e-Learning at Work in the Knowledge Virtual Enterprise

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Abstract

The purpose of this paper is to propose an overview of the Knowledge Virtual Enterprise model, where the Virtual Enterprise vision is extended with Knowledge-based assets in order to provide an agreement model to support the interoperability among organizations.

Every enterprise or organization, by itself, is a source of original knowledge that, if exploited, can contribute to its competitiveness. If this is true inside the enterprise walls, it is more relevant when extended to Virtual Enterprises, especially when they operate in a tumultuous and unsettled context, like ICT, strongly bound to the so called soft skills and even more to the capability of carrying out just-in-time knowledge take-over and transfer.

In order to explain the advantages of the Knowledge Virtual Enterprise model we define some real-world business scenarios, to be executed within the context of a Knowledge Virtual Enterprise instance. The scenarios are based on the idea that several organizations could put together their competences, human resources, expertise, technologies, etc. to carry out complex project activities, requiring resources that are usually difficult to be found in a single organization.

The scenarios are particularly focused on how the Knowledge Virtual Enterprise model can support personalized, contextualized, effective and efficient e-learning at work experiences.

Finally, the Knowledge Virtual Enterprise model vision is concretized through the description of a feasible technological mapping between its main concerns and existing software technologies and specifications.

1. Introduction

e-Learning is usually identified as a formal piece of learning or specialist software, but the simple use of a computer frequently means involving someone in formal or informal e-learning processes: looking for subjects in internet, watching online tutorials and interacting with something or, simply, communicating.

e-Learning at work was born few years ago when Ministries and Institutes (for example the National Institute for Continuing Adult Education in UK) looked at the way to involve adults in e-learning programs. By doing this, they found the key challenge: how to link employees' personal skill needs with organizational learning and development processes.

To describe what really is the e-learning in the workplace we should mention three trends. The first one is the internet-based educational model (by using of "learning management systems" and "learning content management systems"). The second one is the classroom model in learning designs (often identified as "informal learning" or "work based learning"). The third one is based on exchange of experience and development of knowledge. Many of these models evolved to the "socio-cultural approach" to human learning, by means of "practice communities" and "collaborative construction" of knowledge.

e-Learning at work could mean using these evolved models and coordinating them with all HR management as well as management processes so to develop an organizational climate and social and physical environment beneficial to organizational learning.

Thus, e-learning programs should be quite easily used to teach a wide range of skills, job-specific skills able to give professional qualifications.

Although employers are keen to learn more about e-learning and its business impact, they would like to make better use of interactive software, receive well personalized e-learning path and be involved in programs very closed to their activities, useful to improve their ranking or receive rewards.

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Aware of the objectives of e-learning at work [1][2], this paper tries to describe a possible approach based on a Knowledge Virtual Enterprise.

2. Knowledge in the virtual enterprises

A Virtual Enterprise (VE) may be considered as a temporary association of autonomous and heterogeneous enterprises (for instance a network of SMEs), whose aim is the building of ties and relationships that can be easily translated into business processes to gain profit [3].

Every enterprise or organization, by itself, is a source of original knowledge that, if exploited, can contribute to its competitiveness. It frequently happens that a solution developed in a department could be reused with benefit by another department or these ideas that are not useful in a particular moment become successful in the future. If this is true (and someway managed, with some limitations, by the current enterprise Knowledge Portals) inside the enterprise walls, it is more relevant when extended to VEs, especially when they operate in a tumultuous and unsettled context, like ICT. This sector is indeed strongly bound to the so called soft skills (relational and communication capabilities, knowledge transmission, management, organization) and even more to the capability of carrying out just-in-time knowledge take-over and transfer.

A Virtual Enterprise is able to efficiently react to change only through reusing and synergetic combination of knowledge that can be found in different nodes of its structure.

The conceptual model of the Knowledge Virtual Enterprise is built around three main roles that can give life to different applicative scenarios:

- **KBroker**: who receives a request for information retrieval, looks for the provider that is likely to be able to satisfy the request, contacts the provider and forwards the request.
- **KProvider**: who supplies resources and services to be shared in the network.
- **KConsumer**: the user of resources supplied by providers.

A layered conceptual view of the Knowledge Virtual Enterprise (KVE) model is depicted in Figure 1.

