# Ontology-Based Evaluation of Organizational Memory

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**In this article we offer a new approach to evaluating Organizational Memory (OM). Our proposed evaluation methodology, named KnowledgeEco, is based on an ontology for the domain of OM. Its key steps are: 1) mapping the OM in the evaluated organization onto the ontology concepts; 2) noting which entities from the ontology are missing in the OM; and 3) applying a series of rules that help assess the impact of the OM on organizational learning. This systematic evaluation thus helps to propose ways to improve the evaluated OM.**

**We present three case studies that demonstrate the feasibility of KnowledgeEco for evaluating OM and for suggesting improvements. We also identify some weaknesses in the OMs common to the three organizations cited in the case studies. Finally, we discuss how the KnowledgeEco ontology-based methodology establishes utility and contributes to further research in the field of OM.**

## Introduction: Evaluation of Organizational Memory

*Organizational Memory* (OM) is crucial for managing knowledge in learning organizations (Jennex & Olfman, 2004; Lehner & Maier, 2000; Nevo & Wand, 2004). Previous evaluations of Knowledge Management (KM) in general and OM in particular have followed a piecemeal approach, assessing the quality of design (Ackerman, 1996; Nilakanta, Miller, & Zhu, 2006) or measuring system performance (Kankanhalli & Tan, 2004; Vekrasalo & Lappalainen, 1998). Other research has taken the user perspective as a basis for evaluation (Ackerman, 1998) or has focused on the usability of knowledge (Marcus, 2001).

There is therefore a critical need for comprehensive evaluation of KM systems and practices that is systematic, replicable, and theoretically based (Weinberger & Frank, 2006; Zhang & Zhao, 2006).

In this article, we propose a methodology to evaluate OMs based on domain ontology (Holsapple & Joshi, 2004). This ontology, called *KnowledgeEco*, generalizes several previous concepts of OM, integrating people and information systems, as advocated by Stein and Zwass (1995) and Ackerman (1998), and in this sense is more comprehensive than previous studies. Rooted in the domain-analytic paradigm of Information Science (Hjorland & Albrechtsen, 1995), our treatment of OM attempts to tie structure (Abecker, Bernardi, Hinkelman, Kuhn, & Sintek, 1998; Edington, Choi, Hensen, Raghu, & Vinze, 2004; Walsh & Ungson, 1991), content (Wijnhoven, 1999), and processes (Davenport & Prusak, 1998; Dieng, Corby, Gibon, & Ribiere, 1999; O'Leary, 1998, Wijnhoven, 1998) to the desired impact since without addressing impact, the evaluation would be meaningless. Following several researchers (Boland, Tenkasi, & Te'eni, 1994; King & Ko, 2001; Majchrzak, Malhotra, & John, 2005; Mullaholand, Zdeahal, Domingue, & Hatal, 2001; Tippins & Sohi, 2003), we concentrate on the impact of OM on learning.

KnowledgeEco can be used to study the usefulness of OMs in organizations and evaluate a specific OM in a three-step methodology:

1. mapping the actual OM onto the KnowledgeEco ontology;
2. noting the differences between KnowledgeEco and the specific OM; and
3. applying a series of evaluation rules that help assess the impact of the OM on organizational learning.

This article reports on the results of an empirical study, which is part of yet a larger theoretical study (Te'eni & Weinberger, 2000; Weinberger, Te'eni, & Frank, 2007). Based on the application of KnowledgeEco to three case studies, we illustrate its relevance to practice.

Following the introduction, we briefly describe the ontology used in KnowledgeEco (for a full description, see

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TABLE 1. Description of the four core classes of KnowledgeEco.

| Class | Description |
|---|---|
| Structural Memory | SM is an abstract class that aggregates two interrelated classes: Type (Individual Memory and Organizational Memory) and Component (Content and Means) to enable organizational learning processes. |
| Type | Type is an abstract class that generalizes individual and organizational memory structures. |
| Component | Component is an abstract class that aggregates Content and Means of the SM. Each Type is realized by a set of components. |
| SM Lifecycle | SM Lifecycle is an abstract class that defines the processes required for the development and evolvement of memory types in an organization. |

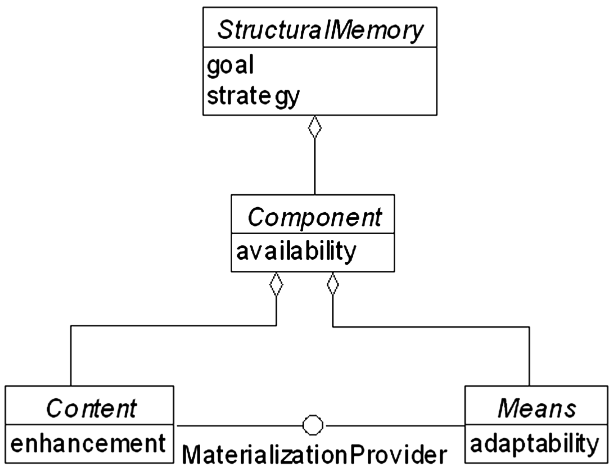


FIG. 1. KnowledgeEco: Ontology for OM—the Structural Memory dimension.

Weinberger et al., 2007), present the ontology-based methodology, and test its feasibility and utility in the three case studies. The article concludes with a discussion of KnowledgeEco and its practical and theoretical contributions to the field.

## KnowledgeEco Building Blocks

We begin with a description of four core classes (Table 1): Structural Memory, Type, Component, and SM Lifecycle. [1] Each of these classes represents a different perspective of an OM, and together these classes form a multi-perspective view that is considered an important feature of a reference model used for evaluation (Frank, 2007; Holsapple & Joshi, 2004).

KnowledgeEco was developed using conventions of the object-oriented paradigm (Booch, Rumbaugh, & Jacobson, 1999). We make use of two object-oriented concepts, inheritance and relationships. Inheritance enables a singular representation of an element, such as an attribute, to be further exploited by other related classes. Relationships can be one of three kinds (defined in descending order of sharing obligation): (a) an aggregation relationship that represents a part–whole relation, (b) a generalization relationship that relates a general description with a more specific one (i.e., a kind-of relation) enabling inheritance, and (c) an association relationship which indicates a binary relation between two classes.

The highest abstraction in the KnowledgeEco ontology is the newly coined (Weinberger et al., 2007) concept of *Structural Memory* (SM) (Figure 1), which is an abstraction of several types of memory and includes diverse knowledge structures as well as the means required to manage the knowledge. The concept enables this unified representation.

SM is assigned two attributes: *strategy* and *goal*. The value assigned to each of these attributes (e.g., <set of goals>) enables an organization to express its unique value properties. As shown in Figure 1, SM aggregates type and component. Type (Figure 2) defines various kinds of OM such as individual- and organizational-level OM (Ackerman, 1996, 1998; Dieng et al., 1999), and component defines the static and dynamic aspects of an OM (Davenport & Prusak, 1998; Kankanhalli & Tan, 2004; Nilakanta et al., 2006). The static aspect refers to entities such as knowledge in the OM and the mechanisms used to manage it, and the dynamic aspect refers to the processes involved in managing an OM (Weinberger et al., 2007).

Type differentiates SMs that represent individual-level memory (IM) (e.g., Person Memory, which is the memory maintained by a specific person) from those that represent organizational-level memory (e.g., Group Memory) using three attributes common to both individual and organizational aspects: field of practice, core competency, and organizational ecology. Attributes that are specific to organizational-level memory include prevailing culture, constraints, memory profile, and other relevant enterprise information (Fox & Gruninger, 1998). One attribute specific to individual-level memory is the individual's expert activity. These attributes are used to characterize a specific OM.[2]

Nonaka and Takeuchi's (1995) model of knowledge creation served as a basis for further research on the varied aspects of the compound nature of knowledge creation, sharing, and transfer in an organization. Considering a spectrum of organizational settings, goals, and constraints, Marcus (2001) suggested a typology of knowledge-reuse situations to instruct OM design while Leonard and Swap (2005) investigated modes for sharing tacit knowledge to promote further knowledge creation.

