DESIGNING KNOWLEDGE INFRASTRUCTURE FOR VIRTUAL ENTERPRISES IN ORGANIZATIONAL LEARNING

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Abstract

This paper investigates the design of knowledge infrastructure to support organizational learning through the notion of virtual organization. The infrastructure is conceived to comprise the knowledge management architecture (KMA), acting as the middle-layer to support front-end knowledge management services (KMS) and back-end organizational memories (OM). Specifically, we describe the business and technology components constituting the KMA of our virtual university (VU) model. We interpret the KMSs as the iterative means to realize the KM processes offered dynamically by the VU through the construction of Web information systems (WISs). The paper also addresses the importance of positioning the OM for various domains of reusable knowledge, which allows the organization to evolve as rapidly and continuously as today's fluid electronic markets. The paper concludes by examining some typical examples of knowledge management in the VU, especially in the areas of knowledge creation, organization and application.

1. INTRODUCTION

Today the view that knowledge is a valuable organizational resource has become widely recognized and accepted in the business community. This is largely due to the emergency of the knowledge-based economy [11] characterized by a highly competitive and turbulent business environment. One consequence is the increase in organization's efforts to deliberately manage knowledge. And organizations are realizing that their competitive edge is mostly the intellectual capital (brainpower) [16] of their employees, and they are particularly interested in harnessing their human capital in order to stay ahead of the pack. The soaring attention on knowledge management (KM) [3] deals with the conceptualization, review, consolidation, and action phases of creating, securing, combining, coordinating, and retrieving knowledge. With Web-based and intranet technologies, the connectivity and possible sharing of knowledge are greatly enabled to build the knowledge infrastructure of the organization. This paper investigates the design of such a knowledge infrastructure in an electronic university environment we call VU, representing our Virtual University model [21]. The knowledge infrastructure is designed to comprise a three-tiered configuration, including: the front-end KM services (KMS), the middle-layer KM architecture (KMA), and the back-end organizational memories (OM). Currently the KMSs are conceived as Web information systems (WISs) [6], each being interpreted as the iterative means to realize the specific KM processes of the organization. And the KM services, incrementally prototyped for the VU, could be made available to its business partners in the form of a virtual enterprise [5], through re-configuring its intranet-based services to extranet-based operations [4]. Also we are experimenting with the design of our knowledge infrastructure under the notion of the virtual organization model [8]. According to Mowshowitz [7, 9], this model can be conceived as an approach to management that explicitly recognizes the conceptual distinction between functional requirements and the means for their realization in practice, as well as providing a framework for accommodating dynamic changes in both requirements and available services.

2. THE CHALLENGE OF KNOWLEDGE CREATION

Undeniably, the core of today's knowledge-based economy is knowledge work and its workhorses are the knowledge workers. Knowledge work involves the creation of knowledge and its application to the organization as new or improved technologies, products, services, or processes. A critical feature of knowledge work is that it requires multi-disciplinary expertise and mutual learning in order to achieve a synthesis of technology and knowledge domains [12]. The management of knowledge is an attempt to recognize the human assets within the minds of individuals and leverage them as organizational assets that can be accessed and used by a broader set of individuals on whose decisions the organization depends. According to Nonaka and Takeuchi [10], organizational knowledge can be created through interactions between tacit knowledge (i.e., knowledge not easily expressed and communicated) and explicit knowledge (i.e., knowledge codified and expressed in formal language). And four distinct interaction modes have been identified: from tacit to tacit (socialization); from explicit to explicit (combination); from tacit to explicit (externalization); and from explicit to tacit (internalization). Knowledge socialization generates new tacit knowledge by sharing and exchanging know-how and past experiences among employees. Knowledge combination generates new explicit knowledge by combining pre-existing explicit knowledge and bringing it together to produce new insight. Knowledge externalization involves structuring or articulating tacit knowledge into explicit knowledge, thus allowing it to be communicated to other users. Finally, knowledge internalization maps explicit knowledge into internal knowledge when individuals, exposed to others' knowledge, make it their own. In a knowledge-creating organization, employees are continually improvising, inventing new methods to deal with unexpected difficulties and to solve immediate problems, and sharing these innovations with other employees through effective communication channels. Thus, although organizational knowledge is created via individual knowledge, it is more than the sum of individual knowledge. Complete organizational knowledge is created only when individuals keep modifying their knowledge through interactions with other organizational members. It is believed that a well-devised OM with user-friendly KMSs enhances the probability of seamless, flexible knowledge acquisition, sharing, and integration among knowledge workers throughout the organization. The challenge that organizations now face is how to devise KMSs to turn the scattered, diverse knowledge of their knowledge workers into well-structured knowledge assets ready for deposit and reuse in their OMs [20]. Thus, KM presents significant organizational and technical challenges that require the integration of an effective human network with a wide range of technological opportunities.

