

# Knowledge Maturing Services: Supporting Knowledge Maturing in Organisational Environments

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**Abstract.** The changes in the dynamics of the economy and the corresponding mobility and fluctuations of knowledge workers within organizations make continuous social learning an essential factor for an organization. Within the underlying organizational processes, Knowledge Maturing refers to the the corresponding evolutionary process in which knowledge objects are transformed from informal and highly contextualized artifacts into explicitly linked and formalized learning objects. In this work, we will introduce a definition of Knowledge (Maturing) Services and will present a collection of sample services that can be divided into service functionality classes supporting Knowledge Maturing in content networks. Furthermore, we developed an application of these sample services, a demonstrator which supports quality assurance within a highly content based organisational context.

## 1 Introduction

Since the world became more and more dynamic in recent years, the mobility and fluctuations of knowledge workers within organizations made continuous learning throughout one's career an essential factor. Within underlying organizational learning processes, knowledge is passed on, learned and taught. Corresponding knowledge objects are transformed from informal and highly contextualized artifacts into explicitly linked and formalized learning objects. This transformation of knowledge artifacts together with the corresponding organizational learning processes, is commonly known as Knowledge Maturing. The knowledge maturing process theory structures this process into five phases: expressing ideas, distribution in communities, formalization, ad-hoc learning and finally, formal training (see [Maier and Schmidt, 2007] and [Schmidt, 2005]). Knowledge Maturing Services refer to integrated support for this knowledge maturing process, bridging the separation along the dimensions of knowledge construction and knowledge sharing. They are needed not only to help knowledge workers to handle different knowledge assets, but also to entice them in sharing and negotiating among them.

In this work, we will present a definition of the concept of knowledge (maturing) services and in addition to that, five service functionality classes of knowledge maturing services will be described in detail where each of the described sample services can be classified into. These service functionality classes for classification of knowledge maturing services support negotiation, formalization, standardization and deployment of knowledge assets.

This paper is organized as follows: In section 2 we will present a definition of knowledge services in general and knowledge maturing services in particular, including related work. Section 3 introduces five service functionality classes and corresponding example services including their detailed description and impact on knowledge maturing and organizational learning. Finally, section 4 discusses our work and concludes the paper.

## 2 Knowledge Services

We define Knowledge Services as (composite) software services that are concerned with three knowledge entities – people, content, and semantic structures and the relationships between them. The results of Knowledge Services improve or extend the knowledge available within these three entities and their relationships. This can be achieved by either enabling people to add or improve knowledge contained in the three entities or by providing automated services to discover knowledge based on the available knowledge entities and their relationships. In doing so Knowledge Services enable a knowledge (eco)system (comprised of the three knowledge entities) to learn. This learning can take place on very different levels. For example, people can learn by interacting with other people, content, and structures; here the knowledge entity improved is people. On the other hand, the (eco)system can learn more about its users by e.g. analyzing their interactions with people, content, and structures; here the knowledge entity improved might be a structure representing a user (e.g. user profile).

Knowledge workers need Knowledge Services to improve (learn) the knowledge (eco)system. Whereas the technical definition of services is supported by a set of standards (such as web services), it is the conceptual part (i.e. defining types of services that are useful) that is currently lacking. But exactly this conceptual part matters most when organizations attempt to profit from the promised benefits of service-oriented architectures.

Knowledge Maturing Services are a form of complex Knowledge Services, which in turn are composed of basic services. These may be either already offered in heterogeneous systems as part of an enterprise application landscape, implemented additionally to enrich the services offered in an organization or invoked over the Web from a provider of maturing services. They operate on several kinds of external knowledge representations, [Maier and Schmidt, 2007] suggests several of these knowledge representations that are worth considering: contents, semantics and processes. These are represented in external knowledge artifacts but also have their corresponding representation in individual or collective knowledge. Accordingly, we initially differentiate Maturing Services into

two broad categories according to the type of external knowledge representation they operate on: **Structure Services** operate on a more or less formal knowledge structure. Semantic structures (corresponding to conceptual or declarative knowledge) and process structures (corresponding to procedural knowledge and drawing out temporal characteristics) can be distinguished. **Content Services** operate mainly on texts composed of natural language. **Usage Services** act as a third category of Maturing Services. Knowledge Maturing Services mostly work in the background to analyze several kinds of knowledge contents, processes, structures and their use within an organization to discover emergent patterns and support individuals, communities or organizations in dealing with the complexities of these underlying structures and their evolution over time.

