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Semantic Innovation Management

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ABSTRACT

Innovation within industrial environment can be viewed as a cyclic loop consisting of four distinct phases, i.e., recognition, initiation, implementation, and stabilization. Different information technology enabled innovation management tools supporting the lifecycle of innovation are classified as five layers, i.e., individual innovation, project innovation, collaborative innovation, distributed innovation, and semantic innovation. According the fact that the current state is evolving from distributed innovation to semantic innovation, this paper focus on the realization of Semantic Web technologies enabled semantic innovation. To explicitly and formally specify all the different perspectives of innovation related information, a shared ontology is proposed as the common language of innovation management, which describes the critical and minimal information about the innovation process in a holistic way. Then, a technical framework which employs the machine readable innovation ontology to actually improve innovation management inside an organization and among loosely coupled organizations is presented. Finally, some features of the semantic innovation are discussed.

Keywords: Innovation management, Semantic Web, Innovation ontology, Goals collaboration

1. INTRODUCTION

Innovation [1] is "the process of making changes in something established by introducing something new", which can be viewed as a cyclic loop consisting of four distinct phases, i.e., recognition, initiation, implementation, and stabilization. Within a typical organisation, there are various degrees of innovation from simply suggesting ideas or managing a single project to managing an entire programme of change comprising various performance indicators and portfolios of projects. To support the lifecycle of innovation, different innovation management tools or tool families have been developed. Conceptually, they can be classified as five layers, i.e., individual innovation, project innovation, collaborative innovation, distributed innovation, and semantic innovation.

Individual innovation concentrates on the development of effective ways to enhance creative potential for individual work. There are many tools or techniques available (e.g., mind mapping, brainstorming, cause-effect diagrams, Delphi forecasting) to support individuals and small groups engaged in single innovation tasks such as problem solving and idea generation. Project innovation concerns about the systematic techniques that support the change manage of project teams in a distributed asynchronous environment. This area is currently saturated with various software tools that support distributed project management and information sharing between distributed individual or small groups in a project teams. However, very few tools explicitly link project actions (e.g. tasks) with project goals. Collaborative innovation focuses on the change management among a large group of individuals within a whole organisational unit and where there is typically a portfolio of projects (rather than one single project). In this type of innovation, the organizational unit will also typically have multiple goals such as a strategic plan, group of performance indicators or international standard, and the goals of the organization unit replace project goals. Current research focuses on the development of structured collaboration environments, and the entire system is designed to be used collaboratively by every user of the system to gather information and update their own contributions to their community. Distributed innovation is innovation across a particular intranet within an organizations supply chain and even a specific virtual team. This level of innovation is defined by all of the 'collaborative', 'project' and 'individual' innovations, taking place lower in the innovation hierarchy. The tools required for distributed innovation, which build mostly on portal servers (e.g., Sharepoint, Lotus Notes, and Plumtree), are in their infancy. Principal design features include enterprise wide search and navigation, user personalisation, integration and content management, notifications (push technologies), workflow, and application integration to other information sources. Since current state of the art is manual browsing, a well designed collaboration/management structure is necessary to allow any individual easy access to the information that they are looking for.

The generation of semantic innovation is derived by the emerging semantic web technology. According to Tim Berners-Lee [2], the Semantic Web can be envisioned as an extension of the current web, which makes the web more understandable to computer programs, and then allows data to be shared and reused across application, enterprise, and community boundaries easily. The original intention the proposition of semantic innovation is to exploit the potential of semantic web technology to improve the effectiveness and efficiency of innovation

management in the large networked organization.

2. INNOVATION ONTOLOGY

An ontology [3] is a general conceptualization of a specific domain in a both human and machine understandable format. In general, it consists of classes, properties, relationships, and axioms. As the backbone technology for the Semantic Web, ontology promise a share and common understanding of a domain that can be communicated between people and application.

To realize semantic innovation, it is necessary (as the prerequisite) to build a formally and explicitly expressed conceptual framework (i.e. ontology) about innovation related information. It should include all the necessary information for innovation management to facilitate the collaboration and innovation management in a networked organization and provide the conceptual underpinning for making the semantics of innovation related metadata machine interpretable.