3. THE DESIGN OF KNOWLEDGE MANAGEMENT SERVICES (KMS)

It is believed that designing a knowledge infrastructure is a multi-disciplinary venture, requiring specialty in strategic development, business process engineering, change management as well as technology expertise. And KM must involve the development of new and the sharing of existing knowledge, as well as the establishment of the appropriate organizational culture, and value systems that measure and reward the application of intellectual capital to achieve performance. In an effort to characterize a KM framework based on the knowledge interaction modes described, we define some KM services (KMSs) that will involve both the necessary information and communications technologies (ICT), and the related organization management issues.

- *Knowledge Socialization.* This process usually occurs in the form of informal communication when someone raises a question for discussion or an issue to be responded. It should receive direct ICT support from technologies that make users communicate without imposing any particular structure on their interaction. The suitable KMSs include e-mails, discussion lists, bulletin boards, or some brainstorming applications.

- *Knowledge Internalization.* This process occurs when we are actively searching for methods or lessons learned to solve problems at hand. We do knowledge interpretation from other colleagues' previous work. We internalize knowledge by doing, and also by observing what other people have done in a similar context and by example. The suitable ICT element should focus on recording explicit knowledge, making it available to potential users and enabling them to re-experience what others have done in similar situations. The corresponding KMSs could include lessons-learned databases, process history tracking, hypermedia computer-based training (CBT), and data mining.

- *Knowledge Externalization.* This process, aimed to structuring knowledge and making it available to other users, involves concept mapping, tacit knowledge categorization and representation. The ICT elements could include semantic networks, knowledge ontologies, network publishing, data warehousing, and other push technologies for personalized pathways to knowledge. The appropriate KMS should focus on creating an organizational memory aimed at supporting knowledge preservation, knowledge capitalization and knowledge creation.

- *Knowledge Combination.* This process involves various knowledge sharing and decision coordination. The ICT element should focus on combining pre-existing explicit knowledge to produce new insights. The KMSs could appear in the form of document management system, the group decision support system or the workflow system.

4. THE DESIGN OF KNOWLEDGE MANAGEMENT ARCHITECTURE (KMA)

The KMA acting as the middle-layer in support of the front-end KMSs through the back-end OM, should be open, flexible and customizable to the ways communities of practice communicate, learn and evolve. Its logical requirements are to satisfy the KM concerns to create, retain, share, account for, and leverage knowledge from the personal level to the team level, the organizational level, and even the inter-organizational level. Its development is currently conceived from two architectural perspectives: the business architecture, and the technology architecture. The former involves the development of organization and management solutions and methods that are related to modeling the business functionality of the organization; namely, business strategies, processes and structures that enhance and facilitate organization-wide knowledge leveraging. The latter involves the development of the ICT components within an intranet-based knowledge medium to translate the organization's business vision into effective electronic applications that support the intra- and inter-organizational KM processes. In other words, we are tackling the design of our KMA from the perspective that KM should be implemented as a business activity. This transcends into two essential concerns: Treating the knowledge component of business activities as an explicit focus of business; Making a direct connection between an organization's intellectual assets (explicit and tacit) and positive business results.

4.1 The KMA's Business Architecture

The KMA's business architecture is designed to comprise a number of distinct KM-related components: e-Business models, e-Process models, and e-Application models, where "e" denotes electronic. The e-Business model is aimed to provide a high-level perspective of the business initiative. An example might involve the knowledge-related audit of the organization. The e-Process model is aimed to describe the internal and external processes representing the organization's daily behavior. An example would be to establish the relevant KM processes, to define the organizational roles, to determine the audit details, to evaluate organizational performance, to link measures explicitly with learning-related efforts, and to develop certain

innovation and renewal indices. The e-Application model is aimed to represent the electronic applications to be developed to streamline business processes from the end-user perspective. An example might be to support such aspects of a learning organization as knowledge diagnosis, and knowledge transformation. Knowledge diagnosis helps determine the most critical areas of knowledge capture and creation within the organization. Knowledge transformation involves such issues as the mapping of knowledge to empower personnel to quickly and accurately locate sources of knowledge applicable to specific business problems; and creation of reward systems that facilitate openness, improvisation, integrity, creativity, team-spirit, trust and ability to change.

