial to transfer the knowledge back into the organization, where the knowledge can be reused, reviewed and renewed. The knowledge lifecycle is an on-going process, knowledge should be constantly accessed and renewed according to the organizational needs and relative to time. It is useful to note that the process of unlearning (McGill and Prahalad, 1993), whereby the organization lay aside its old knowledge by considering it as obsolete. Unlearning can be differentiated into explicit and tacit unlearning. Explicit unlearning includes a controlled process of deleting explicit knowledge (like user documentation of an old ERP version). Tacit unlearning takes the form of 'learning to forget', i.e. disremember old techniques and ways of doing tasks in preference of new methods.
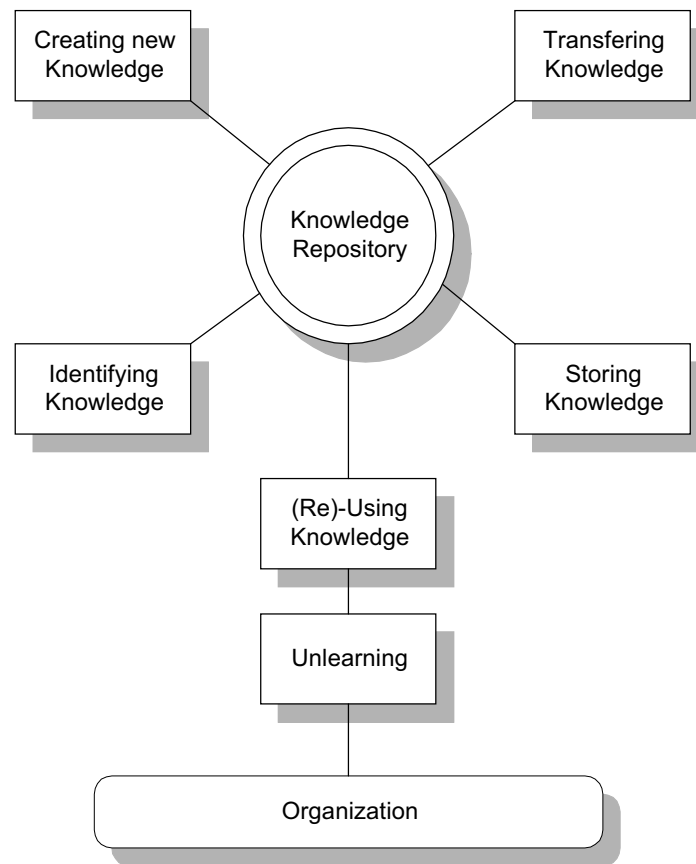
Fig. 3. The Knowledge Management Lifecycle

3.2 The ERP Lifecycle

In addition to the general knowledge lifecycle, the ERP lifecycle stresses the special focus of this framework. The lifecycle of an Enterprise Resource Planning system includes the selection, implementation, use and continuous change of this software. The *selection* stage includes the definition of the companies' requirements, a first market overview, pre-selection of ERP solutions, a request for proposals, detailed system evaluation, economic evaluation and final ERP selection. The *implementation* consists of the configuration of the ERP software and the introduction of corresponding organizational and technical changes like the definition of new responsibilities or the design of new interfaces (Kirchmer, 1999; Keller and Teufel, 1998). Typically, the implementation process takes between 6 and 24 months and external support is involved in the most cases (Parr and Shanks, 2000). In relation to the entire life span of an ERP software, the implementation is rather short, however it usually consumes the most of the budget. An ERP can be in *use* for many years without major changes. In order to execute the ERP processes the staff member needs a precise understanding of the software and related business knowledge. In contrast to the implementation, far more explicit knowledge is available. Finally, an ERP has to be continuously changed as it reflects usually a major part of the companies' business. Thus, it has to represent every new market, product, location, etc. ERP-related *change management* requires knowledge about the influence of business changes on the ERP and the opportunities in the ERP to depict these changes. This could be a new group of business partners and the corresponding configuration of processes like order processing, dunning or payment procedures.

3.3 Types of knowledge required for the ERP Management

The demand for ERP implementation knowledge and support resources is high and the lack of expertise has resulted in the turnover and poaching of ERP-knowledgeable staff (Gable et al., 1997). The loss of employees with ERP knowledge reduces often significantly the available knowledge for post-implementation challenges and leaves these enterprises with the inability to further evolve their business processes.