Type (Figure 2) synthesizes this previous work on knowledge sharing and reuse, and underscores the importance of individual-organizational interaction using methods that enable knowledge diffusion and elaboration. For example,

[1]We use an uppercase first letter to designate a class name, following UML conventions, but we do so here only in the first reference to each class, though in all the figures.

[2]The term OM is used here, as is common in the literature, to indicate an instance of an individual- or an organizational-level OM.


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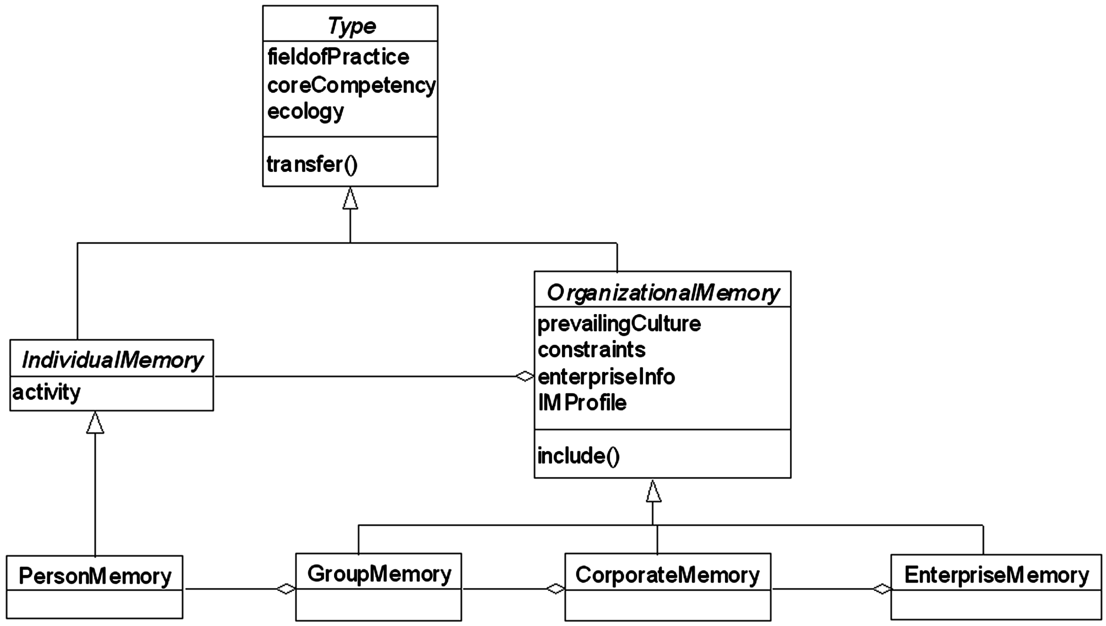


FIG. 2. KnowledgeEco: Ontology for OM—the Type dimension.

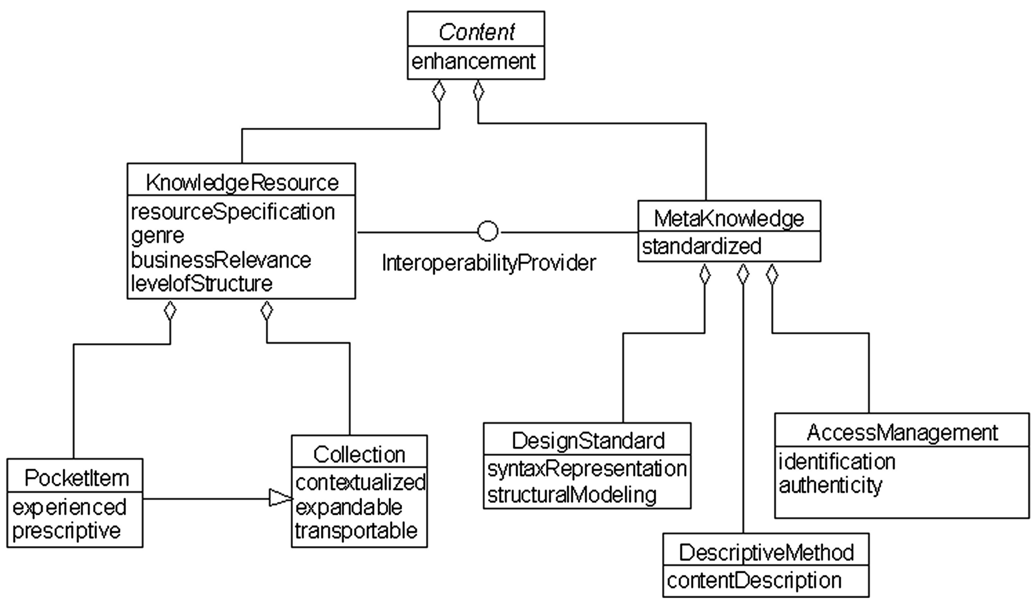


FIG. 3. KnowledgeEco: Ontology for OM—the Content view.

the method "transfer" denotes the possibility of an instance of IM becoming part of another SM through socialization and externalization, and the method "include" denotes the possibility of an instance of OM evolving through combination and internalization. Knowledge diffusion capabilities also are represented by relationships between OMs, which in turn affect components of the same SM.

Component defines the SM Content–Knowledge Resource and Meta-Knowledge (Figure 3), and Means–Agent and Process (Figure 4) that are appropriate to a specific Type. Means enable knowledge creation and use.

The notion of component reveals not only the mechanisms of an OM (Stein & Zwass, 1995; Verkasalo & Lappalainen, 1998) but also the products made available in an OM (Tippins & Sohi, 2003). Subclasses of knowledge resource are Collection (e.g., Best Practice, Lesson Learned, Guide) and Pocket Item (e.g., Heuristic, Idea, and Story). Pocket items are usually tacit while collections are explicit and often contextualized, expandable, and transportable. Collection may require Meta-Knowledge to enable knowledge sharing (Jennex & Olfman, 2004; O'Leary, 1998; Walsh & Ungson, 1991). Figures 3 and 4 illustrate these entities


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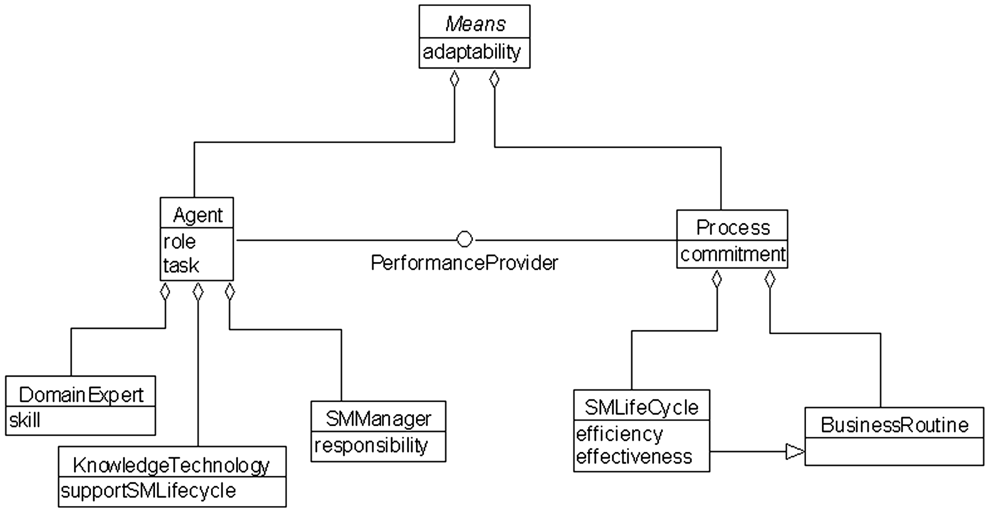


FIG. 4. KnowledgeEco: Ontology for OM—the Means view.

and relationships that are part of component, using the aggregation, generalization and association relationships.

