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An Approach to Knowledge Management in Research Organization

Gubanov D.A.

Institute of Control Sciences RAS,
Moscow, Russian Federation, (e-mail: Dmitry-locke@mail.ru)}

Abstract: On the increase of uncertainty and in the absence of coordination it is getting more and more complicated for companies to work successfully. In this concern Knowledge Management is of great interest as effective solution to the problem of effective adaptation of research companies to constantly changing environment, where new knowledge development and training are key factors of success. It is necessary to develop Knowledge Management System architecture taking into account unpredictability of the situation: what kind of knowledge may be required and how it may be connected with the knowledge available. Semantic Web technology make it possible to attach a special meaning to the data and information, contribute to the implementation of semiautomatic and automatic processes for effective knowledge use, new knowledge output based on a situation context. Synergetic effect after implementation of knowledge available will be motivating researchers more and more to replenish it and work with it. At present knowledge management tools should be prepared.

1. INTRODUCTION

Under the transition to the economy based on knowledge, knowledge has become one of the most significant resources of an organization, influencing considerably the efficiency of its work and competitiveness. But in practice, however, much essential knowledge is not made known and is not spread even within the framework of a organization, and due to it a necessity appears to systematically and purposefully deal with all kinds of knowledge of the organization (explicit and tacit, personal and corporate etc.) and to establish a Knowledge Management System (KMS). Organization strategies on knowledge management should be mainly aiming at the provision and improvement of business process efficiency to synergically combine the potential of information technology for data and information processing and creative and innovational potential of people to provide adaptation, survival and competence of the organization facing constant change in the competitive environment. According to observations the following constituent parts to implement KMS in an organization exist (Stankosky M., 2005 and others): 1) Leadership (supports KM strategies and infrastructure, regulation processes and confirms KMS as one of the constituent parts of the research organization's future); 2) Business processes (arranged in due order to bind knowledge and knowledge processes to them so that under lack of knowledge to provide an easy access to them or to provide an opportunity for competent staff to establish them on their own…); 3) Culture (assists to expose implicit knowledge and encourages collaborative work and training allowing to generate new knowledge…); 4) Information technologies.

The authors of the given article have found very few works, particularly related to knowledge management in a research organization. A direction of search is to try to form/generate a framework (theory) of knowledge creation of a research organization, to create the complex architecture of information system based on this framework.

2. KNOWLEDGE MANAGEMENT AND RESEARCH ORGANIZATION

A research organization, as well as any another, has the same problems and, hence, necessity of knowledge management. In every research organization a continuous process of knowledge transformation is carried out.

An organization appears at a certain level of knowledge of its employees and leaders, and it functions by using and enriching scientific knowledge, being at the same time both a consumer and a source of this knowledge. One of the key factors influencing the work of the research organization, is a high level of uncertainty, thus there is a high demand for KMS. Another key feature is that out all of knowledge processes (creation, exchange), carried out in a research organization, the most important is the generation of knowledge. Therefore in our work we shall lay special emphasis on the support of KMS of the process of knowledge generation.

Let us consider the peculiarities of new knowledge generation process in a research organization.

Problem. In case scientists discover new experiment and observation results, the generation of the elicited scientific concepts or modification of the available ones, i.e. the revision of scientific concepts (Chalmers, A., 1991; Dunbar K., 1999) happens time- dependant through one of the following ways: 1) knowledge addition to the existing conceptual structure (no restructuring of the underlying representation of scientific knowledge is required); 2) radical conceptual change, it is required to acquire a new conceptual system to arrange knowledge through innovations.

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Hypothesis putting forward. As it is shown by psychological experimental data, hypothesis putting forward occurs during the process of scientific thinking, on the basic of inductive and deductive reasoning. When putting forward a hypothesis scientific thinking is guided by causal relations. If visual representation of different causal paths is a way to design an experiment and to predict possible results, than hypotheses are focused on analogies based on a number of relations, the essence of which to form image features (or the system of relations among features) of the source of the knowledge available on the target features so that new target features may be exposed. Or target features will be predetermined, a new scientific concept will be invented and a scientific discovery will be made. If should be mentioned that according to our data, when putting forward a hypothesis very often researchers pick up the most convenient one and ignore alternatives.

