Knowledge economy in Next Generation Enterprise Environments

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Abstract

In the post-crisis era, the world economy will be transformed into a knowledge economy, as the appropriate application of knowledge will be the main means of production, since the availability of traditional resources such as labour, capital and raw materials has already been limited. Thus, knowledge economy is of paramount importance in designing successful enterprise environments. Recycling and amalgamating knowledge are the main economic activities, the results of which will maximize in short terms the productivity values of any organization.

In this paper, the Next Generation Enterprise Environments are defined as those that inherently exhibit intelligent behaviour and adaptive functionality, which is achieved by analyzing the asset factors that lead the knowledge of such environments to be transformed from implicit to explicit. An innovative approach is proposed, based on ontologies and ontology alignment, since they provide means for explicit and formal representations of knowledge and ways of harmonically interrelating them.

Key Words: knowledge, economy, ontologies

JEL codes: O300, O310

1. Introduction

Enterprise environments (EEs) are human (producers, vendors, customers) activity spaces populated with multiple computer systems and networks of different types, which are able to store, manage and exchange data. These environments are capable of receiving and providing services to other external spaces and to society in general. A new challenge in the post-crisis era will be that of redesigning the EEs in order to create the Next Generation Enterprise Environments (NGEEs). The NGEES will be designed in such a way, to inherently exhibit intelligent behavior and adaptability, in order to provide optimized resource usage and support consistent functionality. Human beings, as the main actors of those environments, still continue to play the same variety of roles, as producer, vendor, and customer, in order to realize their tasks successfully. However, the intelligence of these environments will be relied upon knowledge, because as it is stated in [Drucker: 1993] "The basic economic resource is no longer capital not natural resource,
nor labor. It is and will be knowledge.” Moreover, as claimed in [Bogdanowicz, Bailey: 2002], knowledge is an asset that should be valued, developed and managed, since it is a component of the intellectual capital of an organization.

New opportunities emerge, in NGEEs, since knowledge has some special characteristics: (a) it is independent of space, that is, its use by one person or organization does not exclude its use by another; (b) it is unlimited and renewable; (c) its value is unrelated to the cost of creating it; (d) it is time independent and (e) technology can replicate knowledge easily and quickly. In these environments, knowledge economy is an umbrella term which includes the intention of firstly, limiting the effort and the time for the management of collections of documents and emails that exist in large numbers in nowadays EEs, or the different descriptions of business processes and, secondly, augmenting the exchange of data, which is not physical anymore, but being part of the global web, is a commodity for most enterprises [Ehrg: 2007].

As different kinds of knowledge will be encoded in NGEEs, including knowledge about manufacturers, products, currency, the availability and state of resources, the tasks to be achieved, the preferences of the customers and the policies that are to be followed, the management of whose is tedious and time-consuming, may lead an entire organization or enterprise to total confusion. Hence, the capture of different kinds of knowledge, as well as their appropriate combination, is a necessity in order to minimize the inaccuracy of knowledge and the ambiguity regarding its interpretation [Heinroth, Kameas, Puvost, Seremeti, Bellik, Minker: 2011]. Moreover, for the sake of economy, pre-existing knowledge can be used towards producing new one, through recycling the pre-existing one, or by merging different pieces of knowledge and thus enabling NGEEs parties and networking components to interact successfully through a common communication channel, despite their variety and heterogeneity.

In this paper, the use of ontologies, which are means of knowledge representation and, merging processes as the homologue economy activities, that is knowledge recycling and knowledge amalgamation, respectively, are suggested. In terms of ontology field, these two processes are based on the identification of the relations between different ontologies, which in turn, are knowledge representations that are not always compatible with each other. In that sense, in section 2, an example is presented, explaining the use and exploitation of ontologies, in two different real life scenarios that can emerge in NGEEs. In sections 3 and 4, we analyze how ontology processes can be used in order to implement the recycling and amalgamation of knowledge activities, where the presented scenarios focus on. In section 5, the meaning of ontology alignment as the first step towards the achievement of knowledge economy within and among NGEEs, is explained.

2. Knowledge representation in NGEEs through ontologies

Business activity, productivity, offer and demand, billing, currency, exploitation, human resources, raw material management and, the use of technology are nowadays economic terms associated with EEs, whose use varies from individual or company requests, preferences, biases and knowledge background, that is, from their conceptualization. These terms are formed differently through the ages because of changes in society, or, perhaps, their different perceptions bring about changes to the society.

Knowledge is the key asset of any modern organization, in the sense that, customer knowledge and knowledge about products should be shared among departments within an enterprise and enterprises within a supply chain. Moreover, knowledge about the overall
enterprise is necessary, in order to be adapted to different conditions, that is spatial, temporal, environmental conditions, personnel skills and customer preferences.