### Related Work

The concept of Knowledge Services has surfaced within research literature only recently. Due to the novelty of the concept it is not surprising that a widely agreed definition is not yet available. Nevertheless, it can be traced back to at least two schools of thought: Knowledge Management Systems (KMS) and Knowledge Market.

The Knowledge Management Service concept (and its subset Knowledge Services) were developed in response to monolithic knowledge management systems (KMS). Currently, one can observe a clear convergence of application development and service oriented application development. Important approaches in research are service oriented architectures (SOA) and (semantic) web service technologies. Knowledge Management Services or Knowledge Services are a subset of services, both basic and composed, whose functionality supports high-level knowledge management instruments as part of on-demand knowledge management initiatives, e.g., find expert, submit experience, publish skill profile, revisit learning resource or join community-of-interest ([Maier and Remus, 2008]). These services might cater to the special needs of one or a small number of organizational units, e.g., a process, work group, department, subsidiary, factory or outlet in order to provide solutions to defined business problems. Knowledge Management Services describe aspects of Knowledge Management instruments supported by heterogeneous application systems. [Dilz and Kalisch, 2004] and [Maier et al., 2009] both propose similar typologies of Knowledge Management Services. A related definition of Knowledge Services by [Mentzas et al., 2007] defines them as services for knowledge trading and managing electronic knowledge markets.

The knowledge services which will be described in the next section are specific services aiming at identifying and supporting Knowledge Maturing. Several kinds of Knowledge Services have already been developed for certain purposes: context-aware knowledge services ([Rath et al., 2008]), competence identification services ([Lindstaedt et al., 2006]), work-integrated learning services ([Lindstaedt et al., 2008], [Lindstaedt et al., 2007]) but in addition to that, other knowledge services can be envisioned, for example collaboration services, etc.

### 3 Service Classes

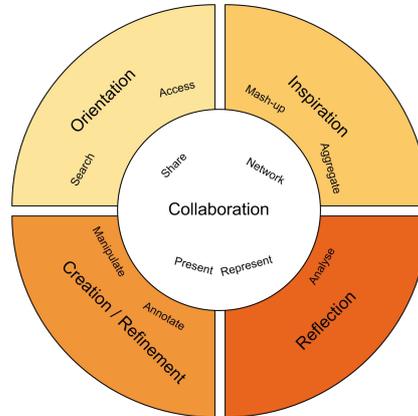
Knowledge maturing services can act on both, the organizational and personal perspective to support knowledge workers in their daily work and learning process. Whereas organizational learning (and maturing) services provide structural guidance that enables users to collaboratively develop knowledge assets of organizational interest and to align them with organizational goals, personal learning (and maturing) services involves guidance from the perspective of the guided person, i.e. it makes the results of the maturing activities visible and digestible for the individual.

This work is part of MATURE (<http://mature-ip.eu/en>), an ongoing EU-founded project, whose objective is to understand the maturing process and provide maturing support for knowledge workers in a collaborative environment. The sample Knowledge Maturing Services for each of the service classes described in the following, were gained from a maturing scenario to support quality assurance within the context of highly content based organisational environment, based on results of a previous design study ([Weber et al., 2009]). The underlying maturing scenario for this field is described in detail in [Attwell et al., 2008] where maturity stages necessary for a new knowledge worker in the field of career guidance are described. These maturing phases include access and search of information, aggregation of information, manipulation of documents, analyze and reflect previous work, present and represent created knowledge objects, share of information and finally network with other people.

The derived service functionality classes for classification of knowledge maturing services supporting the knowledge maturing phases for career organizations are the following: (I) Orientation Services, (II) Inspiration Services, (III) Creation and Refinement Services, (IV) Collaboration Services and (V) Reflection Services and will be described in detail in the following sections. Figure 1 depicts the interplay of these five knowledge maturing service classes. The service classes are arranged in a circle to emphasize that different services used by knowledge workers during their working process (to e.g. create a document of high quality for training) do not follow a strict consecutiveness of the use of services of one service classes and then from another, they rather enable a flexible process of knowledge object creation and refinement with iterative use of collaboration and reflection services to enable knowledge maturing in this setting. Though the service functionality classes for knowledge maturing support were derived from this setup of knowledge workers in the career guidance sector which is heavily content dependent, they can easily be adopted for other setting where knowledge is heavily content and structure based.