The layers of the KVE model Conceptual View (as illustrated in Figure 1) are:

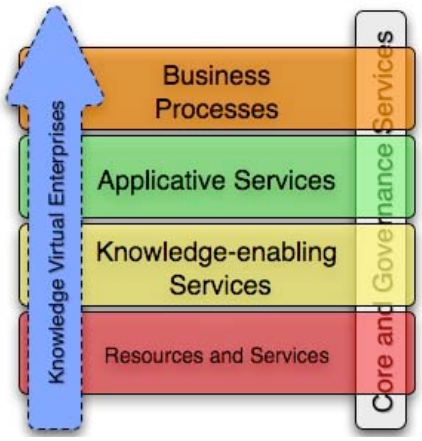

Fig. 1. KVE model Conceptual View

- **Core and Governance Services** collect services useful to a manager to administer all dynamic aspects that can occur during a KVE lifetime, such as Membership Services and Policy and Enforcement Services. Core and Governance Services are deployed towards the IT infrastructure of every organization subscribing KVE rules.
- **Resources and Services** of single organizations are exposed through a virtualization process realized following the rules defined by the KVE. An organization could expose, for instance, its human resources (skill, availability, salary, …), its products (price, availability, features, …), its services (e.g. on-line assistance through an automatic responder).
- **Knowledge-enabling Services** must:
  - realize a semantic correlation among resources and services exposed by organizations belonging to the KVE (e.g. offering functionalities to implement KBroker, KProvider e KConsumer roles)
  - manage knowledge that has been generated and used during a KVE lifecycle
  - model, through taxonomies and ontologies, the KVE structure and processes.
- **Applicative Services** belong to the set of services, eventually based on Knowledge-enabling Services, operating on both the "horizontal" level (e.g. Business Process Definition and Execution, Project Planning, Document Sharing services) and the "vertical" level (e.g. e-learning, e-commerce services).

The following picture (Figure 2) shows a schema of a possible configuration (network deployment) of a KVE. The KVE, from the network deployment point of view, is represented by a graph, whose nodes are the different organizations.

Fig. 2. A sample KVE configuration for four organizations

The KVE model could not be applied in the real world if the involved organizations do not share:

- the same representation model for their internal structures (strategies, mission, relevant case history, in progress activities, etc.).
- the same representation model for their applicative domains.
- the same representation model for their processes.

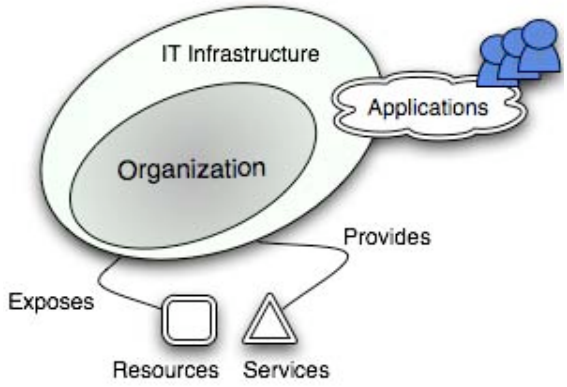

Fig. 3. Every organization exposes resources and services through an IT infrastructure

Semantic structures like taxonomies and ontologies are used to formalize knowledge on a specific domain and on processes definition. In particular, for ICT domain (adopted as the reference domain in this work), Knowledge-enabling Services manage an Enterprise Ontology (model used by ICT enterprises to expose their internal structure) [4], an ICT Process Ontology (used to identify components needed for processes definition - like a software development process) [5], and an ICT Taxonomy (model used to structure skills related to ICT domain and allow therefore expertise identification across different organizations).

3. e-Learning at work: some business scenarios

The Ministry of Agriculture announces a notice of competition for the realization of a platform to support and manage the supply chain of agro industrial sector.

Bob's company, specialized in Engineering in manufacturing industries, considers this job interesting as an incentive for its core business development but, for the complete satisfaction of the competition requirements, he needs to find partners to cooperate with. After a negotiation activity, two companies are involved: Alice's company and Fred's company. They, all together, prepare and submit the project proposal. The Ministry committee awards the project realization to the consortium established by Bob, Alice and Fred companies.

Bob's company is in charge of the project management. At this stage a recurring problem in ICT dynamic contexts is perceived: no resources with enough expertise are available in the organizations belonging to the pool. The decision is therefore to create a training project customized and tailored on the problem to be faced and to involve additional resources. But the companies, as always, have processes and in progress activities not so convergent. Fred's company is a "young" company, so intensive training during office hours is preferred. Bob's company, on the contrary, can rely on skilled and busy, as well, staff, so they usually spend few time for learning. For these reasons, customized learning projects are designed for each worker allowing him/her to acquire skills with respect to the foreseen activities. At this stage production activities start.

At the same time, a high school is starting training and learning activities to involve students in scientific experiments, but, indeed, it haven't adequate laboratory equipment to employ for motivating experiments.