Means are composed of two subclasses: *agents* and *processes*. There are three agents, of whom the first two may be human and/or computer agents: SM Manager, Domain Expert, and Knowledge Technology. There are three subclasses defined for knowledge technology: Resource Discovery (e.g., data analysis, search engines), Sharing and Collaboration (e.g., content management system, collaboration), and Knowledge Repository (e.g., online repository, data warehouse). The UML interface notation is used to represent interdependencies between subclasses: the Interoperability-provider indicates the dependency of knowledge resource on meta-knowledge; the Performance-provider indicates that agent executes process, and the Materialization-provider indicates the extent that means support content.

To be useful, knowledge must evolve as a means for supporting action (Richards, & Simoff, 2001), and hence, the OM must be planned accordingly. Following Siemienuich and Sinclair (1999), we borrow the idea of a systems development lifecycle and adapt it to the specification of developing and applying SM components (Te'eni & Weinberger, 2000).

SM lifecycle has two attributes: *efficiency* and *effectiveness*. Efficiency describes the utilization and management of components, and effectiveness describes accomplishment of SM goals and strategy. The lifecycle stresses the need to represent the dynamics of knowledge in the sense that knowledge continuously evolves to be effective (King & Ko, 2001). The lifecycle begins from requirements specification to achieve specific goals and continues with analysis, design, and construction. To ensure effective learning, the SM lifecycle supports the stages of evolution and evaluation. Evaluation of SM is important to control and guide evolution (Abecker et al., 1998; Ackerman, 1998). Additionally, methods to support OM-related processes are represented as part of the SM lifecycle.

## KnowledgeEco Ontology-Based Methodology

In applying KnowledgeEco ontology-based methodology, we first identify the goal of each OM initiative in the target organization. For each OM, we proceed in three stages: *knowledge acquisition* (using semistructured interviews and questionnaires), *modeling*, and *evaluation*. In knowledge acquisition, we map the OM to the ontology. In modeling, we identify the entities of the ontology missing in the OM. In evaluation, we apply a series of rules that help assess the impact of the OM on organizational learning. This systematic methodology therefore suggests ways to improve the evaluated OM.

### *Knowledge Acquisition*

Knowledge acquisition rests primarily on face-to-face, semistructured interviews using ontology-based questionnaires and documentation. We designed a questionnaire as the basis for a semistructured interview and improved it using an iterative process (Weinberger, 2004). Prior to the interviews, we explained KnowledgeEco (for ~20 min). For instance, we discussed the structure and selected entities described in the ontology, and elaborated on the modeling technique, using the ontology glossary and UML diagrams. To ensure a spectrum of perspectives, for every OM we interviewed the various stakeholders (i.e., management, technology, and field personnel).

The questionnaire provides the information necessary for comparing the OM with the ontology. Participants responding to the questionnaire were requested to determine the missing classes and their attributes. Appendix A lists selected questions.

### *Modeling*

The information obtained through knowledge acquisition was examined and modeled as UML diagrams, corresponding to the notation describing the ontology. UML class diagrams


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TABLE 2. The four evaluation rules.

| Rule | Description |
|---|---|
| SM strategy | For every SM, there should be a strategy for developing and utilizing its components to achieve specified goals. |
| Sharing between SMs | Sharing between SMs should enable the sharing of knowledge from one to another. This rule is represented by the aggregation relationship between SM types and the methods for transfer-include that enable knowledge transfer. |
| Design of components | The SM Means should be designed to support effective utilization of the SM Content. This rule is represented in the SM by interfaces between Content and Means, between Knowledge Resource and Meta-Knowledge, and between Process and Agent. |
| Dynamic SM lifecycle | The development and utilization of the SM should progress within a controlled lifecycle. The SM lifecycle should include (a) planning through requirements specification, analysis, and synthesis; and (b) development and control through design, implementation, evolution, and evaluation processes. |

are used to model the static aspect of the ontology (e.g., Figure 1) while the dynamic aspect is modeled using the use case, activity, and sequence diagrams (Weinberger et al., 2007). Additionally, we used UML object diagrams to document instantiations of classes. The diagrams were then presented to the interviewees in specific organizations and adjusted according to the feedback obtained to validate the findings.

### *Evaluation*

The evaluation process is comprised of two procedures. First, we assess whether the comparison between the OM and the ontology yields a *full match*, *partial match*, or *no match*. A full match means that all classes and subclasses of the ontology—as far as the sixth level (e.g., subclasses of Collection)—are represented in the OM. A partial match occurs when at least one of the concrete-level entities of the model exists in the OM. Pictorially, we used shades of gray to show the match levels. When there is no match at all (i.e., no concrete-level entities in the OM), the class box remains white; for the other two conditions, we use dark and light gray, respectively (see Appendix B). The assessment is based on the identification of terms and practices identified for the specific OM, based on the classification and description provided for these in the ontology documentation.

In the second step of evaluation, we assess the significance of the match or mismatch by applying four evaluation rules: *SM strategy*, *Sharing between SMs*, *Design of components*, and *Dynamic SM lifecycle* (Table 2). These rules are based on concepts and notions described in the ontology, and thus form an integral part of it. Since the rules can be applied to the OM as a whole or to any part of it considered as an SM, we use the term *SM* in the description of the rules.

In this context, KnowledgeEco also suggests a set of evaluation rules based on a spectrum of decisions made by individual organizations that can be considered—in view of their respective needs (Frank, 2007; Holsapple, Raj, & Wagner, 2007). These rules help to assess the impact of an OM (SM) on organizational learning by examining how well the ontology is applied to the SM in question.

The first rule, *SM strategy*, suggests that for each OM there should be a strategy for developing and utilizing its components to achieve specified goals. The rule suggests that there should be compatibility between the OM goals and the mechanisms chosen to meet these goals. The rule does not, however, prescribe a particular way of achieving a goal because of the wide range of possibilities available to satisfy OM goals.

The second rule of *Sharing between SMs* is based on the crucial role of knowledge sharing within and between OMs for organizational learning. One way of meeting this rule is for the component dimension to show a spectrum of means to help the creation of content, for instance, using both the human resource alongside information systems. Yet another way is by maintaining continuous knowledge-sharing procedures between OMs using the methods transfer-include that enable knowledge transfer, as in Figure 2.

The third rule is *Design of components*. This rule highlights the significance of effective manipulation of content and means, for instance, to support sharing between SMs, as in the previous rule. It asks whether the goals and the mechanisms deployed for achieving these goals are in accord. In the ontology, the utility of the concrete-level content and means is interdependent. For instance, the creation of resources is the result of an agent—human or technology—manipulation. Following these notions, in parallel to understanding the OM's goals, it is possible to comprehend if an OM is indeed effective.

The fourth rule is focused on the *dynamic aspect of SM*. With this rule, we assess if an organization maintains an OM through a complete lifecycle—from planning to evaluation and evolution—to indicate a methodological approach at the development of an OM. This rule introduces the vitality of planning, and the importance of control to the successful development of an OM.

These rules represent not only the various dimensions of OM evaluation but also the relationships between these dimensions to create a unified understanding. Hence, the rules can be used to instruct OM design towards organizational learning.

The discussion of the evaluation of each case study described herein is arranged by these evaluation rules.