Implementing an ERP system, a.k.a. Enterprise-*wide* System, (given its namesake) requires a wide range of knowledge. The question lies: What is this extensive pool of knowledge? What is the knowledge required for the management of an ERP system?

In order to come up with a list of the required areas of knowledge for the ERP management, an intensive literature review was conducted. This review included especially case studies and papers discussing the critical success factors for the ERP implementation (Bancroft, 1996; Clemons, 1999; Davenport, 1996; Gable et al., 1997; Gable, 1998; Gable et al., 1998; Gable and Stewart, 1999; Mahrer, 1999; Parr and Shanks, 2000; Scott, 1999; Slooten and Yap, 1999; Sumner, 1999). The areas of knowledge that are mentioned are similar and the repetitions of the need for this knowledge from these case studies emphasize the need for knowledge to be made explicit. However, it is necessary to organize these areas of knowledge into a more manageable form. Therefore, from the literature reviewed, five different types of knowledge are clearly identified and categorized for the successful management of ERP software. These five types to be taken in mind are:

- Business knowledge
- Technical knowledge
- Product knowledge
- Company-Specific knowledge
- Project knowledge

3.3.1 Business Knowledge

This type of knowledge covers the business issues in the management of ERP. Business knowledge is indispensable as the ERP is only a tool to support the business needs.
Most of the attributes of this dimension should be addressed *before* the actual implementation of ERP in an organization. Typical business challenges during an ERP project are restructuring the chart of accounts, the cost center hierarchies or the various master data. Business knowledge includes among others:

- Expertise in functional areas like general ledger accounting, purchasing, sales, human resource management, strategic planning
- Organizational knowledge like business process management, communication policies, document management
- Training and education
- Knowledge about organizational culture, motivation, etc.

Business knowledge in this sense is general knowledge. Company-specific knowledge uses parts of it in a specific context. However, business knowledge is far more comprehensive as it also includes knowledge about business practices and methods, which is not used in a

company. New staff members, which may be recruited for an ERP project, often have business knowledge, but no company specific knowledge.

3.3.2   Technical Knowledge

Technical knowledge in an ERP project represents all knowledge that is necessary in conjunction with issues like the selection and use of database management software, the sizing of the hardware, network management, add-on programming, client-server-architectures, performance measurement, and so on. This area of knowledge can be further distinguished in ERP-specific technical knowledge (e.g. knowledge about the interrelation of an ERP system and a database system) and ERP-independent knowledge like general network management knowledge.

3.3.3   Product Knowledge

The most of the current ERP solutions are comprehensive packages with a high degree of complexity. Consequently, Enterprise Resource Planning became an area with an enormous importance of product-specific knowledge. This area of knowledge includes among others the understanding of the product architecture, knowledge about the functionality and constraints of applications, which often has to be limited due to the comprehensive ERP approach, the implementation methodology, the release strategy or knowledge about the ERP-specific programming language (like SAP's ABAP). Thus, this area of knowledge combines from a product-individual point-of-view business, technical and project management knowledge.

3.3.4   Company-Specific Knowledge

ERP software is selected, implemented, used and changed in a specific company with individual characteristics and an individual organizational population. The knowledge type company-specific knowledge takes this into account. ERP can not be managed successfully without having a precise understanding of these company individual factors. This is the reason, why the participation of the end users is a critical success factor for EERP implementation projects. This type of knowledge also includes specific business and technical knowledge. Furthermore, company specific product knowledge is a part of this knowledge (e.g. knowledge about existing legacy systems).

3.3.5   Project Management Knowledge

A project is defined as an endeavor to create a service/product in a certain time with limited resources. The implementation of an ERP system in an organization is a challenging project and requires a project management for a time between 6 to 24 months. It also seeks to achieve outputs such as milestones and objectives (Weiss and Wysocki, 1992). Duncan (1996) describes project management as an organizational approach to the management of on-going operations. One main challenge for the project manager (who often does not have detailed business, technical, product or company knowledge) is to bring project members along the different stages of the project in a way together, that they together represent the required knowledge.