Information technology has made it possible for enterprises to accumulate a large volume of knowledge considering their management, organization and function, but as it is mostly stored in databases or in knowledge bases, any new and useful knowledge can hardly be induced. Furthermore, in order for the knowledge to be understood and processed in a meaningful way, more semantic descriptions are needed.

Ontologies have become a promising technology to express semantics. They are used to capture knowledge about some domain of interest, by describing the concepts and relations that are important in that domain, as well as a computerized specification of the meaning of the terms used [Seremeti and Kameas: 2010].

Ontology is defined as an explicit and formal specification of a shared conceptualization [Gruber: 1995]. A conceptualization refers to an abstract model of some phenomenon in the world, which identifies the relevant concepts of it. Explicit means that the type of concepts used and the constraints on their use are explicitly defined. Formal refers to the fact that the ontology should be machine readable. Shared reflects the notion that ontology captures consensual knowledge, that is, it is not private to an individual, but accepted by an entire group. Thus, ontology is a structure of knowledge which provides semantics and can be understood in the same way by different persons and among computational devices.

According to our vision, within NGEEs or among different NGEEs, for example, customer knowledge or the knowledge of a product can be defined in a machine readable way, providing a communication channel between human resources and business processes, despite the fact that they have their own conceptualization.

In order to further explain the exploitation of ontologies in knowledge economy terms, two real life scenarios that may happen within or among NGEEs are described.

1st scenario: As a result of the economic crisis, one bookshop has decided to expand its activities, by using the advantages of the Internet in its selling policy. Thus, it must improve its product database and add more information to it, or it must find a way to almost automatically evolve a previous description of a product by changing some piece of information about it. For example, the price of a specific product, requires to be indicated not only in euros but also in another foreign currency i.e. dollars.

Considering this scenario, the proposed solution is to use ontologies in contrast with databases or simple collections of documents that were used up until recently as the main knowledge representations. In this way, for example, the knowledge concerning a book in reference to "Ontology Alignment" can be represented by the part of the ontology shown in figure 1, which describes the notion of Book, just as a specific bookshop owner has imagined it.
Figure 1: A Book ontology

An ontology contains: (a) classes, which represent the main concepts of a domain of interest; (b) hierarchy of these classes; (c) relations between classes, which indicate how two different concepts are meaningfully combined; (d) properties, which are relations attached to specific classes, and; finally, (e) instances, which are particular objects that refer to a specific class. The ontology in figure 1 is explicitly explained below.

The class *Volume* has properties as *hasAuthor* and *hasISBN*, which both have range string, as well as *hasYearOfPublication*, which has range integer. *Essay* is another class of the book ontology, which is a subclass (given by the labeled arrow *is a*) of the class *Volume* with the property *hasSubject* that has also range string. *Literature*, *Bibliography* and *Politics* are also classes that are subclasses of the class *Essay*, which means that each of them is a kind of essay, and so on. One instance of the class *Volume* (given by the labeled arrow *is*) named *ontology_alignment_book* is presented.

Given the above scenario, the most convenient way to evolve this knowledge representation is to follow an ontology evolution process, which is described in section 3. In this way, we do not leave scrap behind us, by throwing the previous book ontology in the litter bin and creating a new one from scratch, but we are to recycle knowledge, by adequately handling the changes which occur.

2nd scenario: Suppose two different bookshops need to amalgamate because of the economic crisis. It is evident that carrying out their activities, they used a majority of documents, emails and databases where the relevant pieces of knowledge are described. In order to obtain their amalgamation, they need to re-accumulate the required information and create a new schema for describing it. As this is an anti-economic process, concerning time and effort, the proposed solution is to use ontologies in order to describe their products and business processes. As these companies have different conceptualizations of
the same domain of interest, the generated ontologies are heterogeneous, which means that the two knowledge representations use different concepts, relations and properties in order to semantically describe, for example, the instance of the `ontology_alignment_book` of the ontology of figure 1.

According to this scenario, we assume that one bookshop uses the book ontology of figure 1, while the other uses the product ontology of figure 2, which describes a `Book` as a `Product` which `hasTopic`, `hasId`, `hasPrice` and `isProducedBy` a `Company`.

**Figure 2: Another Book ontology**

![Ontology diagram](image)

Given the difficulties which arise in this scenario, the most convenient way is to exploit the ontology merging process, which is described in section 4, in order to successfully amalgamate the knowledge of the two companies, and, at the same time respecting knowledge economy.

3. Recycling knowledge through ontology evolution

Recycling knowledge is not based on the obsolete idea of reusing information but it stems from transforming implicit knowledge into explicit, by aligning previous information with new pieces of knowledge in a meaningful way. The variables that affect the recycling of knowledge are the previous knowledge schemes, the new information, the
means of links and the resulting conceptual model. In ontology terms, recycling knowledge means applying an ontology evolution process.