#### 3.1 Development and Evaluation of the Service Demonstrator

As already mentioned, the description of the services (and corresponding software requirements), which we will describe in this section, were derived from a real-world setting to support quality assurance within the corresponding maturing scenario in career guidance sector. This scenario is heavily content dependent,



**Fig. 1.** Interactions between Service functionality classes: It should not be seen as a strict consecutiveness usage of service, they enable rather a flexible process of knowledge creation with iterative use of collaboration and reflection services

such that we have chosen as a basis for the demonstrator the MediaWiki, which allows community driven knowledge creation. A first prototype has already been developed and evaluated within a design study ([Weber et al., 2009]) and the results of this evaluation including a more detailed requirement elicitation lead to the development of a demonstrator enhancing the existing services and providing additional ones. We used a bottom-up and top-down approach to meet both, the software requirements for implementing these knowledge maturing services within our project and the requirements of knowledge workers within career organizations by regular feedback from potential end-users throughout the software development cycle. The implementation of these services was done using rapid prototyping which involved iterative design phases using mock-ups and development phases combined with regular input to generate feedback of the viability of our approach on supporting knowledge maturing in these organizational settings. The sample services for each service functionality class described in the following are part of this demonstrator.

### 3.2 Orientation Services

The purpose of orientation services is to provide support for identifying already existing relevant knowledge objects, related topics or colleagues working in related fields. With the help of these services, the user gets an overview of what is important in relation to his topic of interest in order to ensure organizational consistency and avoid redundant actions. In accordance with the knowledge maturing for career guidance model, this set of services support the access and search phase. In relation to the knowledge maturing model, orientation services are supporting the first phase, namely, expressing ideas, since having an overview of the organizational knowledge is necessary to develop and express new ideas

whilst trying to keep organizational coherency. This set of services supports a knowledge worker who is new to a certain area of interest, e.g. because (s)he is newly appointed within an organization or is supposed to write a report about a certain topic.

**Visual Semantic Browsing Service.** This service provides a visualization for the organizational and personal workspace. Resources in an organizational environment cover a broad range of information sources like web-pages, mail, wiki articles or local files and the visualization provides an overview over the organizational semantic model and the (semantic) relations between objects in this model. Each node in the graph represents an annotated resource, a user or a tag, directed edges represent a relation between two nodes: A user is for example related to artifacts which he has created/edited, a resource might have one or more assigned tags and a category might contain one or more artifacts. Clicking on a node in the graph leads to an update of the visualization.

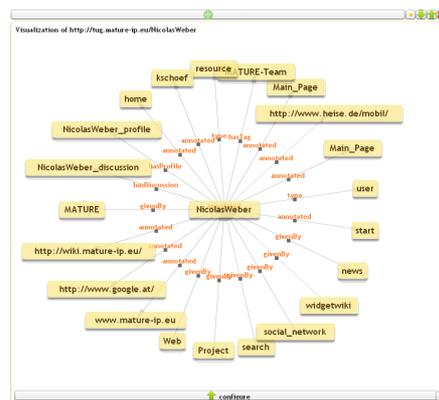


Fig. 2. Semantic Browsing Widget

This service supports the daily work of users by enabling visual browsing through the semantic content of a knowledge base from resources to resources via their relations, thus pulls together related information for a certain resource at a glance. During the browsing process, the user gains a detailed overview of the organizational knowledge base and how it is semantically structured. If a user takes a look at for example all resources and their tags which are related to a certain category, (s)he is able to identify missing topics within this category and is motivated to start creating a new resource with the missing information. Furthermore, depending on the choice of the user the service enables to show either the public, personal (or both) relations and resources, such that a user can analyze her/his own contributions within the organization in relation to certain topics. In addition to that, the visual browsing service allows for personal settings depending on individual preferences and learning styles. Thus, the features offered by the visual browsing service covers relevant requirements for getting

an overview of the organizational knowledge base and its semantic model and operates on the structure of knowledge objects.

**Summary Service.** Knowledge workers might experience time pressure for certain tasks and the easier it is to get to know about relevant knowledge objects the faster the worker can execute what (s)he is supposed to. This service offers a short summary for each content based knowledge artifact such that the user don't need to go through the whole document to know what it is about. The summary of a knowledge artifact is based on its semantic markup and automatically generated by using information extraction (by using services of the KnowMiner framework, see [Klieber et al., 2009] for details) which can finally be extended and improved manually. In addition to that, it is updated (or users are asked to update the summary) if the content of a knowledge artifact remarkably changes. The summary service not only incorporates a summary regarding the content, but also giving an overview of document length, rating of the artifact or readability measures.

### 3.3 Inspiration Services

The purpose of this set of services is to support inspiration for probably interesting topics and offering new perspectives on already existing topics of a knowledge worker's field of interest. This class of services support brainstorming, organizing and analyzing ideas and encourages knowledge workers to gain new knowledge by presenting for example mash-ups of existing knowledge assets including videos or pictures or an aggregation of organizational knowledge assets related to a certain topic. In accordance with the knowledge maturing for career guidance model, this set of services supports the aggregate and scaffold phase.