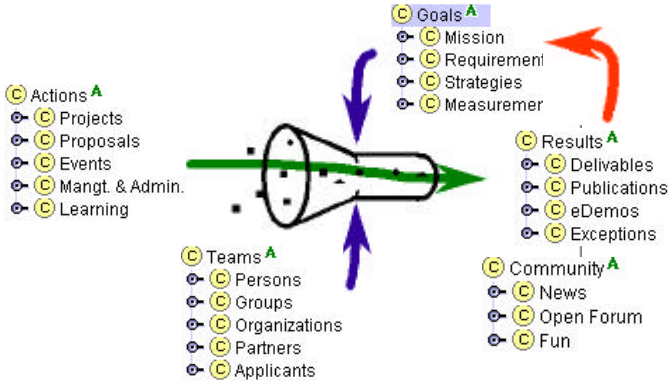

Figure 1. Conceptual Framework for Innovation Management

Considering the fact that different organizations have different concepts and relationships of their work activities and context, but on the other hand they all have a set of innovation related information for their very own, local (private) and shared (public) ontologies are distinguished here. The semantics of an organization's specific working context is captured by its local or private ontology which serves the problem solving purposes (particularly in communication and information exchanges) of this organization. A public or shared ontology are used to articulate the intersectional semantics about a common subject (or domain) which need to be shared and communicated across multiple local contexts. The main role of shared ontology is to support the common subject related interoperation across multiple organizations. Obviously, the ontology we try to build here is a shared ontology and the common subject refers to innovation management.

Since innovation can be visualised as the interaction of various types of information and in particular the organisations Goals, Actions, Teams and Results. The ontology for innovation management derived from the iTeam methodology [4] includes five correlated concepts or classes as shown in Fig. 1.

In this innovation management oriented ontology, all the information about innovation management is classified as five categories and specified as five abstract classes, i.e., Goals, Actions, Teams, Results, Learning, and Community. Goals are defined as the objectives of a networked organization's effort. It can be embodied as Mission, Requirements, Strategies, and Measurements. Obviously, these four subclass are closely relevant each other. For example, the performance indicators of the Measurements are the quantitative estimation of the Strategies. Actions are defined as expenditure of the effort to achieve the goals, which are materialized as Calls, Proposals, Projects, Events, Learning. To realize the alignment of goals and actions, the concept of Goals should be linked with the concept of Actions. For example, a projects is aligned with which strategies and how to measure the performance of the project. Teams describe the human elements of the organization that interact within the innovation process and permit the effective management of their involvement. It includes five subclasss, i.e., Persons, Groups, Organizations, Partners, and Applicants. All individuals should be linked to the goals of the development process through an inbuilt performance appraisal system. In fact, most parts of the Teams classes are inherited form FOAF and extend FOAF with innovation related information, such is each person or organization has a property representing his/its goal. Results specify the extensive yet concise reporting of outcome for all goals and actions, which are refined as for subclasses, i.e., Publication, eDemos, Deliverables, and Exceptions. The results area deploys effective management techniques such as the 'traffic lights' metaphor and control charts that allow results to float within predefined limits before they attract attention. Community provides team members with different collaboration spaces for their different interest. Currently, it is divided into News, Fun, and Open Forum, which are necessary supporting tools for goals directed collaboration.

Using a same conceptual framework to formally specify different perspectives of innovation related information extracted from different specific organization context, the innovation ontology can serve as the common language to describe the critical and minimal information about the innovation process in a holistic way. It is independent of the specific work context whichever the corresponding organization resides in and can be constructed from scratch or by composing selected parts of existing ontologies in the networked organization.

It is generally accepted that it is impossible to achieve a comprehensive and globally consistent ontology about the world [3]. In fact, it is even difficult to build a generally accepted ontology about a specific domain. The innovation ontology built here is mainly suitable for

semantic innovation of a research institute. But it can easily be adapted to the semantic innovation of other kinds of organization or other levels (e.g., 'collaborative', 'project', and 'individual' innovations) in the innovation hierarchy.

The ontology in which information is given well-defined meaning and accessible to potential semantic web applications will enable computers and people to work cooperatively and efficiently in the innovation process. It also serves as the base for the design and implementation of specific tools or application for semantic innovation management.

3. A FRAMEWORK FOR SEMANTIC INNOVATION

Creating such an ontology– a consensual understanding of the key terms used in innovation management is only the first step to realize semantic innovation management. How to employ the machine readable metadata to actually improve innovation management inside an organization and collaboration among loosely coupled organizations is the next step to be considered. A framework for exploiting the potential of semantic web technology to improve the flow of innovation process is proposed as Fig. 2.

