An Agent-based Knowledge Management Framework

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Abstract

We propose a theoretical reference framework for a *Knowledge Management (KM) Information Technology (IT)* system in organizations. We take a holistic perspective on KM and derive the required features for the framework from KM-related research in psychology, business management and computer science. We propose classifications of organizational knowledge and *knowledge entities* (sets of people) either within an organization or associated with it. The framework comprises the derived features for the derived knowledge classes and knowledge entities. We motivate why agent technology is suitable for implementation of the framework. We give an overview of existing KM IT solutions and map them to our framework.

Introduction

The need for effective *Knowledge Management (KM)* in organizations has been largely recognized. Tools and strategies from research have been put to work in organizations. However, many of the Knowledge Management efforts were futile. There are two main reasons for this: firstly, information management software that does not consider psychological and organizational aspects of KM has been used. Secondly, existing information management software components are proprietary and not integrable with existing software, creating new barriers for the information flow. The goal of a KM effort is the facilitation of the *knowledge flow* (Borghoff & Pareschi 1998) among people. The knowledge flow describes the distribution, recombination and creation of new knowledge. We consider knowledge as information put into an individual context of existing knowledge of a person. Thus psychological aspects of knowledge creation have to be considered. People in an organization can be grouped into *knowledge entities* (sets of people) among which certain restrictions for the knowledge flow apply. We see that organizational aspects are also important for a KM effort. These aspects are taken into account when we derive key features of a KM IT system in the section *Core Knowledge Management support functionalities*. We will propose an IT system architecture providing those key features in the section *Information Management Architecture*. A number of existing implementations for some of the proposed features as well as areas for future research will be presented in the section in the section *Related Work*.

Core Knowledge Management support functionalities

A KM IT system has to support storage and retrieval of information. However, we concentrate on the retrieval for two reasons: firstly, retrieval processes are performed more often and are thus the economically driving force for a KM effort. Secondly, It can only marginally contribute to storage support, the bigger part has to be achieved by organizational incentive systems.

We will fist explore psychological issues of KM. One is not always aware of all relevant information sources. Moreover, human information behavior makes the actual level of information that the user has available to create knowledge a small subset of the information needed for a certain task (Heinen & Dietel 1991). A KM IT system should **autonomously** present the user with assumed relevant information. The system thus has to autonomously observe the user, infer her task and search for relevant information. In (Hacker 1983), it is shown that it is the planning phase of a task when information is used to create knowledge the most. A **pro-active** delivery of information ensures that more potential problems can be identified and potential mistakes avoided. Double work can be avoided and new knowledge is continuously created (Probst & Büchel 1998). The better the provided information is adapted (**Personalized**) to the user's qualification and interests, the better it is acknowledged and internalized by the user (Forgas 1985).

An important organizational aspect is the existence of different *knowledge entities* (sets of people) in organizations. In (Schlichter, Koch, & Xu 1998) the entities *user*, *team* and *community* are characterized. For a KM IT system, it is important, that characteristic restrictions apply to the knowledge flow within and among the respective entities and must be enforced. The information objects owned by a knowledge entity must be under its exclusive control.

To support the knowledge flow, the flow of different classes of knowledge has to be supported. The notions of *explicit knowledge* that can easily be coded into information and *tacit knowledge* that is a collection of experiences,

which is hard to express in natural language, were first introduced in (Polanyi 1958). In order to be managed by an IT system, knowledge has to be made explicit and coded into information. This process is analyzed in (Nonaka & Takeuchi 1995), which extends the analysis of Anderson's *ACT-theory* (Singley & Anderson 1989). The economic implications of the process are analyzed in (Trittmann & Mellis 1999). Knowledge can be further classified by field of application. We choose the *intangible assets monitor*, an inductive-analytical approach for knowledge accounting (Sveiby 1998), (North, Probst, & Romhardt 1998). Sveiby proposes, that intangible assets (in contrast to visible equity) in an organization can be classified into *external structure* of the organization, *internal structure* of the organization and *staff competence*. The internal structure is defined as business processes and technologies, whereas the external structure is defined as relations along both directions of the value chain (i.e to customers and sub-contractors). Staff competence is seen as functionally applicable knowledge. From Sveiby's model we derive three classes of knowledge that we can capture: **explicit technical knowledge** (from internal structure and staff competence), **tacit process knowledge or process experience** (from internal structure and staff competence) and **explicit relational network knowledge** (from internal and external structure).

Information Management Framework

We will present an IT framework that incorporates the above derived requirements. We model our framework with software agents.

Why agents ?

Since information to be managed by a KM IT system is inherently distributed, we require a distributed system infrastructure for implementation. *Agent Communication Languages (ACL)* (e.g. FIPA ACL, KQML) specify a high-level abstract means of communication among agents. The flexibility of ACLs in terms of language (e.g. KIF) and ontology usage provides a powerful tool to model communication in a KM IT system in a way that is as close to the application as possible (see also (Weiss 1999)). ACLs also allow for loose coupling of components and thus assure an open architecture and easy integration of future new components. Further, the agent-specific notion of autonomously acting objects fulfills one of the key features derived above.