## The Application of KnowledgeEco: Three Case Studies

Herein, we report on three case studies we conducted to test the feasibility of KnowledgeEco:[3] (a) *Health Services*,

[3]The names of the organizations that took part in the case studies have been disguised.

which is a large health services organization in Israel; (b) *Civil Engineering*, which is a civil engineering organization in Germany; and (c) *Research Institute*, which is the German chapter of a European research initiative. We selected a diverse set of organizations that could each demonstrate at least one formal initiative in promoting KM through the use of information technology. In each of the three organizations, we studied several OM initiatives at the individual- and organizational-memory levels.

*The Case-Study Approach*

Following Yin (1994), we regard a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real life context" (p. 13) and apply three guidelines to its implementation. The first guideline prescribes heterogeneity in the selection of the cases (Hevner et al., 2004; Mingers & Brocklesby, 1997). To this end, we select organizations that differ by industry and by country of origin, and ensure that the participants differ in their orientations, representing management, technology, and field-oriented perspectives (Mingers & Brocklesby, 1997). The second guideline recommends the use of a logical format, which we use consistently in all cases. Third, we use two evaluation methods: a comparative method and a qualitative one. Taking the interpretive perspective, we used multiple sources of information, primarily from interviews and documents, to direct the learning process while making the research more relevant to practice.

The description of each of these three case studies begins with an organizational overview, continues with a description of the first stage of knowledge acquisition (for the questionnaire, see Appendix A), and is followed by a discussion of the modeling process. The discussion of the evaluation of each case study is arranged by the four evaluation rules. A summary of the findings is shown in Appendix B.

*Case-Study 1: The Health Services Organization*

Health Services is a large healthcare provider in Israel. With nearly 50,000 employees and over 3.7 million insured consumers, it maintains a wide spectrum of healthcare services, owning 14 hospitals as well as 1,200 clinics, 4,000 pharmacies, and specialized medical institutions. Following privatization of the sector, Health Services faces significant competition and, in response, has embarked on a KM strategy.

Based on the responses obtained from key KM personnel, we decided to focus on three distinct OMs. The first, herein named the *society of physicians* OM, originated with an initiative of a task group of physicians belonging to different organizational units, and united to create a repository of best practices (see Appendix A,[4] Question 1) for the prevention of hospital-acquired infections.

The second OM, named the *community clinic* OM, was intended to meet a spectrum of KM needs of a regional health services clinic. The Chief Knowledge Officer (CKO), a practicing physician, described it:

> Physicians on site often introduce contextualized insights that pave the way to the design and definition of innovative best practices as a result of daily exposure to community health challenges. This knowledge, though shared among colleagues in the same clinic, ends up, at best, filed as hardcopy in the clinic. Other clinics and physicians—who encounter similar situations—do not share their experiences. There are several distinct disadvantages to this deprivation of knowledge and organizational learning processes.

*Information management* is the third OM. There are three goals which motivate this OM: (a) establishing a patient-record-management system for supporting strategic-level decisions of senior management (e.g., prioritization of healthcare services and budget allocation); (b) providing an administrative management guide to train physicians for administrative positions in the face of decentralization; and (c) establishing an up-to-date competence library to aid physicians with best practices, lessons learned, and FAQ repositories, which also could prove beneficial for other populations.

*Knowledge acquisition.* Knowledge acquisition for the *society of physicians* OM commenced with an interview of a senior physician functioning as the SM Manager. He personally invited more than 35 physicians from different hospitals throughout the country to join this initiative as domain experts and to contribute their best practices and lessons learned. Of these, we interviewed 7 physicians practicing in different hospitals, of which four interviews were face-to-face whereas the other three were done by e-mail questionnaires. Additionally, on-demand phone calls and e-mail correspondence were employed for clearing out unresolved issues.

Knowledge acquisition for the *community clinic* OM commenced with an interview of the practicing manager of the clinic, a KM-minded physician, who initiated this OM through routine weekly meetings of practitioners. This was followed by a series of individual meetings with other participants (i.e., 2 physicians, 1 nurse, and 1 secretary).

For the *information management* OM, knowledge acquisition was carried out in three tracks, corresponding to the three aforementioned goals, with three different groups of participants. We began with informal discussions with senior management, and continued with formal interviews and filling in the questionnaires with the CKO and his team who represented technology-oriented participants. Finally, we interviewed a learning center representative and individual physicians. Usually, interviews were conducted on an individual basis, apart from several group sessions with the CKO and his team. Additionally, we had full access to the organizational knowledge including information systems and documentation. A summary of the findings is shown in Appendix B.

*Results*

**Society of physicians OM.** The strategy of this OM (Appendix A, Question 2) emphasizes the reliance on peer

[4]All herein references to questions used for knowledge acquisition and mentioned as part of the findings analysis are from Appendix A.


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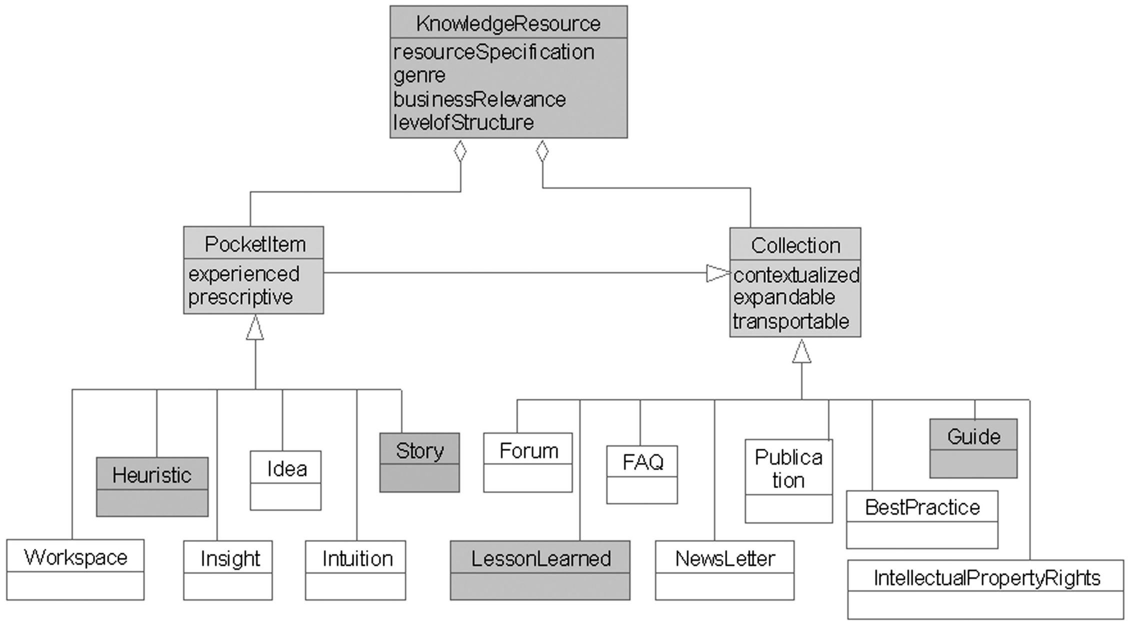


FIG. 5. Knowledge Resource and subclasses in Health Services: Society of physicians OM. Shaded class indicates the existence of an instance in the specific OM.

participation for contribution of the required knowledge. Based on common core competency (Question 4) that is focused on the subject of inflammatory diseases, the organizational norms (Question 5) acknowledged here are of the kind that encourage sharing and peer consultation. However, we found these norms translated to a prevailing culture of "laissez faire" that was met by limiting organizational, technical, and economical constraints (Questions 8 & 9). As a result, the content gathered was mainly the contribution of 8 devoted physicians.

The genre of the knowledge resources was procedural (Question 14), based on the physicians' experiences, and prescriptive, aiming to suggest solutions to common problems. Since e-mail was the only dissemination tool, the contributions were mostly semistructured and included what we identified to be instances of story, heuristic, lessons learned, as well as a guide—although no such classification was available in practice (Figure 5). From a methodological perspective—that is, in terms of SM lifecycle—the only identified processes were knowledge-creation and knowledge-sharing processes.

