Chapter 1

REAL WORLD APPLICATIONS OF SEMANTIC WEB TECHNOLOGY AND ONTOLOGIES

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1. THE EARLY SEMANTIC WEB

The original idea of the Semantic Web was to bring machine-readable descriptions to the data and documents already on the Web, in order to improve search and data usage. The Web was, and in most cases it still is, a vast set of static and dynamically generated Web pages linked together. Pages are written in HTML (Hyper Text Markup Language), a language that is useful for publishing information intended only for human consumption. Humans can read Web pages and understand them, but the inherent meaning is not available in a way that allows interpretation by computers.

The Semantic Web aims at defining ways to allow Web information to be used by computers not only for display purposes, but also for interoperability and integration between systems and applications. One way to enable machine-to-machine exchange and automated processing is to provide the information in such a way that computers can understand it. To give meaning to Web information, new standards and languages are being investigated and developed. Well-known examples include the Resource Description Framework (RDF) (RDF 2002) and the Web Ontology Language (OWL) (OWL 2004). The descriptive information made available by these languages allows characterizing individually and precisely the type of resources in the Web and the relationships between resources.

Today, the Semantic Web is not only about increasing the expressiveness of Web information to enable the automatic or semiautomatic processing of Web resources and Web pages. Academia and industry have realized that the Semantic Web can facilitate the integration and interoperability of intra- and inter-business processes and systems, as well as enable the creation of global infrastructures for sharing documents and data, make searching and reusing information easier.

Figure 3-1 illustrates the various tasks for which semantic technologies can be used. We can see that semantics can help not only system (semantic machine interface), but also human integration and interoperability (human machine interface). In both cases, semantic functions can be used to discover, acquire and create semantic metadata and provision, present, communicate, and act using semantics.

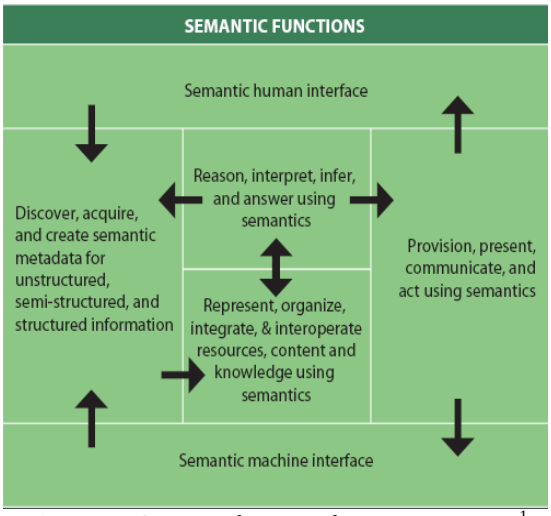

Figure 1-1. Semantic functions for inter-enterprises[1]

2. ONTOLOGIES: THE CORNERSTONE OF THE SEMANTIC WEB

The Semantic Web relies on the theoretical research done in the context of ontologies as a formal support for communication between agents and for the exchange of knowledge representations. Ontology-based human communication aims at reducing and eliminating terminological and

[1] Source: TopQuandrant

conceptual confusion by defining a shared understanding, that is, a unifying framework enabling communication and cooperation amongst people in reaching better inter-enterprise organization. Presently, one of the most important roles an ontology plays in communication is that it provides unambiguous definitions for terms used in a software system, but they can also support communication, coordination, and cooperation between human actors.

The use of ontologies for improving communication has already had been shown to work in practice. Interesting examples of successful ontologies include the Disease Ontology[2] (a hierarchical and controlled vocabulary for human disease representation), the FAO[3] (Food and Agriculture Organization of the United Nations) – which is committed to help information dissemination by providing consistent access to information for the community of people and organizations – and the Open EDI ontology[4] which defines the ontology for data management and interchange between enterprises. Other well-known and successful ready-to-use ontologies that have been developed include: CYC upper ontology[5], LinkBase[6], Towntology project, DAML ontology library[7], Ontolingua[8], OWL ontology library[9], Kactus library[10], and eClassOWL[11].

The most referred-to definition for ontology is given by Gruber (Gruber 1993), describing an ontology as an explicit specification of conceptualization. Explicit means that it cannot be implicitly assumed and should be processable by machines. This definition has been criticized by Guarino (Guarino 1998). After examining many possible interpretations of ontology, Guarino concluded that an ontology describes a hierarchy of concepts related by subsumption relationships; in more sophisticated cases, suitable axioms are added in order to express other relationships between concepts and to constrain their intended interpretation.