**Mashup Search Service.** During the browsing of the organizational knowledge base with regard to a certain topic, a knowledge worker might have figured out that that information on a subtopic of a certain category is missing. In order to write a meaningful article about this topic, one of the first steps in this process is to collect related information in addition to the user's informal knowledge and context. This service provides a search interface which helps the user to aggregate information related to a certain topic without the need to use multiple search engines for different knowledge databases. Using different search facilities of various web resources (yahoo search, YouTube, wiki articles, Xing) and IBM OmniFind (Yahoo! edition) to enable including local information sources (which are for example only available within an organization or on one's own computer), the Search Support Service provides a combined interface. As users might have different background, e.g. one is already an expert on a certain topic, another one is a novice, different resources are ranked higher depending on the user's context. The wide range of information sources which are provided, varying between textual content, pictures, videos and persons stimulates the user's inspiration on a certain topic for extending and improving already existing knowledge artifacts or creating new ones.

**Aggregation Service.** This service is an extension of the Mash-up Search service. When the user is presented the search results of certain keywords, (s)he can choose from a variety of results and create one or more collections of the search results for later use. These collections can include complete knowledge artifacts (emails, pictures, documents, ...) but in addition to that, also parts of e.g.. a wiki article. A semantic description for the collections can be added (in form of semantic annotations or assigning categories) such that the service can automatically update collections with appropriate information when needed, for example by suggestion new knowledge objects with related semantic description that might be suitable. The user can assign knowledge objects to collections by using drag-and-drop of the search results into existing or new collections for easy use.

### 3.4 Creation and Refinement Services

The purpose of creation and refinement services is to generate knowledge artifacts that meet a certain form of (higher) quality standard (e.g. reports, presentations, learning material) by aggregating existing knowledge assets. Furthermore, the services help to identify available or newly created knowledge objects that need an improvement in their maturing levels or can contribute to a given maturing process, for example by offering access to meaningful maturing indicators. The aim is to provide knowledge workers at every moment with adequate information (e.g. when generating a report that satisfies a given quality standard) in order to guide the users towards a common organizational goal. In accordance with the knowledge maturing for career guidance model for, this set of services supports the manipulation, analyze and reflection phases.

**Maturing Indicator Service.** The objective of analyzing content is to facilitate the assessment of the maturity of a content based knowledge artifact. This maturity level allows to decide whether the maturity of a certain document should be improved by supporting the user in creating or editing the knowledge artifact. The bottleneck in assessing the maturity of knowledge artifacts is the selection of qualified attributes reflecting the maturity of the artifact. Attributes describing an object which is an instance of content, semantic or processes can be used to determine the maturity of the artifact. Quantitative and qualitative parameters or a combination of them are the basis for the assessment of the maturity. In case of content we assume that the readability and the maturity have a strong correlation ([Braun and Schmidt, 2007]), two metrics for readability scores are offered in this service. Both of them analyze text samples: In the Flesch Reading Ease Score ([Si and Callan, 2001]), higher scores indicate material that is easier to read while lower numbers mark passages that are more difficult to read. The second score, the Gunning fog index, is an indication of the number of years of formal education that a person requires in order to easily understand the text on first reading.

Since semantic mark-up is a crucial factor for identifying relevant information during search, a semantic indicator provides a quantitative measure for the semantic annotations of a document which enables the user to access the amount



**Fig. 3.** Widget providing Maturing Indicator Services

of semantic mark-up of the current document. The value for this indicator is given by the relation of markup and length of a document. Figure 3 shows the graphical interface to these indicators.

**Relation Service.** Objective of the Relation Service is to interconnect knowledge artifacts with other resources. Referring to the functionality of Maturing Services, this service enables the improvement of emerging semantic structures. Relation Services aim at providing a tool enabling the user to create meaningful relations without having modeling skills or knowledge about description languages. So the service facilitates the informal expression (externalization) of relational knowledge and nevertheless the information is stored in a structured and formal representation. The formal relational knowledge provides the foundation for other maturing services like semantic search and visual browsing. Since the user contributes to the organizational knowledge and benefits only indirectly, creating annotations and relations between knowledge artifacts has to be easy and fast. Following this idea, this service offers the user to drag and drop knowledge objects a new relation should be added. When defining the new relation between these objects, the system suggests already existing relations to pre-consolidate the relations, though new relations can be easily added.