**Community clinic OM.** With the *community clinic*, we found an integrated, devoted, and diversified group of experts who were encouraged to contribute from their own experiences. In our intent to identify the organizational prevailing culture and organizational constraints (Questions 8 & 9), we note that the CKO also foresaw the need to rely on a spectrum of information systems, which were not yet budgeted.

We found diversified knowledge resources. For instance, there are instances such as heuristic, insight, and story identified in the ontology as kinds of pocket item, alongside more formal knowledge resources identified in KnowledgeEco as kinds of collection, such as guide, FAQ, lessons learned, and best practices. One example of a creative best practice is a protocol for yearly checkups for youngsters and workshops for parents of newborns and adolescents. Yet another example of a best practice is a yellow sticker on a nurse's gown, designed to remind visitors to the clinic of important procedures (e.g., vaccinations). While this is the kind of convention common with electronic products, it is not yet common in healthcare.

Much like in the former OM, this OM was not provided with means to share its experience and knowledge with other parties in the organization; however, colleagues from other community clinics were occasionally exposed to the knowledge resources of this OM, either as part of yearly seminars or by word-of mouth. These colleagues acknowledged the significance and potential contribution of an OM, and hence were motivated to also establish one. For instance, they addressed the community clinic personnel with requests for guidance and help on constructing an OM. Nevertheless, there was nothing in these occasional sharing events to alter the situation by which the existing knowledge remained exclusively within the *community clinic* OM.

**Information management OM.** The strategy of this OM was focused on the exploitation of capabilities associated with knowledge technology (i.e., rather than individual knowledge); hence, the question of organizational norms which concern knowledge sharing is to be considered in a different context. The expertise of individuals belonging to this OM was varied, in accordance with their goal. There are two prominent differences between this OM and the previous two OMs. First, here the intention was to support knowledge dissemination between all distributed units of service, and to encourage their utilization. Second, the locus of activity of this OM was the dissemination of declarative knowledge (i.e., record management and procedural knowledge, alongside


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different kinds of meta-knowledge, governed by admission control; Questions 14 & 9, respectively).

For instance, this includes the assimilation of resources such as drug registries into everyday practice, and the development of a patient-record-management system. Additionally, a type of digital library was introduced, alongside an On-Line Analytical Processing (OLAP)-based decision-support system, which includes a resource discovery prototype (e.g., data mining and data analysis). Finally, we also consider a knowledge repository (e.g., data warehouse, document repository—both external and online) of procedural knowledge, which originated from peer-reviewed publications.

Based on a relatively wide coverage of knowledge technology, there is in this OM evidence for a routine practice of design and construction activities, coordinated directly by the CIO and CKO and their teams (Appendix B).

*Case-study evaluation.* Our discussion commences with the first rule, *SM strategy*. While there is evidence of measures taken to meet the goals in each of the three OMs discussed, there are several reasons to assert that this rule was ill-maintained. This is because while each of these OMs was indeed striving to meet its goal, each was lacking the required holistic approach.

For instance, we note the *society of physicians* OM. While this OM has accomplished some progress and managed to create a knowledge network, it was prevented from keeping up maintenance and growth because of poor allocation of means. In the case of the *community clinic* OM, indeed, there is evidence of an established knowledge-intensive work procedure; however, this effort lacks a supportive network of knowledge technology, such as would promote its effectiveness and stimulate organizational learning. Partially, it could be argued that since the *information management* OM realizes a successful integration of several knowledge resources, it thus meets its goal. An exception is made due to budget constraints: While this OM enjoys generous funds, prioritization considerations show that it is held responsible for the shortage of means among the other OMs. Consequently, the lack of tacit knowledge in an all-organizational scale was noted. For instance, failure to support the development of individual-level memory results in a shortage of tacit knowledge, which in turn prevents organizational learning opportunities. While this shortcoming can be an indication of a certain strategic stance, it also is an indication of the prevailing organizational culture, which underestimates the value of individual knowledge and its role through an OM's lifecycle. Specifically, we acknowledge this issue as part of the scope of the second rule.

We find that the principles of the second rule, *Sharing between SMs*, are poorly met for several reasons. Mainly, we attribute this to management orientation, which underestimates the merit of the human resource—as a knowledge resource. For instance, in the *society of physicians* OM, there was a small minority who actively contributed, and a large majority who avoided direct contribution—unless specifically approached. The latter phenomena can be attributed to lack of motivation on a personal level, which could have been altered by an organization incentive to encourage individual-level contribution. A different situation was found with the *community clinic* OM, where we observed an exceptionally intensive involvement from the clinic's head, along with all other employees involved (e.g., a family doctor, a pediatrician, nurses, a physiotherapist, and a nutrition expert) who contributed their skills, experience, and knowledge. Practitioners in the *community clinic* OM set an example for knowledge sharing and reuse. Yet, they lacked resources for extending this experience and sharing with other OMs.

In the case of the *information management* OM, individuals were concerned with the administrative aspects of KM rather than involved with knowledge creation. One aspect of this activity is the management of knowledge resources among OMs. Different than in the cases of other OMs, these resources were of external origin, and were circulated using a group of dedicated computerized agents.

Applying the Design of components rule indicates insufficient allocation of means. Consequently, there are shortcomings in the execution of knowledge-sharing and knowledge-evolution processes, and of knowledge-creation processes and therefore also organizational learning. An exception is the arena of knowledge-technology-based solutions, introduced by the *information management* OM. Of particular note is the newly developed patient-record-management system; that although it did not do away completely with the "paper and pen" problem in the healthcare practice, it significantly impacted practiced procedures. Unfortunately, the opportunity to produce the kind of knowledge classified as best practices and lessons learned based on this system's information was not exploited, and potential learning was not realized.

Applying the rule of *Dynamic SM lifecycle* also is a way of validating findings for the first rule since a sustained strategy should be reflected in a corresponding methodology, such as the one introduced by the SM lifecycle. However, our findings indicate that while there is evidence for the development and maintenance processes, evolution and evaluation processes were usually neglected. One exception is the case of *community clinic* OM, where a continuous development effort was integral to the practiced routine.

Against this background, it appears that there is an imbalance between the efforts made by the human resource and the lack of measures by which these efforts should have been provided for by the organization. As much as these findings exhibit an obstacle to organizational learning, they also indicate that merit to the organization from various OMs is possible, provided these are met by appropriate organizational culture and means.

### *Case-Study 2: The Civil Engineering Organization*

The Civil Engineering organization studied is responsible for statewide construction and maintenance of the infrastructure of all traffic facilities (e.g., roads, highways, streets, bridges, airports, tunnels, etc.) in one of the regional states in Germany. The scope of routine work carried out by Civil


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Engineering amounts to over 100 million euro per year. The number of employees (e.g., engineers, architects, and their teams) is 6,100.

Insofar as Civil Engineering was operating as a government body, it was motivated solely by the needs of local communities; that is, beyond considerations of cost control and competitiveness. However, in the face of imminent privatization and the need to improve its efficiency in the business arena, the organization entered a process of change and adaptation, which included an OM initiative launched in 2003.

Based on the same method used in the first case study, we identified three OMs to be investigated as part of this second case study. First is the *executives* OM, designed to serve a task force on the subject of introducing change and encouraging a knowledge-sharing corporate culture, which was headed by a team of management executives. The second, the *field engineers* OM, is run by a unit of engineers and is motivated to capture and disseminate experience-based knowledge. Third, the *documentation management* OM is in charge of the continuous update and dissemination of information (e.g., technical papers, legislation, and construction plans) to all concerned units.

*Knowledge acquisition.* For all interviews, we were assisted by local, German-speaking colleagues who offered to act as translators. Since these colleagues were familiar with KnowledgeEco, these sessions were run in cooperation, though not coordinated in advance.