The effort of the Semantic Web community to apply semantic techniques in open, distributed and heterogeneous Web environments are beginning to pay off. Not only is the number of developed ontologies increasing, dramatically but also the way that ontologies are published and used has

[2] http://diseaseontology.sourceforge.net
[3] http://www.fao.org/agris/aos/
[4] http://www.jtc1sc32.org/, known as ISO/IEC JTC 1/SC 32
[5] http://www.opencyc.org/
[6] http://www.landcglobal.com/pages/linkbase.php
[7] http://www.daml.org/ontologies/
[8] http://www.ksl.stanford.edu/software/ontolingua/
[9] http://protege.stanford.edu/plugins/owl/owl-library/index.html
[10] http://web.swi.psy.uva.nl/projects/NewKACTUS/library/library.html
[11] http://www.heppnetz.de/eclassowl/

changed. We see a shift away from the first generation Semantic Web applications towards a new generation of applications, designed to exploit large amounts of heterogeneous semantic markup.

3. CHALLENGES FOR A NEW SEMANTIC WORLD

As every technological evolution, Semantic Web and ontologies need to promote their unique value proposition for specific target groups in order to achieve adoption. A common pitfall made in the studies of Semantic Web is the limited focus on "technological perspectives" or in the other extreme the difficulty to communicate the underlying capacity of semantics and Ontologies to meet critical real world challenges. An interesting starting point of analysis, which justifies also the contribution of this edition, relates with some of the characteristics of our world and society.

3.1 Characteristics of a new world

We live in a world where information and knowledge are considered to be key enablers of business and economic performance and critical pillars of sustainable development. At global level the following are some of the characteristics of the new world context:

- **Globalization**: Creation and consumption of knowledge and information are made in the global context. From this perspective the elimination of local boundaries and the exploitation of synergies and capacities beyond local boundaries require advanced adoption mechanisms that permit realization of opportunities, deep understanding of threats and strategic fit to human and social networks towards new levels of performance.
- **Networking**: In our era, business and economic activities as well as competition require new models of business networking. Within this context, advanced documentation of skills, competencies, business models and context based collaboration define new demands for advanced business and social networking at global level.
- **Shared Models**: A global consensus towards peace, development, prosperity and a better world needs to be based on shared conceptual models that define the average common understanding of human societies for the "issues" that matters at global scale. And while this can be perceived as a "too optimistic" scenario or it can be characterized as wishful thinking case, in the Global information Landscape shared models are required for interoperability, exploitation of synergies and definition of new milestones for collective intelligence.

- **Collective Intelligence**: The increased capacities of networking as a result of globalization and widespread adoption of share models has resulted to the development of a global trend to applying collective intelligence filters or collaborative filtering in the context of the global information world. Such development challenges many traditional models of business performance, marketing and profitability.
- **Open Paradigm:** This is a key new characteristic of our world. Open paradigm relates with several complementary movements, like the ones of open source software paradigm, open content, open access, open knowledge, open research, open culture. The underlying idea has an amazing capacity to support new business models and several applications in the short and long term horizon.

3.2 Challenges for Semantic Web applications

The previous list of the characteristics of the modern world provides the "playground" for the Semantic Web based applications. Globalization, networking, share models, collective intelligence, open paradigm are only a few of the silver bullets for the exploitation of Semantic Web technologies. In the next list we summarize a selective list of challenges for Semantic Web applications in close relevance to the previous discussion:

- **Definition of new modes for human, knowledge and business networking beyond local boundaries**: Traditional business and knowledge networking emphasized on a narrow perspective for the ultimate objective of networking. Semantic Web through Ontologies and Social networks anchors networking to well-defined conceptual models that match information sources and human services. By providing an infrastructure of shared semantics and Ontologies where reasoning and trust are "process and service oriented", we have a great opportunity at business level.
- **Globalizing information and definition of new Contexts for value exploitation**: The provision of local information assets at global level and the design of new contexts for exploitation are for the Semantic Web two of the key value proposition. The design of multiple reference levels to the same set of information and knowledge delivers a new level for dynamic, personalized systems.
- **Delivering and integrating quality to information**: One of the main obstacles in the current web relates with a very limited performance on the quality assessment of content. It seems that we suffer from an enormous explosion of content diffusion and a very poor performance on capacities to explore qualitative information. And

while information quality is a very subjective concept, the same moment businesses and people as customers, citizens, patients, learners, professionals, etc require systems and infrastructures that deliver assessment models of information quality.