In our first scenario, in order for the services to be provided by the bookshop, the Book ontology must be kept up-to-date and evolve, for example, by adding the price of a book in another currency, different from the one already used.

Taking into account the assumptions of this scenario and the idea that ontologies are not static, as they are abstract views of domains of interest, there are several occasions which can make it necessary to change an ontology. Such occasions may be corrections in the conceptualization, adapting the ontology to changing facts in the current reality, etc.

To change or evolve an ontology is not an easy task, because one has to take into consideration all the possible effects a change may have on the components of an ontology [Yildiz: 2006]. The first step, in order to achieve ontology evolution, is the ontology alignment process, which is described in section 5.

4. Amalgamate knowledge through ontology merging

In the second scenario of business amalgamation, knowledge merging is the main notion to consider, it refers to the combination of distinct pieces of knowledge in order to form a new knowledge schema, which includes the complete set of knowledge associated with a specific domain of interest. In the case where pieces of knowledge are explicitly represented by ontologies, we tend to use the most appropriate ontology merging [Seremeti, Goumopoulos, Kameas: 2009].

Ontology merging means creating a new one from two or more ontologies. The newly created ontology unifies and replaces the original ones [de Bruijn, Martin-Recuerda, Manov, Ehrig: 2003]. The merged ontology can then be, either the union of all entities (classes, relations, properties, instances) from both source ontologies, or it consists of only the parts of the source ontologies that overlap. In this case, it is also necessary to, first of all, relate the ontologies, that is, specify how the entities in the different ontologies are linked in a logical sense. This can be achieved by the ontology alignment process.

5. Aligning knowledge as the first step

According to the above description, aligning knowledge is synonymous to aligning ontologies, as they are explicit representations of knowledge about a domain of interest, since aligning ontologies means bringing the ontologies into mutual agreement. In contrast to ontology merging, during the alignment, the source ontologies are kept unaltered and ready to be recycled repeatedly, as the aim of this process is to identify specific relations between individual elements of multiple ontologies.

Ontology alignment is described as follows: Given two ontologies, aligning one ontology with another one, means that for each entity (class, relation, property, or instance) in the first ontology, we try to find a corresponding entity that has the same intended meaning in the second one. An alignment therefore, is a one-to-one equality relation and, obviously, for some entities, no corresponding entity might exist [Ehrig: 2007].

Summing up all the above, alignment is a pre-step to detect the overlap of entities in the scenarios presented here. The following example illustrates the generated set of
correspondences, that is, the alignment between the Book ontologies, which cover the same domain but they are modeled in a heterogeneous way.

Figure 3: An alignment between the two ontologies

A critical issue in aligning ontologies is to find some entities of the source ontologies, which are semantically equivalent. In our example, Book of the first ontology is semantically equivalent with Volume of the second ontology. There are many techniques currently used for implementing the process of ontology alignment as well as many systems have been developed based on these techniques [Euzenat, Le Bach, Barrasa, Bouquet: 2004]. These techniques use either (a) lexical matchers, which try to analyze the labels used in each ontology, or (b) structural matchers, which examine the position of each entity within each ontology [Euzenat, Shvaiko: 2007], or (c) semantic matchers which use external knowledge sources, e.g. WordNet [Tongchim, Kruengkrai, Somlertlamvanich, Srichaivattana, Isahara: 2005], in order to find corresponding concepts.
There are also some techniques that use a parallel or a sequential execution of these matchers in order to produce semantically equivalent concepts between two or more source ontologies.

Thus, aligning knowledge is the fundamental point to consider when seeking knowledge economy. However, linking semantically two heterogeneous pieces of knowledge is an error prone process from the ontology point of view, because the same concept may have many different interpretations, or different concepts may have the same meaning. In NGEEs though that inherently exhibit intelligent behavior, trusted specialized agents are used for optimizing the management of the organizational knowledge, in order to overcome these discrepancies.

6. Conclusion

Contemporary manufacturing-based and service-based economies consist of tangible assets, whilst the future entrepreneurship innovation, as it comprises the most decisive factor in influencing an organization’s growth, will depend upon intellectual capital and, thus, the appropriate management of organizational knowledge is its fundamental building block. In that way knowledge economy may be safely transformed into economic growth.

The objectives of the approach presented here were to enable active (human beings), as well as passive (computer systems) participants of NGEEs to interrelate harmonically in a productive, meaningful and economical way. This can be considered in a theoretical way by recycling and merging knowledge. In practice, however, it can be achieved through the use of ontologies for explicitly representing knowledge, as well as ontology alignment process for appropriately combining the heterogeneous pieces of knowledge. In order to emphasize and demonstrate the importance of this approach, two examples -real scenarios- were demonstrated, describing the need for the optimum knowledge management, since as it is widely believed knowledge will be the basic economic resource in the post-crisis enterprise environments.

References