4.2 The KMA's Technology Architecture

The KMA's technology architecture can be conceived as an integrated suite that intelligently collects the information from various sources, and presents it to KMS users so that they could take immediate action. These users are indeed both the knowledge consumers and producers who continually respond to and build on one another's addition to the OM. And knowledge evolution is a continuous activity with those users making improvements, updates and suggestions in a way tightly integrated into their work processes. Technically, this architecture is composed of distinct stages of development such as e-Application rules, e-Application data, and e-Application distribution, where "e" denotes electronic. The e-Application rules are the technical mechanisms, which enforce business rules that are peculiar to every business process to govern its operation. Typical components of e-Application rules include business objects and application frameworks to implement the business requirements. The e-Application data comprises data (information or knowledge items) stored and manipulated by the electronic applications (KM services). Such data must be monitored and distributed to applications within and outside the organization in a way that first anticipates data requirements and second enforces data access policies to what are often sensitive items. The heart of the e-Application distribution is a distributed architecture, which allows application resources to be located on individual application servers. And these servers are connected by a network infrastructure, which provides a backbone of communication between the multiple distributed platforms of the organization, and which communicates using standard such as CORBA [14].

5. THE DESIGN OF ORGANIZATIONAL MEMORIES (OM)

The VU's KM processes require iterations of references and modification of the components developed in the business and the technology architectures of the KMA. This requirement implies the importance of a reusable asset repository for storing various business-specific and technology-related components in the form of tacit and explicit knowledge items. Our OM is designed to fulfill this specific requirement. Particularly, the OM could be configured differently for various purposes. For example, it could be structured into the business repository and the technology repository. Typically the business repository stores knowledge items which we can use to standardize definitions of business and process models. And we can archive existing process components, including entities such as degree programs, course structures, and professor profiles. These archived entities can then be recalled later by coworkers in other departments to be reused or modified for new process models. Similarly, the technology repository stores technology resources such as business objects, pre-built and purchased components, developer documentation, and other technology standards. Actually, since the OM is intended as a mechanism for securing organizational knowledge, it is evident that it should be populated with knowledge items. However, such items can be specified at different levels of details. An example of specification following the CommonKADS organization model [2, 13] is to model knowledge items as objects with different attributes commonly classified into three groups as follows:

General	Name: Role description: Activity: Domain(s):	 The Role the knowledge is associtated with The related organizational task(s) Reference to organizational areas/objects/processes
Content	Generic task type: Nature: Products/services: Functions:	From the CommonKADS library tree Heuristic, formal, uncertain … Marketable products of the organization Organizational functions involved
Availability	Time: Location: Form:	When available Where available Paper, electronic, mind, collective

Table 1: Knowledge items as used in the CommonKADS organization model [2, 13]

And van Heijst et al. [19], in their elaboration of the OM knowledge items, expounded on the set of attributes we can define according to our specific macro-level knowledge contexts:

- *Activities.* This attribute refers to the organizational activities to which the knowledge item is related. Every organization should have an explicit model of the activities that are performed as part of the work processes. The names of these activities can then be used as values on this attribute.

- *Domains.* This attribute is related to the subject of the knowledge item. To use this attribute, organizations should have an inventory of relevant knowledge domains. This inventory is a meta-description of the types of knowledge that exist in the organization. And it is specifically developed according to the contexts of knowledge work in the individual organization.

- *Form.* This attribute concerns the physical representation of a particular piece of knowledge. De Hoog et al. [2] identify four possible values for this attribute: paper, electronic, mind and collective, where the last one is actually referring to the availability issue instead of the physical form. Overall, the number of possibilities should be sufficient to allow an organization to specify the different forms in which knowledge is available physically.

- *Type.* This attribute specifies the type of document relating the knowledge item. Possible values include concepts such as protocol, procedure, guideline, handbook, manual, best/worst practice, progress report, white paper, evaluation report, and many others. Such values are assumed to be reusable across a wide range of organizations, even though individual organizations may choose to use only a limited subset.

- *Products/Services.* These attributes relate the knowledge items to the products and services of an organization. These attributes enable the OM to improve communication with the knowledge workers and outside clients. The possible values are often organization-specific, and should be obtained with no particular difficulties.

- *Time and location.* These attributes are relevant for knowledge items, which have “mind” as value on the form attribute. Since certain knowledge is only available in a personal form, the OM should make it easy to find out how and where this particular person can be contacted. Actually, the OM should contain knowledge profiles of all the workers in the organization. These profiles should be formulated using the same attributes and attribute values as used for knowledge items. More specifically, such profiles, usually under the control of knowledge workers, should carry knowledge items that are about the activities, domains, and products/services, which are directly related to their current knowledge work.