- **Integration of isolated information assets**: In any context, personal, organizational or global the integration of isolated information is a key challenge. The "value" related with integration is always related with the inquiry. In simple words integration has always a very concrete "gap" component. Individuals, Organizations, society require integration for addressing specific performance gaps that relate with limited capacity to build more meaningful services.
- **Support of business value and co-located/distributed business models**: It is obvious that Semantic Web evolution requires the adoption from industry. This critical milestone implies that Semantic Web technologies can integrated to the business models of modern organizations and businesses. As always such a requirement challenges the strategic fit of technologies to business perspectives. From a business strategy point of view there is a key demand to "translate" the key aspects of Semantic Web technologies to business terminology. Semantics, ontologies, resource description frameworks, etc, means nothing to business people that have an absolute different way to interpret business requirements.
- **Promotion of a critical shift in humans understanding and interacting with digital world**: Semantic Web needs to respond to the great demand of humans to explore new modes of interactivity with the digital world. And it is obvious that people prefer to behave with similar conscious and intelligent mechanisms. The soonest the Semantic Web will prove its capacity to provide these intelligent mechanisms the greatest its adoption and support at global level.

4. THE IMPORTANCE OF SEMANTICS FOR ORGANIZATIONS

Today, integration is a top priority for many European and worldwide enterprises. The European community alone is investing, through the Seventh Framework Program, more that €200 million on research involving inter-enterprise interoperability and semantics. Most organizations have already realized that the use of Semantic Web technologies is a promising candidate solution to support cross-organizational cooperation for SME that operate in dynamically changing work environments. Semantic Web technologies are more and more considered as a key technology to resolve

the problems of interoperability and integration within the heterogeneous world of ubiquitously interconnected systems with respect to the nature of components, standards, data formats, protocols, etc. Moreover, we also believe that Semantic Web technologies can facilitate not only the discovery of heterogeneous components and data integration, but also the communication between individuals.

Semantic inter-enterprise interoperability is the key for the implementation of the idea of a knowledge-based economy where networks of enterprises (and SME in particular) can gain advantages from the peculiarities of the productive European fabric (many small companies, highly specialized, closely connected with each other, highly flexible thanks to the diffusion of knowledge and very skilled people in the whole fabric). The world-class competitiveness of enterprises strongly depends, in the future, on their ability to rapidly set-up, and maintain, virtual, networked enterprise structures. Novel technologies for interoperability within and between enterprises need to emerge to radically solve a problem that has not been sufficiently addressed by the research community before. In fact, managing the semantics of business-to-business interaction may be the most challenging task in integrated e-business value chains, and there is more and more evidence that Semantic Web technology has the potential to actually mitigate such problems.

4.1 Ontology management Systems

In the previous section, we saw that ontologies are the latest technological innovation that can enable inter-enterprises to establish dynamic working networks. Therefore, to provide a holistic management, there is the need to support the entire lifecycle of inter-enterprise ontologies, including ontology creation, storage, search, query, reuse, maintenance, and integration (Li, Thompson et al. 2003).

Modern organizations are realizing that shared ontologies and understanding is fundamental to create the next generation of networked inter- and intra-enterprises (Wache, Voegele et al. 2001). Shared understanding is a basis for communication, coordination, and collaboration between people and interoperability between systems (Vernadat 1993). It should be clear to the reader that interoperability is not only a concern for software applications and hardware platforms but also for human resource enterprise (i.e., employees, managers, and individuals in general).

In the near future, an increasing range of inter-enterprise applications will be requiring an Ontology Management System (OMS) that helps externalize ontological information for a variety of purposes in a declarative way. Such

management systems provide ontology independence to applications and people in a similar way that database management systems provide data independence. The primary objective of an OMS is to provide a full and efficient control over management activities for ontological information by externalizing them from application programs. One of the pragmatic challenges for ontology management system research is how to create the missing technology pieces, and to engineer them with existing results from prior research work to provide for a holistic management system (Harrison and Chan 2005).

OMS needs to address a wide range of problems: ontology models, ontology base design, query languages, programming interfaces, query processing and optimization, federation of knowledge sources, caching and indexing, transaction support, distributed system support, and security support, to name a few (Lee and Goodwin 2005). An inter-enterprise ontology management system provides a mechanism to deal with ontological information at an appropriate level of abstraction. By using programming interfaces and query languages the ontology management system provides application programs, can manipulate and query ontologies without the need to know their details or reimplement the semantics of standard ontology languages.