For the executives OM, the participants were the general manager, the CEO, and several other chief executives. The participants in the field engineers OM were interviewed in a group session—for language-related reasons. Noteworthy is the level of cooperation in terms of goodwill and consideration from both senior management and engineers, which was likewise an expression of high motivation. The openness of the discussions was important for enabling the sharing of thoughts and reflections while obtaining the required information. Knowledge acquisition for the documentation management OM was performed during interviews with personnel from two departments: IT and Documentation.

*Results*

**Executives OM.** While the need to address change was obvious, the details of implementation were not, particularly since these challenges were amplified by a rigid and hierarchical administrative structure. An example consequence is the prevailing corporate culture, characterized by its tendency to undermine interpersonal communication.

Against this background, a most prominent finding for this OM is that it met its targets. This mainly was achieved using a change perception questionnaire, which was distributed throughout the entire organization as part of introducing the forthcoming change. This document addressed three targets on an organization scale: (a) understanding of knowledge intensive tasks in the face of change, (b) shaping opinion and feelings toward forthcoming change, and (c) avoiding misinformation regarding such forthcoming changes. The filled-in questionnaires included data, information, and knowledge (e.g., stories, ideas, and insights). Partially, the information gathered and the knowledge extracted from the questionnaires were included in the newsletter and frequently asked questions distributed by this OM. In this case, we noted simultaneous negotiation of processes of OM requirements specification and of preliminary construction processes to aid building on organizational culture as an agent of change.

**Field engineers OM.** Individuals belonging to this OM emphasized their need for tacit knowledge (Question 14) that is best shared through interpersonal communication, as noted by the CEO:

> The complexity of the work dictates an inter-disciplinary view, since decisions are based upon an arena of information sources, among which are: engineering rules, international and state standards, as well as environmental, ecological, and socio-cultural considerations. Practicing the integration of all these, for example, in the design of a road, demands the utilization of hands-on knowledge acquired through years of practice. The knowledge available through books and manuals does not compensate for the gap that has been created as a result of changes that have occurred in practice—due to reorganization.

Unfortunately, economic considerations and efficiency measures (i.e., taken as part of the organizational change) dictated that teams who were previously assigned to one site at a time—thus enjoying daily availability of peer consultation—be simultaneously involved in several separate projects. The two factors, remote locations and lack of communication options, altered the conventions of interpersonal communication. Indeed, some individuals were highly motivated towards knowledge sharing; yet the potential benefit of their experience could not be exploited. In this context, there was not an abundance of design and engineering-oriented systems to compensate for the aforementioned shortage.

**Documentation management OM.** This OM mainly followed a routine practice of all organization information distribution, focusing on informative publications, manuals, and standards, rules and regulation, and different instances of guides. These collection items were mostly in the form of books, available also on CD-ROM.

Individuals acting on behalf of this OM were responsible for continuous update of the collection, as well as adjunct descriptive meta-knowledge such as subject trees (Question 22). Additionally, this OM formed an intermediate facilitator in the form of a help desk operated by experts who were available for questions posed by engineers. However, since the content provided by these experts was not any different from the information contained in the books, there was nothing in this to suggest value for organizational learning in general and for the field engineers OM in particular. In terms of SM lifecycle, this OM was focusing on design and maintenance activities as well as on control processes while neglecting knowledge-creation processes.

*Case-study evaluation.* Based on the SM strategy rule, we noted two major deficiencies in these three OMs. First, there is no representation of an individual-level memory. Second, there is incomplete representation of the notion of component (i.e., content and means), for either OM studied. As previously acknowledged, an ill-managed strategy is a drawback to an OM.

Applying the Sharing between SMs rule also reflects the lack of a methodological approach to the management of OMs. Since there is a subtle role for individual-level memory in the overall evolution of an OM, its absence also affects related OMs. An OM without an individual-level OM is deprived of certain content items that are necessary. However, some of our findings indicate the future plausibility of sharing. For instance, between the documentation management OM and the field engineers OM, possibly the executives OM will gain enough support to encourage such initiatives, thus outweighing prevailing obstacles.

Yet another weakness is the insufficient flow of knowledge—either for lack of technology support or because of the ill management of knowledge creation and documentation. For this reason, we noted merely an association relationship between the various OMs, which rules out substantial KM activity.

Principles of the Design of components rule were only partially maintained. This could be attributed to the early stage of OM development or to the changing circumstances, neither of which was met by adequate measures. In this context, distributed teams were both confronted with shortages of means and deprived of the development of collection (e.g., best practice, lessons learned). Collection items were indeed accessible through annual seminars and other gatherings, but this limited availability did not compensate for the common shortages nor did it influence routine practice.

Various efforts, such as those of the engineers of documentation management OM who were trying to compensate for the lack of the kind of knowledge KnowledgeEco identifies as pocket item, were to no avail. One reason for this is that for this OM to be able to circulate experience-based knowledge, contribution from the field engineers OM would be required. These efforts could, however, contribute to future plausibility of sharing between SMs. In which case, it also would signify a change in the organizational culture, and create terms for the allocation of resources.

Unsurprisingly, Dynamic SM lifecycle indicates partial representation, based on varied coverage of SM lifecycle in all OMs. While the executives OM advanced planning activities, the documentation management OM catered to creation of collection kinds, and the field engineers OM was found to focus on the creation of instances of pocket item.

### *Case-Study 3: The Research Institute*

The third case study is that of a Research Institute of a German chapter of a European advanced scientific initiative. Practicing KM in a standardized way is an intrinsic part of belonging to this community and its associated benchmark criteria. The organization encompasses 30 research units organized into four subdivisions, with 5,000 employees, of whom 2,000 are scientists. Each of the Research Institute divisions runs several research projects, which involve the academic and research communities of the European Union.

The Research Institute was motivated to encourage OM and organizational learning as a strategic goal of managing intellectual capital. We present three of its OMs. The first is an example of an *individual scientist* OM. Following an all-organizational strategy, each scientist is responsible for an individual-level memory designed to represent the scientist's skill (Question 26), her activity (Question 25), and affiliation to a particular organizational-level OM. The second OM is typical of a *research unit*, designed to create an integrated view of all the information and knowledge available by its related individual-level memories. The third is an OM of the *innovation management unit*, focused on the goal of encouraging innovative projects and identifying their feasibility and supporting their realization.

*Knowledge acquisition.* Focusing on the individual-level OM, we interviewed scientists who each maintained a Person Memory. For the research unit OM, knowledge acquisition was run with two scientists and the program heads (i.e., management-oriented and technology-oriented personnel) during a day workshop. Knowledge acquisition for the innovation management unit OM was held with the personnel of the Innovation Center (i.e., management-oriented and technology-oriented participants), headed by an industrial engineer. Additionally, there was access to organizational reports, presentations, and other internal documentation as well as the company intranet.

#### *Results*

**Individual scientist OM.** The *individual scientist* OM—an example of an IM—was a fundamental part of the management's strategic policy to encourage KM activities. By management decision, scientists dedicated 10% of their time to the management of each Person Memory. This is one example of SM lifecycle being an integrated part of a business routine as envisioned in KnowledgeEco (Figure 4). Reflecting on previously discussed OMs, the management of an individual scientist OM could be used to instruct organizations on the manner by which individuals can be motivated toward knowledge sharing.

Taking the knowledge technology perspective, this task was supported by a dedicated portal. This OM management system was subject to selective dissemination of information, differentiating between three domains: private, project, and administrative. While in his or her private domain, each scientist could make notes of such as pocket-item instances (e.g., sketches, ideas, notes) and concept-map entries of descriptive meta-knowledge, which could become a part of a collective knowledge pool at another time. The project domain was subdivided to administrative and task-specific categories, and was used for the management of task-specific processes, which also includes sharing among other OMs. The public-domain space of the system was preclassified by a list of topics that originated with organization-wide perspective and served the management of general information.