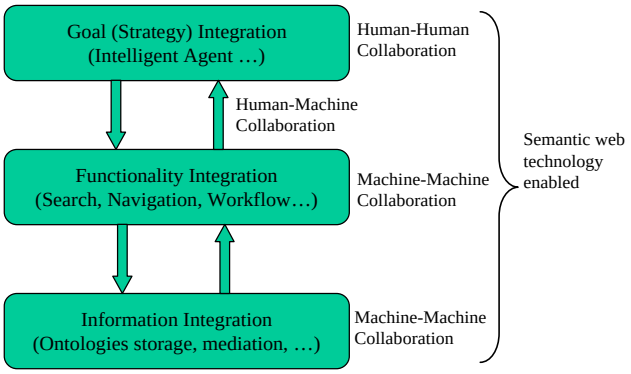

Figure 2. A General Framework for Semantic Innovation

The technical framework for semantic innovation includes three levels, i.e., information, functionality and goal (strategy) integrations. Ontology-based information integration is the foundation of the semantic innovation. Relevant information about innovation management are marked up using innovation ontology, then semantic web based application existing in the level of functionality integration can better understand the semantics and therefore more intelligently locate and integrate data for a wide variety of organizations or projects. Through ontologies storage, mediation, evolution management, it facilitates the smooth flow of relevant information among different involved parts of innovation process. To use the machine accessible information model to realize semantic innovation management needs specific application (e.g., semantic inference, context aware search and navigation, workflow management, and so on) that allow 'machine-machine' interrogation and interpretation of innovation related data. That is what function integration level cares about.

It employed the integrated semantic information to enable the different functionalities and their interoperation required by corresponding innovation process. To encourage the different levels members (individual, project, an organization) to participate in the interactive innovation process, the prerequisite is that there are shared goals or interdependent goals existing in these members. The high level goal integration is the guarantee for the realization of low level information and functionality integration. The goals alignment in distributed innovation is conducted by the human intuitively and manually. However, in the semantic innovation process, intelligent agents specified in terms of the respective goals and obligations are employed as representative of corresponding master (an individual, a project, or an organization) to cooperate with one another to realize goal directed collaboration.

Obviously, goal integration corresponds to human-human collaboration, functionality and information integrations correspond to machine-machine collaboration. The interaction between goal and functionality corresponds to human-machine collaboration. Obviously, the ultimate goal is to improve goal integration by effective and efficient machine-machine collaboration.

3.1 Interface

According to [2, 5], the integration of agent technology and ontologies could significantly affect the use of Web services and the ability to extend programs to perform tasks for users more efficiently and with less human intervention. Agent is naturally selected as the interface for the human-human and human-machine collaboration in semantic innovation process (In fact, software agent is also the generally accepted user interface of Semantic Web). The effectiveness of such software agents will increase exponentially as more machine-readable Web content and automated services (including other agents) become available. In the scenario of semantic innovation, different intelligent software agents work together in anticipating user's information requirements and thus avoid manual browsing for common information gathering tasks. The shared ontology allows for the development of search tools and intelligent agents that can automatically find any information requested by the user and thus avoid inefficient or manual 'surfing'. With semantic innovation any user will have instant access to all of the innovation going on anywhere within the organisation, regardless of language, structure, or location of the information. These semantically rich applications will be capable of real-time event monitoring and handling alerts, ensuring the stakeholder is constantly engaged and provided with priority data.

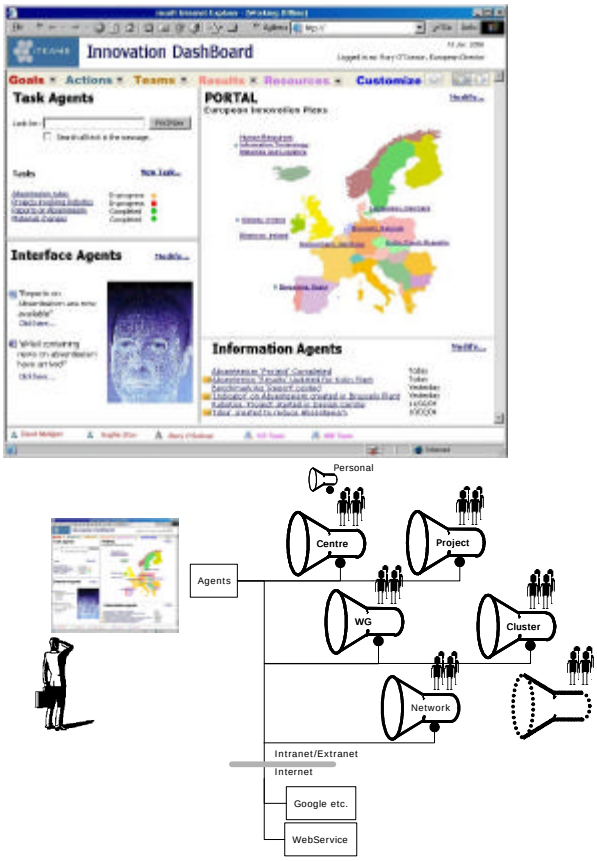

Figure 3. Interface of Semantic Innovation Management

Figure 3 presents a schematic representation of semantic innovation. The user has available to him or her a wide range of innovation funnels – some dealing with product innovation, others based on individual projects and others perhaps for the specific development plans of the corporation. In this vision a number of software agents are deployed across the corporations intranet to communicate with each other regarding the exchange and sharing of innovation information. Interface agents will monitor and track the information needs of the user.