Test of Hypothesis. Test of hypothesis is an important component of any scientific research: it is an assessment of the proposition for conformance with the truth through experiments, observations, discussions etc. (principles are different, particularly, Popper's falsification of hypotheses.

It is obvious, that researches deal with conceptual system of the organization of scientific knowledge.

Research activity in any research organization should be considered from both ontological and epistemological point of view.

The ontological aspect means creation of scientific knowledge in the framework of "of interaction community", for example, of a scientific group, a laboratory, a scientific community. Without this is impossible to create knowledge within the organization.

Epistemological aspect means existence of explicit knowledge (rational, verbal, conscious) and tacit knowledge (nonverbal, such as experience, intuition, emotions).

During scientific discussions and debates, rationalization, understanding, intuitive inspirations (eureka) a spiral transition of knowledge from one to another within framework of scientific community occurs.

3. MODEL OF KNOWLEDGE REPRESENTATION IN A RESEARCH ORGANIZATION

According to Nonaka and Takeuchi (Nonaka, I., Takeuchi, H., 1997) the process of externalization, i.e. the transformation of knowledge from a tacit form into an explicit form, is one of the ways to generate new knowledge. That is why invention of a knowledge representation model convenient for knowledge transformation possessing a good expressive ability is a very significant task. However, a good model also contributes to other ways of knowledge generation: internalisation, combination, and indirectly to socialization.

One of the variants to represent knowledge we believe is the implementation of a semantic model, i.e. ontology, as its advantage is closeness to scientific thinking: presentation of scientific knowledge as concepts (Kuhn, T. S, 1996) and relations among them of various kinds (cause-effect including), resulting in knowledge generation. To begin with, its extensibility provides a basic ontology of the organization, which may be subsequently extended (if it does not run counter to the basic model), supplemented with their specific scientific picture of the world, and shared with their scientific group, community etc. (relations among different concepts, allow scientists of different academic disciplines to expand their own horizon of knowledge and see necessary close analogies to make a scientific discovery…

Besides, ontology, as our observations show, unities the work with different resources of the research organization (video, audio, documents, staff etc.). On this basis thanks to ontology a theorist may obtain data and knowledge verifying his hypothesis from the equipment of an experimenter-practitioner.

Therefore, the model of scientific knowledge representation should be formed on the basis of the concepts, relations and their instances. The basis to manage processes of creation and distribution of knowledge is the ontology of different levels making up a conceptual frame of research activity.

To provide a full and holistic knowledge representation of a research community we suggest the following ontology complex: a) scientific knowledge ontology, b) knowledge domain ontology, c) research organization ontology, d) research project ontology, e) person ontology (scientific community) f) event ontology, g) documentation ontology (Figure 1).

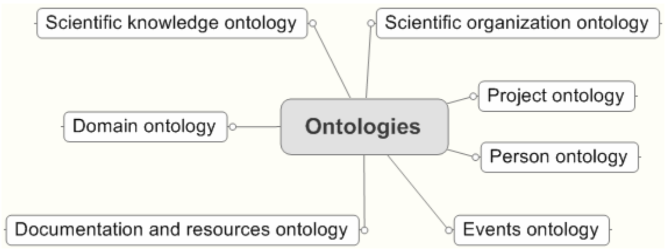

Figure 1. Common Ontology of Research Community Knowledge

The ontology of scientific knowledge also includes classes of concepts with the semantic relations set on them (Section of science, Mathematical theory, Applied theory, Theory structure, Model, A problem…). At present examples of this type of ontology are unknown to the authors.

4. IT-APPROACH

We believe that the most perspective for us is the concept of the unified information architecture based on the knowledge. This system should contain the research organization distributed knowledge base and scientific services. Such services will allow to work with the knowledge base, and the clients can independently carry out the search and form individual collections of the information, etc. Here are the scientific services determined by us: 1) the organization of joint research projects, relations between researchers, scientific groups, and scientific organizations; 2) integration of scientific knowledge (all kinds of knowledge from different sources); 3) search of knowledge and a conclusion on the basis of the metadata; 4) documents management on the basis of semantics; 5) arrangement of automatic work performance on the basis of a semantic link of actions sequence included in this work (not only extraction of available knowledge and data). The actions are performed by the distributed network services advertising their services.