3.3.6   Further Areas of Knowledge

Usually different project participants have the five types of the required ERP knowledge. Consequently, *communication, coordination and cooperation knowledge* is required in order to integrate the five types of knowledge (see Figure 4). It is obvious, that even if the five types of knowledge (business, technical, product, company, project) are available in a project, the missing capability to efficiently interact between the involved knowledge owners might be a reason for a project failure. One reason is also that it takes significant time to develop the required communication, coordination and cooperation knowledge or to get the knowledge from different project members.
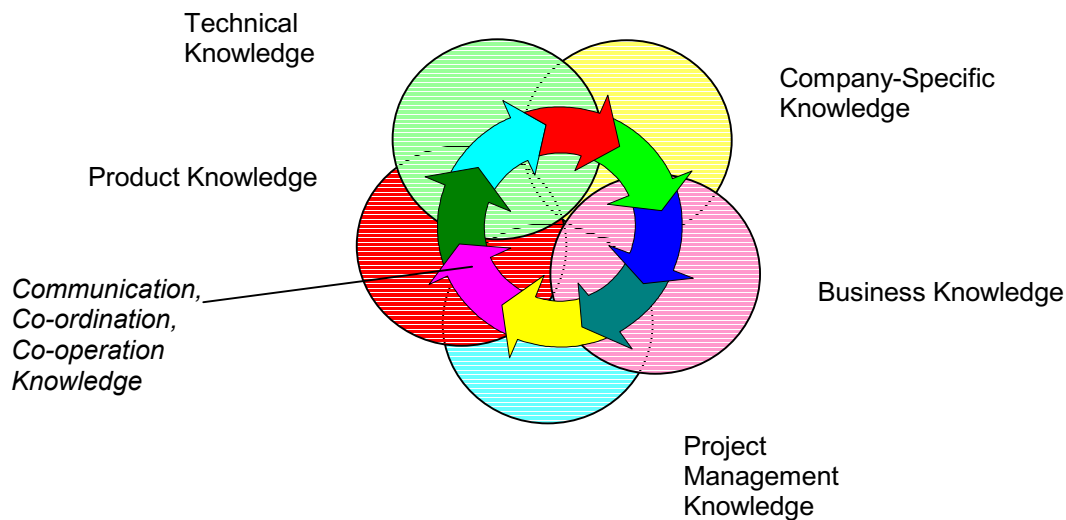

Fig. 4. Required communication, coordination and cooperation knowledge

The proposed framework suggests an approach to structure knowledge in the context of ERP management. As an example for how this framework can be applied, it will be discussed in the next chapter how ERP reference models can be extended in a way that they include the different types of knowledge. This will support a transparent Knowledge Management process.

4.   Modeling Knowledge in the Context of ERP

Many ERP provider designed over the last years comprehensive reference process models in order to document how their solutions support various business processes (e.g. Curran and Keller, 1998). With this approach they captured at the same time knowledge about their product. Figure 5 shows as an example an extract from a simple ERP-specific reference process model. In this case, it is a part of the dunning process within SAP R/3. The modeling grammar is the event-driven process chain (Scheer, 1998a). It consists of events (hexagons) and function (rectangles) as well as control flow constructs (AND, inclusive and exclusive OR), which describe joins and splits in a process model. The model below shows an AND-split.
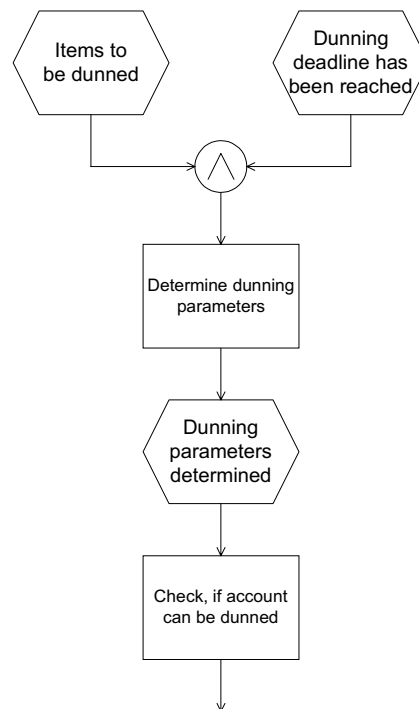
Fig. 5. Exemplary ERP-specific reference process model (extract)

The efforts some ERP providers put into the development of these reference models are impressive. E.g., the market leading ERP product SAP R/3 is documented in more than 800 reference process models. However, these models have the following weaknesses:

- They represent the entire functionality from the viewpoint that the complete system is used. It is not obvious, what configuration alternatives exist. ERP-specific reference models are in general not designed to be modified.
- They focus on the elements that are of importance for the specific ERP system. Enterprise-individual aspects of the organization, business objectives or manual tasks can not be seen in these models. They do not include any references to the involved or required knowledge.