The Principal of the school has to realize this project and so it asks for collaboration from technical agencies specialized in virtual scientific experiments execution. After a negotiation activity, two agencies are selected to work out the project. One of them has a powerful simulator able to create virtual environment where it is possible to study the planets motions, to reproduce the interactions among masses in gravity field, to observe trajectories and reactions. Their researchers know very well all details of these phenomena and related simulations. The other agency has an engine able to design complex mathematical models related to fluid dynamic phenomena. Also the researchers working in this agency know very well all details about that.

In both cases practical and institutionalized knowledge are available. The collaboration with these organizations allows the school to improve the efficiency and efficacy of its learning and training activities. In the first step the teachers of the schools may receive support from the knowledge of the experts of the agencies. In the second step, young students may be engaged in simulations and get in virtual laboratories where they may apply all competencies acquired during the normal lessons, where they may find all knowledge shared by the teacher and the experts, where they may receive detailed and personalized deepening as they could need.

4. How a knowledge virtual enterprise leverages e-learning at work

In this section we are going to see how the scenarios introduced in the previous section could be realized using the KVE model.

To begin, we suppose that a KVE Administration Application Node (KAAN) and a KVE Knowledge-enabling Services Node (KKSN) are available and can be accessed through the network. The KAAN allows to access the functionalities of lifecycle management of a KVE, while the KKSN, beyond other functionalities, exposes a registry service to record the references to all the organizations adopting the model of the KVEs.

Through the KAAN and the KKSN, Bob (who represents his organization) looks for partners to be involved in the activities foreseen by the requirements expressed by the Ministry of Agriculture. The KKSN answers to Bob's query, and returns as a result (using the KAAN front-end) information on Alice's organization and Fred's organization. Once retrieved the references of the two organizations, Bob starts the KVE and a process (in charge of the Business Process Execution Service exposed by the KBPN) with the goal of producing an agreement. After this first task, the KVE may have a new goal: in a collaborating way the involved organizations have to produce and submit the project proposal. When to proposal is accepted, Bob decides his resources to employ for the project and, by using KBPN, define the project workflow. For each activity, he also asks to the other companies to allocate human resources. The request is carried out considering skills and characteristics expressed through a Competency Model and a Worker Model [6]. All the requests referring to the resources needed for project activities are registered by the KKSN.

Once the human resources have been chosen, the processes related to project activities can be activated and therefore run by the KBPN. The KVE is also used to fulfill the skill gap, through the execution of learning experiences personalized and customized on the needs of learners (workers in this case) and adapted to the project context. These services could be deployed on a new network node that is the e-Learning Services Node (ELSN). The ELSN, therefore, receives information about competences of the involved workers/learners and the project requirements and builds a learning path on the best set of learning objects from several Digital Repositories useful for the acquisition of the needed competences. At the end of the learning experience, workers will go through assessment tests and then to the activities if they pass the test or to a remedial learning path.

In the same time, in the other scenario, the Principal of the school looks for expert agencies, through the KAAN and the KKSN, he receives information from two agencies able to create and execute virtual scientific experiments. He creates a KVE with the selected agencies and define the goal to design virtual scientific experiments for his school. He find the right experiments by consulting with the expert of the agencies in a collaborative way and start a new business processes for each of them by the Business Process Execution Service exposed by the KBPN. He allocates right teachers and select young students considering their skills, competencies and real needs expressed through a Competency Model and a Learner Model. All the requests referring to the resources needed for activities are registered by the KKSN. By using the ELSN, all involved users are get in customized learning and training activities: teachers may receive personalized support from the agencies and access to their shared knowledge; students may receive personalized learning and training path to be able to assist to a virtual scientific experiment, to interact with it, to understand which phenomenon it represents.

5. Technological mapping

In this section, our effort is the identification of the existing technologies and specifications that could be exploited to implement in real terms the previously described scenarios, and establish a set of foundations to support design and implementation of a software platform for the KVEs life cycle management. The KVE model defined in this paper is tightly-coupled with the concept of "service", so we believe that we cannot avoid to use concepts coming from the SOA model [7], actually considered at the state of the art for the distributed architectures. Basing on SOA concepts we identify two main critical points (there exist many other critical points) for the implementation of our software platform:

- **Execution of business processes** across several administrative domains. This problem is strictly correlated to the difficulties of localizing, instantiating and orchestrating services deployed in multiple administrative domains. The difficulties are due to the different policies, technologies, etc. used by every administrative domain. The solution for the previously described problem seems to be the Grid Technology. Globus Toolkit 4 [8] and WSRF (Web Service Resource Framework) [9] are middlewares (implementing the SOA model) that provide a framework for the development of the so called Grid Services (i.e. services implemented on the top of Web Service technology and whose life cycle can be managed within a Grid Middleware) and a set of built-in services able to govern the life of Grid Services. The Grid Middleware enables the setting of Virtual Hosting Environments in which service clients can use transparently services deployed in their own administrative domain, as well as services deployed in a foreign administrative domain. Security, Privacy and Policy Management are other important issues related to the execution of business processes [10]. WS-Security, WS-Privacy, WS-Trust and WS-Policy represent a subset of the existing specifications addressing the aforementioned issues [11][12]. Furthermore, with respect to the service orchestration and the business process execution, there exist some formal languages like BPEL (its extension WS-BPEL [13] addresses the orchestration of Web Services) and BPEL4PEOPLE (that enables the definition of human interactions with the activities of a workflow).
- **Re-use of existing IT infrastructure**. The real-world rules say to us that we cannot re-implement from scratch all the services that organizations would like to expose in the context of a KVE. So, we need to re-use more and more existing IT infrastructures available in enterprises. Once more the Grid Middleware provides to us virtualization mechanisms able to hide complexity and peculiarities of existing legacy applications, databases, services, etc. and expose only their functionalities using standard protocols and specifications. Grid Services represent a good "wrapping mechanism" solution for legacy systems. Using Grid Services we can virtualize organization-specific resources and services and plug them into KVE environments. So, consumers, using standard mechanisms, can exploit virtualized resources and services. In the defined scenario, organizations have to expose human resources competences. Nowadays, enterprises choose a Human Resource Management System (HRMS) with respect to their strategies, their budgets and their requirements. SAP ERP HCM, Oracle's PeopleSoft Enterprise and Microsoft Dynamics GP/AX are only few samples of the existing HRMS solutions. SAP, Oracle and Microsoft HRMS have, in general, different ways to manage human resources and different ways to represent human resources competences. In order to plug all of the aforementioned systems into a KVE instance we have to virtualize the way they represent and provide access to human resources competences. In this case, the virtualization process can be realized in two main stages: (a) adhering to a shared vocabulary in order to identify names and semantics of all relevant competences in the ICT world; (b) using the same competences representation format in order to support interoperability across organizations within a KVE. The shared vocabulary in the KVE model is provided by the ICT Taxonomy, that is managed by Knowledge-enabling Services. The common competences representation format could be provided by HR-XML [14]. HR-XML is a XML specification designed to enable e-business and the automation of human resources-related data exchanges. The HR-XML specifications developed by the HR-XML Consortium define the interface necessary to automate background investigation orders and enable fast, easy access to background investigation reports. In the end, we would like to spend some words about the two domain-specific Applicative Services used in the defined scenario: Skill Gap Analysis and Automatic Unit of Learning Building services. In order to provide the implementation of the aforementioned services we could use the IWT (Intelligent Web Teacher) e-learning platform [15], able to offer personalized and contextualized learning experiences exploiting e-learning ontologies in order to represent educational domains knowledge. The pieces of interest of the ICT Taxonomy can be simply mapped onto a IWT-compliant ontology. IWT also provides a mechanism to represent cognitive states and learning preferences of learners using an e-learning standard called IMS-LIP [16]. Competences represented in HR-XML could be mapped (in a simple way) onto a IMS-LIP structure.

6. Conclusions and future works

In this paper, we have presented the Knowledge Virtual Enterprise model, where the management of the virtual enterprises lifecycle is supported by a set of Knowledge-based resources and services. To foster the proposed model, we have defined some real-world scenarios in which several organizations, with different policies and different IT infrastructures constitute a Knowledge Virtual Enterprise with the aim of proposing, planning and executing project activities. The proposed scenarios are focused on the issue of e-learning at work and in particular on the assembling and provisioning of personalized and contextualized learning experiences for effective and efficient training on the job activities. The personalized and contextualized learning paths outcome from the skill gap analysis between human resources (allocated onto project activities) skills and required skills (needed to carry out project activities). Human resources skills are exposed by organizations in the context of the KVE, while, required skills are provided by the ICT Taxonomy. Furthermore, we have identified a set of technologies and specifications useful to implement the Knowledge Virtual Enterprise model and in particular the proposed scenario. The technological mapping has revealed (a) Grid Middleware as foundations to build Knowledge Virtual Enterprises, and (b) a set of specifications as mechanisms to solve specific problems, like business processes definition and execution, security/privacy/policy, interoperability, etc.

Future works on the vision proposed in this paper consist of a definition of a detailed software architecture that implements the Knowledge Virtual Enterprise model.

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