Hence, for each IM, the portal platform facilitated the management of documents, collaboration, search, retrieval, and connectivity. Each individual, running his or her own Person Memory, was assigned one of the aforementioned three distinct spaces within the portal.

**Research unit OM.** For each research unit OM, an SM manager devoted 15% of work time to this task. As in the case of the individual scientist, this procedure derived from a management decision. Partaking in OM management activities involved coordination of individual-level OMs, the integration of relevant content items, and directing collaboration between OMs.

We found in this OM exhaustive coverage of knowledge resources, which includes publication, frequently asked questions, best practice, lessons learned, and a registry of intellectual property rights as well as meta-knowledge kinds of resources of internal and external origins (e.g., thesauri, concept maps, and ontologies). Each research unit OM aggregated several scientists OMs. Thus, the scientist responsible for the management of the research unit OM also was responsible for the coordination of the individual scientist OMs, for collaboration within the OM and between OMs.

**Innovation management unit OM.** The *innovation management* OM was focused upon coordinating the innovation-related activities and concerned publications. The motivation for this strategy was described by the CKO (i.e., practicing as SM Manager of this OM), as he was in charge of coordinating all innovation-focused activities:

> On a yearly basis, we conduct an innovation competition for several reasons. First, we continuously strive to build market value, which in our case is dependent upon creativity, exploring new opportunities and competitions. Second, the reutilized operation of this procedure encourages individuals, project groups, and research units to explore new frontiers (i.e., ideas and best practices), and consequently this event generates positive, proven results.

The innovation collection is run using designated software, which includes features that are unique to the management of inventions. This OM is an exceptional example of knowledge sharing and organizational learning, known also for its exemplary best practice, which is a yearly intellectual capital report also used for benchmarking KM practices.

*Case-study evaluation.* Since there is representation of instances of both individual-level memory and component for each OM, it is evident that the Research Institute realizes SM strategy. This is true despite the occasional partial representation of component dimension in the various OMs, as deficiency areas between SMs overlap and the corresponding areas are represented in other aggregated OMs. These findings are directly descendent from the strategic decision which paved the way to feasibility of the various OMs.

As can be seen (see Appendix B), there is full coverage of SM types, which also includes the representation of an aggregation relationship between OMs, satisfying Sharing between SMs. This is because for each OM, there is representation of dedicated (human and computerized) agents concerned with the promotion of knowledge sharing. Yet another facilitator of this state of affairs is the knowledge-intensive organizational culture, which supports and cultivates the operation of human agents. Subsequently, there is a cumulative effect of organizational learning, as the content of each individual-level memory is part of its corresponding organizational-level memory.

The full representation of content and means for each OM is an example of the concept conveyed by the interface notation. This notation communicates the meaning of interdependency between each of two classes, such as content and means (Figure 1) and between agent and process (Figure 4) as well as between knowledge and meta-knowledge (Figure 3). This concept is further described by the Design of components rule. Indeed, meeting this rule and the aforementioned ontological concept is evident with the OMs of the Research Institute. For instance, the integrated platform of modular and interoperable knowledge-technology applications manifests a formal attitude towards the role of individual scientists practicing as domain experts. These findings are strongly connected to the methodological procession of SM lifecycle activities.

It could be argued that the innovation management unit OM fully realizes the Dynamic SM lifecycle while the research unit and individual scientist OMs realize it only partially. The latter two OMs focus on knowledge creation and maintenance while the innovation management unit OM prioritized iterations between evolution and evaluation activities to encourage innovation through the utilization of the other OMs. However, the processing of SM lifecycle is modified for each OM to best meet its goals.

Note the comprehensive performance of SM lifecycle as part of a business routine—as prescribed by KnowledgeEco—common to all three OMs. This notion is exemplified by particular examples such as continuous knowledge creation, iterative procession of collective knowledge evolution, and continuous procession of evaluation and evolution activities, attributed to each of the three OMs, respectively.

## Discussion

### *Establishing Utility Through KnowledgeEco*

KnowledgeEco can be used to study the usefulness of OMs in organizations and to evaluate a specific OM in a three-step methodology:

1. mapping the actual OM onto the KnowledgeEco ontology,
2. noting the differences between KnowledgeEco and the specific OM, and

3. applying a series of evaluation rules that help assess the impact of the OM on organizational learning.

We demonstrated three aspects of the utility found with KnowledgeEco. The first aspect is the ability to determine deficiencies in specific OMs, based on the first two stages mentioned earlier. The second aspect is the ability to apply the evaluation rules to help improve OMs, based on the third stage of KnowledgeEco. The third aspect is that the ensuing ability to guide improvements in the OMs, based on identifying directions of actions for each organization, supports organizational learning.

Deficiencies in existing OMs were identified in OMs of the first two organizations (i.e., Health Services and Civil Engineering). We demonstrated these deficiencies throughout the sections dedicated to evaluation of the findings of each case study. For instance, we noted the lack of individual-level OM in Health Services and the absence of adequate means to provide for the community clinic—as an example OM, as well as the absence of sharing between the OMs. This results in depriving the organization from the benefits of organizational learning.

Yet another example taken from the same case study is the neglect of supporting the SM lifecycle, which results in insufficient functionality of the various OMs. Evidently, ignoring evolution processes diminishes organizational learning. A similar example can be drawn based on the Civil Engineering case. Focusing on the field engineers OM, we noted the lack of development processes as an obstacle to realizing relationships between OMs and employing organizational learning.

As suggested by the second aspect, the ability to apply the evaluation rules to help improve OMs, we used the detected deficiencies and analyzed them by the rules, for instance, to explore relationships between phenomena. Hence, we can direct further OM development and guide the organization towards organizational learning. For example, in Health Services, we found that both Sharing between SMs and Dynamic SM lifecycle (Table 2) were poorly dealt with in the community clinic OM. Specifically, having applied the Sharing between SMs in Health Services indicates that the organization should further support the community clinic OM as well as develop similar OMs, which in turn promote organizational learning. Further examples are included in the next section.

Considering the third aspect, that the ensuing ability to guide improvements in the OMs supports organizational learning, several other examples taken from each of the case studies were used to demonstrate the utility found with KnowledgeEco through the application of the evaluation rules. Most important, we emphasized specific directions of actions identified for each organization for the purpose of improving their OMs.

### *Case-Study 1: Health Services*

Exposing the findings motivated a series of actions. The first action is supporting the evolution of the community clinic OM by means of relieving existing constraints and providing for appropriate agents, and moreover, launching a program for the development of similar OMs. The second action is providing for sharing between the OMs. This implies the rethinking of the current KM infrastructure to instruct improved design. The third action is applying KnowledgeEco as part of a series of actions intended to identify local initiatives as found, for example, with the *society of physicians OM*. This is for several reasons such as supporting the development of experts' OMs and promoting organizational learning by using several knowledge genres. The fourth contribution we mentioned concerns motivating management to reexamine the definition of goals as reflected in the allocation of means and in cultivation of the prevailing culture. Finally, we mentioned the redesign of the information management OM to meet a wider spectrum of goals. It can be argued that learning in this organization was motivated not only to amend deficiencies found based on this empirical investigation but also to generalize the benefits of this learning. This implies following KnowledgeEco with regard to current and future OMs, as well as the future integration of organizational learning processes as part of business interaction.

### *Case-Study 2: Civil Engineering*

In this case, the findings presented to the organization motivated a series of actions that denote organizational learning. The first action is using the explicit representation of the specific OMs as a basis for future planning and design of the ongoing document-management program. Specifically, this guides the improvement of the document management OM. Second, the results encourage a discussion of potential obstacles and challenges that the organization could tackle to influence performance (e.g., absence of relevant knowledge in the field engineers OM). Third, a finding that directly concerns the document management OM is introducing the organization to a relevant metadata standard (i.e., Dublin Core). Moreover, as in the previous case, here too the organization was motivated to integrate KnowledgeEco as part of a family of methods applied in KM.