In order to overcome the missing link between ERP-specific reference models and Knowledge Management, the use of *extended* reference process models is suggested. Thus, it will be possible to identify what type of knowledge is required in which processes. The proposal is to add further *knowledge objects*, which are related to Knowledge Management (Scheer, 1998b). These knowledge objects represent knowledge in the form of explicit or tacit knowledge and are connected with the functions of a process. The framework introduced above shows how these knowledge objects can be structured.

Following the ERP lifecycle, the knowledge objects are marked by an index, which can be I (Implementation), E (Execution) or C (Change). An 'I' indicates that knowledge about the configuration of the product and/or the process is necessary. This information is only of importance during the implementation stage. It helps to identify for a separated process, which knowledge the responsible project team has to have. After the configuration of this process, the knowledge, which is necessary to perform the activities of a process ('E') as well as the change management knowledge ('C') becomes relevant. Selection criteria can be

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integrated via indexing ("S") entire processes or certain functions as critical for the system selection process. Figure 6 shows how the available ERP reference model can be extended with information about explicit and tacit knowledge.
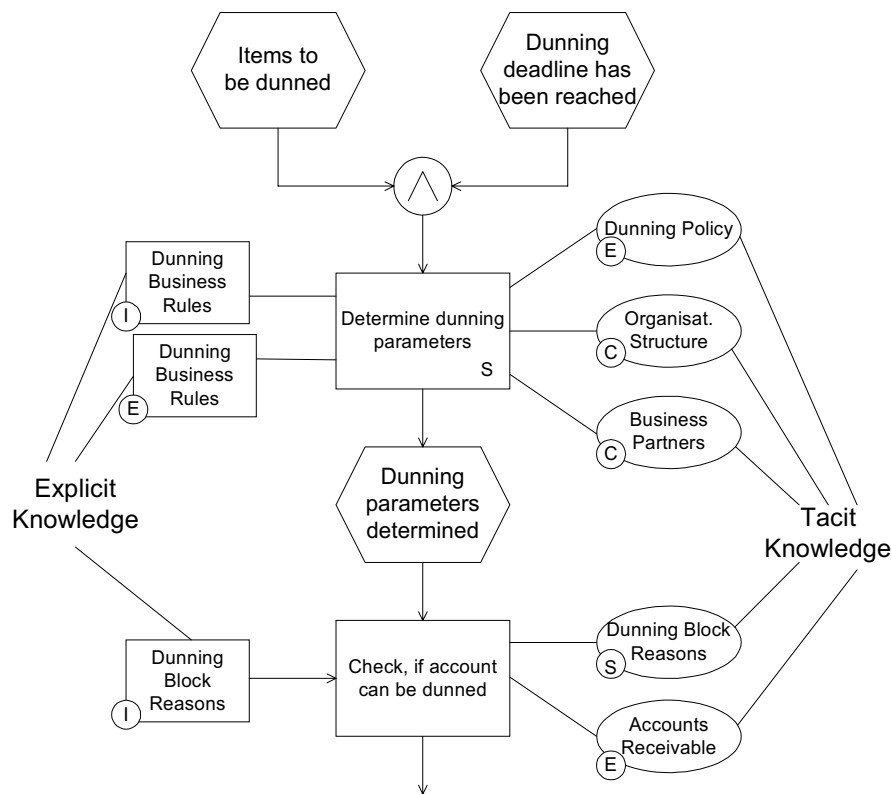

Fig. 6. Extended ERP-specific reference process model

In addition to the phase in the ERP lifecycle every knowledge object can be classified by the required knowledge content. As discussed above this can be business, technical, project, company or product knowledge.