The given work introduces an information model and architecture of information support system of KM in a research organization. It should be noted that a semantic approach to such an architecture is based on the implementation of the interconnected set of methods and techniques dealing with the sense of information (domain ontology, technologies of their construction and maintenance, semantic metadata, semantic search, logical inference systems, semantic shaping of expert knowledge, semantic portals and nets). On the basis of the above mentioned ontology complex we believe it becomes possible to design a wide range of informational structures (a research community, a research organization), depending on the problems set and their scale (Figure 2)

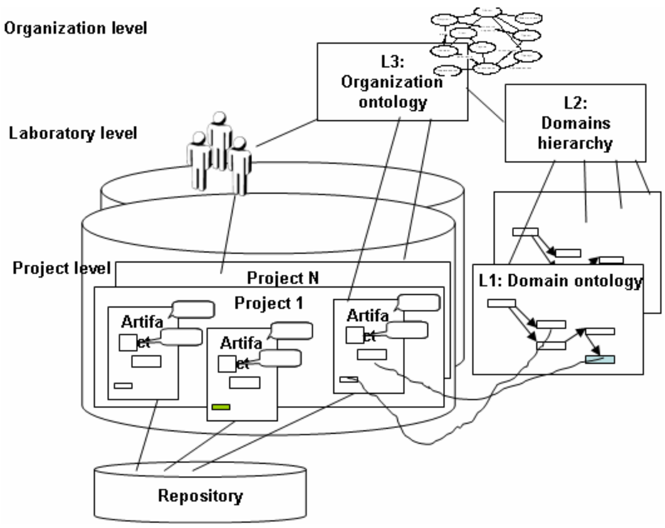

Figure 2. Example of information structure of a Research Organization using some kinds of the ontology considered.

5. SCIENTIFIC ENVIRONMENT IN WEB

Ontology makes it possible to provide search, distribution and creation of knowledge in the Internet in heterogeneous systems and remote communities. Semantic Web technologies provide a computer with an opportunity to interpret information in Web on the basis of the ontology given by users (Tim Berners-Lee et al, 2001; W3C, 2004; Franz Baader et al, 2003). The offered concept scheme of the network environment intended for scientific research support is based on representation of the Internet as a global data base. Its architecture consists of OWL-DL ontology servers; conventional and semantic WEB-services providing support for scientific and research activity; intelligent agents for interaction, customer application and information resources (Figure 3).

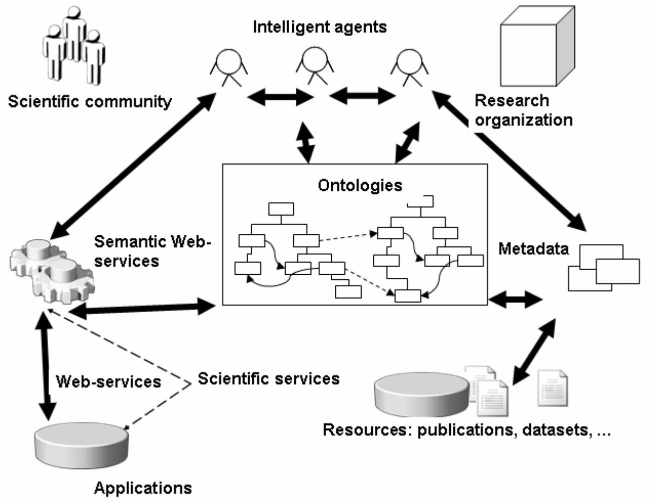

Figure 3. General architecture of network environment to support scientific research.

Ontology servers are used to store ontology providing its integrity and consistency. Personal services, virtual laboratory and project management services, community services, inference and reasoning services and others may be used as support services. It should be also noted that in the given situations a considerable part is played by intelligent agents which serve a common purpose by means of communication and interrelation, cooperating with each other.

Typical architecture of the network environment Thesus

For network environment implementation to support KM academic open-source products, such as Protégé-OWL, may be used. However, such systems are not stable, as a rule, and their development is unpredictable. Besides, it is often required to implement another functional or to be adapted to a concrete field. That is why our own architecture based on the libraries of Jena, Pellet and some others was developed.

Thesus provides divisible information repository based on ontology, to which there is an access for all the members of a scientific community in WWW. It serves to gather, to search for, to create and to modify knowledge such as knowledge on scientific models, research project etc. Support of explicit links presenting semantic relations among stored information resources makes it possible for users to monitor and arrange interconnected fragments of scientific data, i.e. it contributes to the integration, coordination, work of the whole variety of scientific source data (notes, emails, text documents, multiformat data and image data etc.), created and stored by different means in remote district.