4.2 Challenge

Networked enterprises made available a wealth of information to many people worldwide: blogs, wikis, web sites, collaborative and social networks, etc. This has unleashed numerous resources and possibilities. Since the volume of information that is being generated and made available is overwhelming, current software systems are not prepared to deal with this. Nowadays, enterprises have been unprepared for environments where so much information is being generated every year. Since business success often depends on decision makers having timely access to the right information and knowledge (Vernadat 1993), the need arises for systems that are able to provide this knowledge. It is our firm belief that given the growing role of the internet on human and business activity and the sheer growth in the volume of available information, there will be a growing demand for infrastructures such as OMS.

The challenge for inter-enterprises is that there is simply too much content being generated for a human to follow it. Let us illustrate this challenge expressed by one of our partners located in Spain, Arcelor Mittal, the world's number one steel company, with 330,000 employees in more

than 60 countries. Arcelor Mittal produces flat steel products of high quality, according to the customer's expectations many different technical demands have to be fulfilled: innovative and adequate product, research process definition, excellent plant technology, suitable plant maintenance, good quality raw materials, suitable automation systems, proper set points for control systems, etc.

Arcelor Mittal employees, with different profiles have gathered much information/knowledge during many years developing new products, designing and carrying on processes to manufacture those products, investigating cause and effect relationships regarding quality defects and process disturbances. All this knowledge is continuously being formalized in different formats and applications, which in many cases contribute to extract new knowledge. Unfortunately all this information is very often limited to a small circle of persons or to an individual. As a consequence, many times people reinvent known relationships because of poor exchange of information inside the company or because experienced people left the company. The knowledge acquired and put in operation by these individuals in their everyday tasks, should be extended and contrasted with that of other group of individuals or enterprise entities who are operating in a different context.

Search and taxonomies are not the answer!!!

Search is not the answer, because people and work groups do not know that they need to search. Additionally, relying exclusively on existing "top-down" taxonomies is not the answer. If a taxonomy already exists then projects must also already exist, and if projects exist then there are existing procedures that enable people to know about them and contribute to them. We are interested in discovering and mining emerging ideas, new projects and thoughts within the organization, and how to bring together the team that can make them happen. This means that we are interested in "the ontology of tomorrow", which is something that has not been formally built yet.

5. THE CONTRIBUTION OF THIS EDITION

Dealing in this edition with The Semantic Web: Real-World Applications we had to face two critical challenges: From the one hand we had to give answers to "thirsty" people for practical issue, delivering a state-of-the-art edition for the domain and from the other hand we had to give at a glance our perception for the required efforts towards adoption of Semantic Web

technologies to the real world contexts. We decided to organize the contents of the book in six general pillars that represent six excellent contents for the Semantic Web technologies exploitation. The following list provides a summary:

- **Semantic Enterprises**
- **Finance and Government**
- **Healthcare and life Sciences**
- **Education**
- **Business and Customer Management**
- **Enterprise Management and Security**

The twelve chapters of this edition contribute in three directions:

- **Highlight the full range of business and technological issues that must be addressed in every real world application** of Semantic Web Technologies. The variety of the contexts, discussed in the book (e.g. finance, health, government, and education domains) gives the reader the opportunity to see the "forest" of Semantic Web adoption. In fact reader is able to realize underlying methodological approaches, key business issues, decisions related to the selection of technologies and tools, change management approaches, return on investment, alignment with overall IT strategy and many more issues
- **Provide a comprehensive discussion of the required integration of Semantic Web and business strategy.** The presented applications, systems, projects, cases, and implementations help reader to realize the "Business" perspective of the Semantic Web, ontological engineering, Semantics exploitation, Semantic Web services, semantic search engines, semantic interoperability and integration, Enterprise application integration, enterprise information systems, semantic portals that are discussed in this edition are challenging reader to realize that for any successful technology and application within organizations are required business champions, anchors to business strategy and justification of return on investment
- **Set a context for critical thinking.** In the 12 chapters of the book, reader is challenged to explore his/her knowledge in relevance to practical issues faced in real world applications. In a way, this edition goes beyond the academic flavor of most scholar editions. The editing strategy we followed and the excellent quality of the contributors delivered an edition in which in every chapter readers build incrementally a Semantic Web awareness and expertise with great potential.

6. NEXT MILESTONES

We are very happy, since after many months of preparation this edition is finally published. We are really looking forward for your comments, ideas and suggestions for improvement in next versions. In the meanwhile we are planning a new reference edition for the role of the semantic Web towards the realization of close-to-market business strategies.

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