### *Case-Study 3: Research Institute*

In this case, several possible benefits of using KnowledgeEco were shown. One benefit is using KnowledgeEco as a framework to guide OM design and evaluation, which involves exploring future directions for sharing between OMs. Another benefit would be to involve KnowledgeEco as part of an OM evaluation strategy.

Complying with the spectrum of recommendations and applying them to improve OMs is an indication of organizational learning motivated by KnowledgeEco. Doing so, organizations enable the redesign of their OM, and its perception and practice. The lack of organizational awareness (i.e., knowledge) has stifled organizational learning; by acknowledging their shortages organizations pave the way for better organizational learning.


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We believe that the examples discussed herein establish the utility of KnowledgeEco in organizational learning and, consequently, in decision-making processes as well.

## Summary and Conclusions

In this article, we offered an ontology-based methodology to evaluate OM. Based on this methodology, we could map and represent several types of individual- and organizational-level memories, to evaluate the relationships among them, and to reflect on the implications of a well-structured OM on organizational learning.

Evaluation in KnowledgeEco consists of two stages. The first stage is comparative, examining the entities extant in a specific OM in comparison to their representation in the ontology. The second stage is rule-based. Based on findings from the comparative stage, utility for the organization is formulated in accordance with the four rules: SM strategy, Sharing between SMs, Design of components, and Dynamic SM lifecycle.

In most of the case studies, the coverage of all four rules was partial. For example, findings indicated by Sharing between SMs may originate from findings of Dynamic SM lifecycle. From our discussion with CKOs, it became clear that without a strategy for developing an OM, which includes a strategy to encourage members to engage in knowledge sharing, organizational learning is lessened. Indeed, sharing of content begins with recruiting and motivating members of the organization to participate in creating knowledge, and continues with motivating and equipping even more members to distribute, use, and improve knowledge.

We found that in most cases, inadequate means stifled the sharing of knowledge. This is most likely a common phenomenon in many other organizational processes. However, OMs clearly require advanced technologies as well as motivated human agents (i.e., Design of components). Of course, this tentative conclusion from a limited number of case studies will need to be better substantiated to gain credibility with management. Nonetheless, it will be important to accumulate and analyze concrete case studies in which knowledge sharing is limited or even disabled by inadequate means.

In particular, the Dynamic SM lifecycle rule was established in only one case (i.e., in the Research Institute), for which there was complete coverage of the other three rules. We believe that this finding may well reflect the current lack of practice in OM of planning and implementing SM lifecycle to ensure an evolving OM. We further believe that the practice of SM lifecycle usually will be associated with a highly developed set of other components. In other words, a clear commitment to the management of the dynamic aspect of OM signifies the practice of an overall advanced OM. This is perhaps the most pressing research issue to be pursued in the future.

We believe in the merit of practicing the suggested KnowledgeEco methodology for organizations to ensure that the critical OM factors are evaluated. Evaluation of OM practices is required for many reasons, including the need to satisfy management demands for cost justification. Our concern here was the need for evaluation to direct the evolution of OM. Without evaluation, there can be little improvement and adaptation, and without adaptation of OM, there will be no support for managing dynamic knowledge and hence no support for organizational learning. When organizations have appropriate managerial structures, such as a CKO, as well as clear strategies for SM goals and how they match organizational goals, it is possible to effectively evaluate the SM and improve it according to the evaluation results. Most of case studies examined had no such capabilities.

Several suggestions can be made for future work. First, further empirical work using KnowledgeEco is encouraged. Second, based on KnowledgeEco theoretical grounds and its associated empirical evidence, additional measures could be developed, adapted, and implemented for the assessment of utility aspects.

Several conclusions can now be drawn about the merit of KnowledgeEco. First, KnowledgeEco can be used as a reference model to describe what exists and what is missing in an actual OM. Second, KnowledgeEco may facilitate learning in organizations as a source of best practices in processing design solutions. Third, for organizations already involved in an OM initiative, KnowledgeEco can be manipulated as an aid to learning.

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## Appendix A: Extracts From Questionnaire

| Class | Attribute | For the SM in question, describe: |
|---|---|---|
| SM | Goal | 1. The SM's goal. |
| | Strategy | 2. The SM's strategy for accomplishing the goal. |
| Type | Field of practice | 3. The SM's domain of practice. |
| | Core competency | 4. The major expertise and competencies represented in the SM. |
| | Ecology | 5. The organizational norms as it relates to Knowledge Management and Organizational Learning. |
| Component | Availability | 6. The mechanisms by which Agents can access Components. |
| Individual Memory | Activity | 7. The individual's areas of interest, expertise, and activity as they relate to memory. |
| Organizational Memory | Prevailing culture | 8. The organization's rules that shape the SM. |
| | Constraints | 9. The organizational, technical, and economic constraints on the operation of the SM. |
| | Enterprise info | 10. The enterprise model. |
| | IM profile | 11. Related Individual Memories. |
| Content | Enhancement | 12. The activities most influenced by the contribution of the SM content. |
| Knowledge Resource | Resource specification | 13. The standard used to describe Knowledge Resources (e.g., Dublin Core). |
| | Genre | 14. The common Knowledge Resource genre (i.e., procedural or declarative). |
| | Business relevance | 15. The business relevance of the Knowledge Resources. |
| | Level of structure | 16. The level of structure imposed on a Knowledge Resource by means of using meta-knowledge standards (e.g., XML, RDF, OWL). |
| Collection | Contextualized | 17. The knowledge organization systems used to establish the semantics of the Knowledge Resource (e.g., using classification schemes, thesauri). |
| | Expandable | 18. The available mechanisms used for expanding a Collection item. |
| | Transportable | 19. The available mechanisms for transporting a Collection item. |
| Pocket Item | Experienced | 20. The origin of the Pocket Item object. |
| | Prescriptive | 21. The recommended best practice for utilizing a Pocket Item object. |
| Meta-Knowledge | Standardized | 22. The standards applied for Meta-Knowledge. |
| Means | Adaptability | 23. The mechanisms and operations available for adapting Means. |
| Agent | Role | 24. The involvement of an Agent in SM Lifecycle. |
| | **Task** | 25. The activities defined for an Agent. |
| Domain Expert | **Skill** | 26. The professional profile of a Domain Expert (e.g., a formally assigned professional or an informal knowledgeable individual). |
| SM Manager | **Responsibility** | 27. The SM Manager's responsibilities for operating and controlling the SM. |
| Knowledge Technology | **Support SM Lifecycle** | 28. The SM functions supported by Knowledge Technology throughout the SM Lifecycle. |

## Appendix B: Summary of Findings for the OMs of Three Case Studies

| | | | Case study SMs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Health Services | | | Civil Engineering | | | Research Institute | | |
| Component Dimension | | | SoP[a] | CC | IM | Es | FE | DM | SM | RU | IMU |
| Content | Knowledge Resource | Pocket Item | P | P | P | | P | | P | P | |
| | | Collection | P | P | F | P | P | P | F | F | F |
| | Meta-Knowledge | Descriptive MK | P | N | P | N | N | P | | | |
| | | Design Standards | P | N | P | N | N | P | F | F | F |
| | | Access Management | P | N | P | N | N | P | F | F | F |
| Means | Agent | Knowledge Technology | P | N | P | N | N | P | F | F | F |
| | | SM Manager | P | N | P | N | P | P | | | F |
| | | Domain Expert | P | N | P | N | P | P | F | F | F |
| | Process | SM Lifecycle | P | N | P | N | P | P | P | P | F |

F = Full match; P = Partial match; N = None.
[a]Names of the specific OMs are abbreviated.


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