Thesus unites basic elements present in numerous types of knowledge management systems and adds new ones. These elements include management system of scientific models, bibliography management, semantically loaded document-sharing systems to deal with documents, stored in the central file server, electronic pads replacing scientific and engineering organizer, laboratory information management systems, which store information on laboratory samples, test results including, personal information management systems, which arrange and store personal contacts, meetings, notes, emails, and notes for PC and PDA of users, scientific project management systems, to which users may download information on research projects from local PCs, and after the accomplishment of the project research data may be stored as durable archive for future researchers.

The major goal of Thesus is to focus the attention of a researcher on potentially important information (taking into account a concrete context) necessary to conduct research.

Thesus architecture consists of several levels (conventionally defined by us): Thesus server, scientific environment services, ontological repository and database, client application (Figure 4)

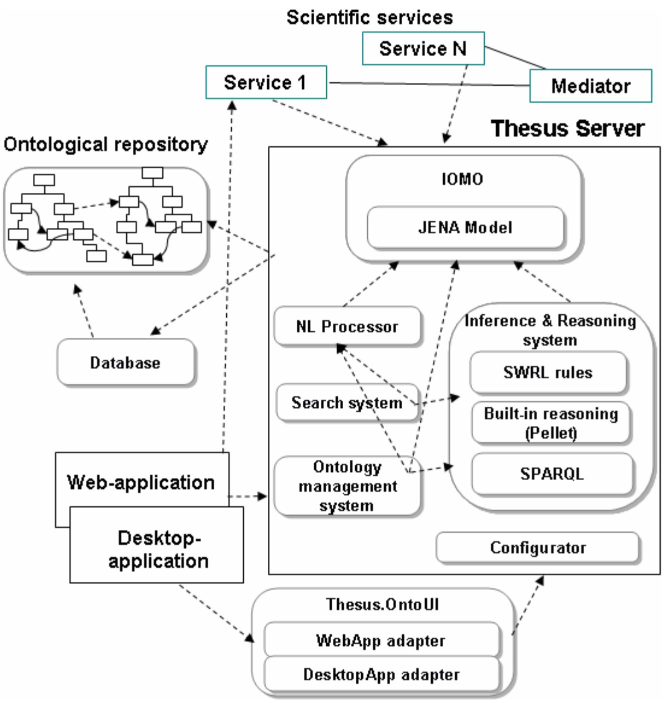

Figure 4. Thesus architecture

Thesus Server. Thesus Server is the central part in the architecture. It is launched on the server machine and usually is in the active state. Its constituent parts are; 1) internal object model IOMO (it encapsulates Jena model aiming at its extension and adaptation); 2) inference and reasoning system (it uses Pellet, SWRL-rules and SPARQL-constructions to infer semantic relations and to check their correctness); at reasoning mathematical apparatus of description logic is used; 3) natural language (NL) translator (it is used for interaction with the user on the subset of the natural language; a subset of the natural language consists of keywords, conceptual dictionary; the translator analyzes requests, using formal grammar, transforms them into internal structure of IOMO; 4) search system (carries out knowledge search on the user request in NL, returns the results obtained in accordance with the relevance; 5) ontology modification system (if necessary a user may modify ontology or its part according to the given rights); 6) configurator fulfils adjustment of the server, in particular, URI server of ontology and data, role privileges, connections among system modules etc.

Thesus. OntoUI component library provides special components to work with IOMO model (dialog windows, taxonomy trees etc.) The library is intended for rapid development of client applications, both Web-application and Desktop applications (corresponding adapters are used for adaptation, for instance, Thesus.WebAjaxAdapter)

Thesus application. Typical client application is mainly for graphical interface and simple logic for interaction (in general for the application development it is necessary to have a server object and Thesus.OntoUI library, and for functionality rise there may be used scientific environment services).

6. CONCLUSIONS

Services and applications of network environment developed by us to support scientific research may be included into the set of instruments of a researcher, and, consequently contribute to the process of new knowledge generation and work effectiveness of a researcher both at individual and at team work. In the sequel, it is expected to implement services of a scientific community according to the introduced information model and architecture.

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