3.2 Semantic Inference

The explicit description of innovation related information makes their formal analysis (e.g., goals or goal-action matching among different part of an organization, detecting partially defined and possibly inconsistent goals, actions, or the relationships between them) feasible, which will reduce the human intervention in distributed innovation management. Ontology inference or reasoning, which can improve the efficiency of query and processing of innovation related instance data, will play the role in realizing the alignment analysis among different goals, actions, and results existing in different organizations, projects, and even individuals. Until now, several semantic specification languages, such as RDF [6], DAML+OIL [7], and OWL [8], have been proposed for semantic web. Correspondingly, inference systems for semantic innovation can adopt Description Logic [9], F-Logic [10], or Horn Logic [11] as its theoretic foundation for the reasoning of innovation related information.

3.3 Semantic Mediation

According to the fact that different organization or project contexts can make statements about the same innovation process using different language, semantic mediation which can make use of concepts and relations defined elsewhere and facilitate the interaction between shared ontologies and different local ontologies is another technical pillar for semantic innovation. Semantic mediation [12] includes ontology consolidation, ontology mapping and alignment. Through ontology consolidation, different parts of a local or several local ontologies are merged as a new shared ontology supporting a specific domain or topic (e.g., innovation management) oriented collaboration. Ontology mapping and alignment allow different terminologies and modelling styles are linked together by creating bridges between separated pieces of knowledge in some domain specific ontologies. These consolidated ontology and the bridges along with domain specific ontologies are then used to perform cross contexts innovation related information search and retrieval (with the ability to query different information sources with different kinds of semantics).

4. SEMANTIC FEATURES

The semantic web is about adding machine-processable semantics to data. The computer can “understand” the information and therefore process it on behave of the human user. Semantic innovation employs the semantic related technologies to improve the collaboration capability inside or across a networked organization. Every organization or individual use the innovation ontology to describe themselves and published in the trust worthy semantic web. This allows software to process these descriptions, perhaps as part of an automated search engine, to discover information about your and the communities of which you're a member. Semantic innovation has following features:

Goal directed: In the networked organization, different individuals, projects, or department have different goals. To reduce the uncertainty that exists in the networked organization, the innovation ontology gives an explicit and formal specification of the goals in terms of its mission, requirements, strategies and performance indicators. Then the process of formulating goals that reflect a holistic perspective of the organization and horizontal goals matching are done through the supporting of intelligent agent. It allows the organization overall direction to be communicated to not only the human but also the application or machine and empowers them to participate in the innovation process, which assure the high level alignment among these different but overlapping goals.

Action based: Innovation process can be looked on as

the temporal sequence of activities or events that occur in developing and implementing new ideas. To support the correct flow of actions through the various stage-gates of the innovation process, innovation ontologies based semantic mediation and inference are employed in the semantic innovation to ensure a low level consistency within the decision making (about plans and their execution) over time. Ontology-based context aware application is implemented to support the decision-making process concerning selection of actions or plans for projects execution.

Team centered: On the one hand, employee of the networked organization are provided functionality by ontology enabled intelligent agent to capture minimum critical information relating to innovation. On the other hand, the innovation process requires much creativity, problem solving and teamwork, which require a diverse skill base hence any management practice. Each action of the innovation process must have an efficient number of personnel (with corresponding knowledge and skills) assigned to them with a leader being ultimately responsible for action achievement. Inheriting from the class "Agent" of FOAF ontology and extending the attributes of its "Person" class with relevant information of innovation management, the individual member in the networked organization is described in terms of role (academic, engineer or manager), task description (which person is responsible for which goal or action), core competency (knowledge &r skills), and relevant area of the task in the innovation process. Through the ontology inference and mediation, semantic matching is realized among goal, capability requirement of action execution, as well as role and the expertise.

Result oriented: The reporting of outcome for all goals and actions are specified extensively and concisely in the innovation ontology, which facilitate the agent which represents corresponding responsible manager to identify all the actions and goals that require immediate attention due to their red status.

5. CONCLUSION

Business competitiveness and sustainability depends on the effective management of innovation. Effective innovation needs to take place within every area of an organisation and by association within key suppliers and strategic partners. Since Semantic Web promises a vision to make information and knowledge machine accessible in the Web rather than displaying them for interpretation by human, a vision of semantic innovation, which exploits the potential of Semantic Web technologies, is presented in this paper to improve effectiveness and efficiency of innovation management in a large networked organization. Several pillar technologies enabling semantic innovation is discussed. Of course, to actually implement semantic innovation, many other Semantic Web related technologies are also needed to be considered, such as ontology editing, ontology evolving management, semantic annotation, semantic web services, and so on. Until now some of these related technologies are still in their infant stages, more work needs to be done before this semantic innovation vision comes true.

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