**Accuracy Control Service.** Accuracy control is necessary to make sure the data is accurate, up-to-date and relevant. Long articles are unlikely to be read and will be too time-consuming to search through for the information one is looking for. Additionally, the number of entries in a knowledge database could get too large. Within this service, accuracy control is divided into two relevant sections: Concerning the time, automatic date flags are used to remind authors and editors to update (parts of) a certain knowledge artifact. Though, depending on the live time of an article, one has to take into account that some articles are more general than others and could therefore have longer shelf-life. Furthermore, warnings are used to show knowledge workers how accurate information is. Concerning the content, a method of controlling the amount of data added is available to make sure information is concise. Therefore, authors are made aware of relatively similar articles and of the amount of content in documents and articles.

**Mark-up Recommendation Service.** Creating semantic mark-up conveys to the enrichment of wiki content. Meaningful semantic annotations offer an easy possibility for users to find useful and relevant information during search within a knowledge base. In addition, mark-up is used as a basis for recommendation of useful resources and visualization of emergent content structures. The mark-up

recommendation services strive for two goals. First, lowering the barrier for creating mark-up which replaces the complex Semantic MediaWiki syntax and second, improving the quality of structure by recommendation of meaningful, pre-consolidated mark-up. Depending on the content of an article, the system analyses used words and their frequencies to recommend the most used keywords as tags for the article. In order to categorize articles, the system suggests already existing categories which corresponds best to the newly created content. Additionally, the user can add a certain category which seems to be appropriate and can train the service with this category such that the system can suggest this category in future for appropriate and related articles.

### 3.5 Collaboration Service

The aim of this set of services is to offer collaboration support in every phase of the maturing process. This includes for example the distribution of knowledge artifacts in communities. The goal is to create opportunities for discussing questions or problems with authors of related knowledge artifacts, share newly created knowledge artifacts with possibly interested colleagues, present/represent newly acquired knowledge to different target groups or simply start a collaboration for developing new ideas related to a topic. The initiation of collaboration and collaboration itself is necessary to reach a consensus and a common understanding of knowledge assets of organizational interest. In accordance with the knowledge maturing for career guidance model, this set of services supports the present/represent, share and networking with people phases.

**Discussion Service.** This offers the facility to initiate easy collaboration with authors of articles or interested persons by not having to switch to another tool since it is embedded into the framework and thus enables easier and faster use. The user can start a discussion concerning any wiki articles and documents in order to support negotiation and consolidation of knowledge artifacts. These discussions are bound to the knowledge artefacts by a relation in the knowledge data base such that other users can easily find them and read through them whenever she wants to improve an article or get more detailed background information. The maturing service in the background informs users who might be interested that a discussion about a certain topic has started and automatically invites them to join. Discussions can also be annotated with keywords to assign them to a certain topic or relations to other discussions, documents, people can be created.

### 3.6 Reflection Service

Reflection is necessary for organizational and individual development. Though it is mainly driven by actions of individuals, reflection can contribute towards improved organizational systems and practices. When people change their way of thinking and how they carry out their work tasks, this has organizational implications. Reflection services aims at guiding knowledge workers to improve organizational knowledge by comparing one's contributions to others with respect to the organization's goals.

**Resource Activity Evaluation Service.** The Activity Evaluation service is supposed to collect all activities related to resources of a user. Such activities are for example opening and reading documents, disseminating or modifying content, rating of a document or giving a feedback. A user is shown the list of activities in addition to who performed these actions (with regard to the user's privacy settings), related knowledge objects and (newly created) objects of possible interest. If for example a document is not read very often and the overall rating is not very good, the user might want to improve the quality of the resource by starting a discussion with the people who performed the rating.

## 4 Discussion and Outlook

In this paper, a definition for Knowledge Services in general and Knowledge Maturing Services in particular was presented, including a discussion of related definitions which includes Knowledge Management Systems and the Knowledge Market. We described in detail sample services of five service functionality classes, which have already been developed within a demonstrator to support knowledge workers in a highly content based organizational setting according to the knowledge maturing process of [Schmidt, 2005] with regard to quality assurance. These service classes are not thought to be used one after another, rather enable the user to use them iteratively during the overall process of content creation in order to support knowledge maturing. Further evaluation of the work presented is still in progress in order to gain new ideas and deeper insight how knowledge maturing can be supported within MATURE. Thus, it has to be clear that the presented services do not provide an overall system supporting Knowledge Maturing, but give practical examples of the five service functionality classes that were presented and are thought to support knowledge maturing in heavily content based organizational environments.

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