Such extended reference process models can be used for the following purposes:
- An *ERP vendor* might offer these comprehensive models to provide his customers and implementation partners with more information. The information objects describing explicit knowledge could be linked to documents, online-help, web links or even seminar offers. First discussions with the major ERP vendor have started in order to evaluate the possibility that parts of the proposed framework or modelling suggestions might be integrated.
- An *implementation partner* can use these models as a starting point for the own ERP-related Knowledge Management. The documents from various projects could be added. New process model releases from an ERP provider would be evaluated and the required knowledge shows where further qualifications of the consultants are necessary.
- Finally, a *company* that wants to implement the ERP solution gets important information about what kind of knowledge is required in which process. For every process that is selected as a relevant process, the necessary knowledge for the system configuration and the corresponding organizational and IT changes can be easily identified. This gives among others important information for the selection of the staff members who should be involved in the project. After the implementation, these models depict what knowledge is

required for the execution of the processes. The models can be continuously extended with enterprise-individual documents and store all knowledge materials related to the business processes.

In the following, it should just be focused how a company that wants to implement and use an ERP solution, might benefit from these models. The (realistic) assumption is that the models are available in a cutting-edge modeling tool with comprehensive reporting functionality and a repository which stores all information objects. Figure 7 shows as an example the structure of a formatted report for an extended reference process model. An "R" indicates in this table that for a certain function specific (business, technical, product, company or project) knowledge is required.

	Product			Business			Project Mana
	IMG	ASAP	ABAP	Customers	AR	Legal Issues	Conflict Handling
Process 1							
- Function 1	R			R			
- Function 2	R				R		R
- Function 3		R	R	R	R		
- Function 4						R	
Process 2							
- Function 1			R				
- Function 2		R					R
- …							

Fig. 7. A process-knowledge report

This matrix of knowledge requirements has to be compared with the available ("A") knowledge resources. A corresponding matrix can have a structure like in Figure 8, in which every row shows one staff member (organized per department, AR: accounts receivable, IT: information technology). This report is based on a knowledge-map, which is independent from process models and links staff members to knowledge objects.

	Product			Business			Project Mana
	IMG	ASAP	ABAP	Customers	AR	Legal Issues	Conflict Handling
AR (Role x)				A	A		
- Gable		A				A	A
- Timbrell							A
- Geib						A	
- Rowena			A				A
IT (Role y)	A	A					
- Chan			A				
- Bhargava							A
- …							

Fig. 8. A staff-knowledge report

Both matrices in comparison show where knowledge gaps exist (see Figure 9: only "R"). In these cases it has to be decided, whether external support should be acquired or internal staff members should be qualified. If all relevant processes and the corresponding reports and matrices are consolidated the analyses per row and column gives information about how well a function is managed from the knowledge point-of-view. Columns with many knowledge gaps might indicate that this sort of knowledge is under-represented in general.

	Product			Business			Project Mana
	IMG	ASAP	ABAP	Customers	AR	Legal Issues	Conflict Handling
Process 1							
- Function 1	R			R			
- Function 2	R/A	A			R	A	R/A
- Function 3	A	R/A	R/A	R/A	R/A	A	
- Function 4		A				R/A	
Process 2							
- Function 1		A	R/A		A		
- Function 2		R/A					R/A
- …							

Fig. 9: Overlapping matrices

5. Outlook

While this paper has based its findings on the types of knowledge, methodologies and critical factors required for the implementation of ERP software from an intensive literature review of case studies (Bancroft, 1996; Clemons, 1999; Kirchmer, 1999; Mahrer, 1999; Parr and Shanks, 1999; Scott, 1999; Slooten and Yap, 1999; Sumner, 1999), an empirical survey is currently conducted underway to find out what managers of ERP projects regard as important issues in the area of Enterprise Resource Planning and Knowledge Management. The survey results will validate the existing framework and highlight other areas of the proposed framework for improvement. Upon further analysis, these survey results can be used to further evolve the current research by identifying any gaps or transitions in the structure of the research.

From a methodological point of view, the on-going research will formally extend the meta-model of the Event-driven process chains and describe the way the reports can be generated from the process models. The documentation from the reports is expected to enhance the knowledge base of the ERP-related personnel. The practical extension in this research will executed using the ARIS-Toolset and ARIS for R/3 to generate more comprehensive process models and reports. Researching into the business processes from ERP vendors' reference process models, knowledge objects required for extension to relevant process models will be investigated and identified.

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