Framework structure

In Figure 1, it can be seen that our framework is built of agencies made up of several agents each. The agencies represent the organizational *knowledge entities* user, team and community and manage the respective information objects. The service agency provides services for the entity agencies and the shared ontology ensures a common domain specification for communication of the components. We consider an organization made up of teams and figure 1 shows the IT system for one team.

The shared ontology (SO) is shared by all team members and provides a concept of the team knowledge domain. The

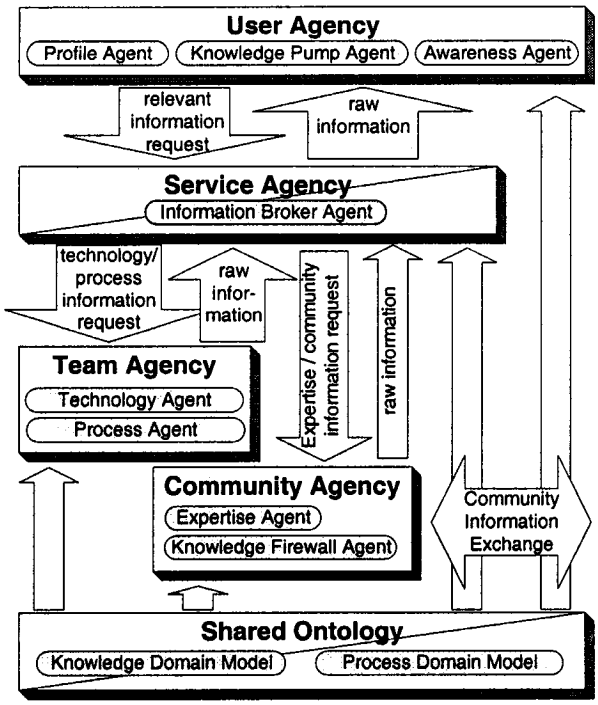

Figure 1: Architecture of a KM IT system

SO is subdivided into a *knowledge domain model* for *explicit technical knowledge* and a **process domain model** for *tacit process knowledge*. The SO is used for consistent communication of the agencies, as a basis for the user profile in the user agency and to specify information requests and replies.

The user agency consists of the **profile agent**, the **knowledge pump agent** and the **awareness agent**. The profile agent keeps a qualification and interest profile of the user based on the SO. The awareness agent analyzes the user's work context, classifies it according to the SO and provides this information to the profile agent and the knowledge pump agent. The knowledge pump agent autonomously requests information relevant to the user from the service agency. The knowledge pump agent migrates to the available information sources if necessary and personalizes the retrieved raw information (including meta-information) according to the user's qualification and interest profile.

The service agency consists of the **information broker agent**, which registers available information sources. When the information broker agent receives a request for specified information, the registered sources are queried for this information

The team agency includes two of the information sources in our framework. The **technology agent** resp. the **process agent** manages the information that has been coded from the *explicit technical knowledge* resp. the *tacit process knowledge*. Upon request from the information broker agent, both agents reply with the raw information requested, which includes meta-information for later personalization. The raw

information including meta-information has to be stored and indexed according to the SO by the members of a team.

The community agency provides for the *relational network knowledge* coded into information. The **expertise agent** manages information about expertise in a team, which is derived from the user profiles. Upon request from the Information broker agent, the expertise agent queries expertise agents in other teams for information. This exchange can only take place if the respective ontologies have a non-empty intersection. The **knowledge firewall agent** controls the import and export of all information from and to the team. The firewall agent also queries information sources of other teams for information upon request of the information broker.

Related Work

We would like to show how our framework comprises existing research projects in the KM IT field.

The SO could be designed with the tools and methods presented in (Gruber 1992) and (Gruber 1993). Another possible implementation for an ontology based on a description logic can be found in (Bullock & Goble 1998). However, research remains to be done on construction of SOs.

The user agency profile agent can be designed with methods presented in (Kobsa & Wahlster 1989) and in (Fink, Kobsa, & Nill 1996). It remains to be explored how the SO can be used as the basis for the user profile. The functionality of a knowledge pump is shown by the example of the XEROX Knowledge Pump in (Borghoff & Pareschi 1998). In (Süß, Freitag, & Brössler 1999), it is shown how XML-based documents can be personalized to the user's needs. Another area for future research is the awareness agent. Existing awareness infrastructures like NESSIE (Prinz 1999) or Elvin (Fitzpatrick *et al.* 1999) supply events from user observation. It remains to be explored how the user's actual task can be inferred from this awareness information.

The team agency and the community agency require methods for storage, retrieval and reuse of information modules. Documents based on XML-applications tagged with meta-information seem to be a promising approach. Existing document management systems, for example, could be integrated as a means of storage for information in the team agency and the community agency.

Conclusion

We designed a KM IT reference framework by taking a holistic KM perspective. We derived core features for a KM IT framework. We defined a scheme to classify knowledge in an organization. An IT framework has been presented that includes the derived features for the derived classes of knowledge. Existing KM IT research has been classified according to our framework and areas for future research have been identified.

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