It is believed that our OM should be codified according to different domains of knowledge to facilitate knowledge capture and reuse. To enable this specific segmentation, we should focus

on various sets of concepts or terms that can be used to describe some area of knowledge or build a representation of it. And the idea of ontology specifications [1, 17] proves useful because they typically refer to taxonomies of the tasks that define the knowledge for different KMSs, providing a shared vocabulary to facilitate communication, search, storage, and representation of knowledge.

6. THE MISSION OF WEB INFORMATION SYSTEMS (WISs)

Our VU positions the WISs [6] as an iterative means to realize the KM services offered dynamically according to the ongoing functional requirements of the university execution models. Technically, WISs represent the important information systems (IS) efforts geared toward exploiting the benefits of the Web platform. They are the systems knowledge-workers use to conduct Intranet-based and Extranet-based distributed applications for the KM processes. So, unlike Web pages designed largely for leisure browsing, WISs should enable users to perform work, and are usually tightly integrated with the OM in the form of say, distributed databases or knowledge bases. We believe that in WIS development, user participation is critical, and we should employ the same disciplined system development principles, rigorous business value assessment, and user-centered approaches that are required to build successful non-WISs, i.e., conventional ISs. Meanwhile, we also believe that WISs development should be sufficiently different from traditional IS development because WISs have the potential to provide distributed computing environments among geographically dispersed knowledge workers. These differences include such Web development details as [18]: 1) navigation structure designed to support specific work flow; 2) structured data modeling representing relationships among pieces of information; 3) features that enable users to process knowledge items interactively; 4) support for distributed collaboration work style; and 5) link referential integrity for mission-critical tasks. Ultimately, it is convinced that WISs should help organizations to enhance their competitiveness and facilitate differentiation of their services from other competitors through the quality of their KMSs.

7. VU'S EXAMPLES OF KM CHALLENGES

One of our VU's learning experiences is to enable knowledge development and transfer among teachers and students in an interactive and collaborative manner. Students actively participate in generating, accessing, and organizing the required information. They construct knowledge by formulating their ideas into words and then develop these ideas as they react to other students' or teachers' responses to their formulations. Knowledge construction can then be considered as the process of progressive problem solving, which encourages students to be innovative, create intellectual property, and develop and acquire expertise. To achieve these knowledge tasks, our academic staffs need considerable skill and knowledge. Indeed, such knowledge tasks deal with the acquisition, creation, packaging, and application of emergent knowledge, and are increasingly identified inside the core competencies of modern knowledge organizations. Examples include the re-structuring of the VU's individual degree programs as webs of logically coherent courses, which are in turn organized as series of logically complete modules that are again expressed as serial sets of sessions, to enable component-based development, renewal and reuse of teaching materials. All these are meant to support one single purpose: each program and all its components need be dynamic so that programs can change their courses; courses can change their modules; and modules can change their sessions. Understandably, it is important to have good coordination, evaluation and evolution of all these instructional units. And such knowledge activities require some meticulous collaboration among knowledge workers (content providers, material reviewers, curriculum coordinators, administrators, and teachers).

8. REMARKS FOR CONTINUING DEVELOPMENT

In the paper, we have presented the perspective of our knowledge infrastructure regarding its structure and behavior according to the virtual organization model, focusing on identifying the abstract requirements needed to realize the KMS, the KMA, and the OM of our VU. A process model for implementing knowledge management is the KM cycle [15], which is composed of four activities: conceptualization, review, consolidation, and action. Conceptualizing is trying to get a view on the state of the knowledge in the organization, and analyzing the strength and weakness of the knowledge household. Reviewing is checking what has been achieved in the past and what the current state of affairs is. Consolidating, directed toward improvements, is selecting the optimal plans for correcting bottlenecks and analyzing them for risks that accompany their implementation. Acting is the effectuation of the plans chosen subsequently. Thereby, in order to enable knowledge sharing among organization members, we have to constantly apply the KM cycle to the following issues: Are we building and maintaining an inventory of organizational knowledge? Are we bringing such knowledge to where it is needed? Are we sure that available knowledge is reused and not being re-invented? Are we capturing and securing organizational knowledge lest it is lost? And have we been doing knowledge creation as expected? These questions represent some of our concerns in performance evaluation, which should include approaches for explicitly measuring and monitoring the quality and business value of organizational knowledge assets, with a set of well-defined indicators based on awareness and insight into intellectual capital development.

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