D 1.4.1v2 Technology RoadMap

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Abstract.
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The Knowledge Web Technology Roadmap (KWTR) activities promote a discussion on (i) the current and future trends on semantic web tools and applications, (ii) general organizational needs (common markets and social drivers, user requirements, etc.), and (iii) technology locks between organizational/user needs and research activities. Some emerging challenges should be unveiled and recommendations should be provided. These results are to be disseminated through the Knowledge Web portal in order to allow researchers and entrepreneurs to address their activities, in a mutually beneficial way.
This document "D1.4.1v2 Technology Roadmap" describes the first results of the technology roadmap activities, and extends the content of D1.4.1v1 (which contained only the skeleton and methodologies that will be used in the KWTR). In particular, it presents the semantic web state of the art, several foreseen evolutions, and some challenges to be addressed.

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Changes

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Executive Summary

One of the main goals of the Knowledge Web Network of Excellence (KW NoE) is the establishing of a beneficial relationship between academic institutions and industries. In particular the purpose of technology roadmap activities in the network of excellence is twofold:

1. to become aware of how, practically, knowledge web or semantic web technologies could help organizations in both delivering new products and services and creating new business value. Thus, to actively encourage industries to effectively introduce semantic web techniques, methods and theories in their value chain.
2. to understand real needs of organizations and the market society, unveiling new desiderata and trends that the KW NoE should try to overcome. Thus, to advice research institutions to invest in specific research challenges, which are helpful for industries.

For this reason, the final document of the Knowledge Web Technology Roadmap (KWTR) should be the result of experts' debates about the future trends on both:
- semantic web tools and potential impacts in industry, business and society;
- semantic web research and its applicability in predicted tools and applications.

Some of the topics that are addressed in the roadmapping process are:
- (i) purposes of the technology roadmap for the network of excellence: the definition of the concept of KWTR;
- (ii) current trends on semantic web research, considering both fundamental theories and applications;
- (iii) current trends on market and society, considering both business models and knowledge flows;
- (iv) problems generated by the evolution of market and society. Gaps that emerge from the comparison of trends on semantic web research and on market;
- (v) challenges for the future semantic web research;
- (vi) research roadmap: some recommendations for the short, medium, and long terms.

In the previous document, "D 1.4.1v1 Technology Roadmap", the concept of the KWTR has been defined, the roadmapping processes and some methodologies have been described, and finally the skeleton of KWTR was provided.
This document "D1.4.1v2 Technology Roadmap" elaborates on KWTR skeleton, and presents some results obtained by applying methodologies described in the D1.4.1.v1. Notice that D1.4.1.v2 is only one thin end of the wedge, it is continuously elaborated and refined in order to obtain (at month 48) the final version of the KWTR. In particular this document reports on: (i) the series of questionnaires that have been circulated among researchers and practitioners, (ii) an analysis of semantic web applications and their potential impact on industry, business and society (taking into account some preliminary results from WP 1.1), and (iii) some challenges that should be overcome. One of the main critical aspects of this activity is to collect and compare the finest expertise in both

academy and industry (in particular taking into consideration the opinions of the Knowledge Web Industry Board) to get the most up-to-date short/medium/long term vision of the technology roadblocks toward realizing the semantic web. For this reason, the involvement of senior researchers has been required, and an analysis of previous research results across the NoE has been taken into account.

Finally, this deliverable and the next versions of the technology roadmap documents will be disseminated through the Knowledge Web portal, and technology show activities (such as conferences, ShowRooms, etc.).

Contents

1. Introduction

Technology roadmaps are widely used within (and among) organizations to identify some economic market and social trends, namely technology methods, instruments, and applications that will be largely used in the future. The technology roadmap is not a static document. Its content is continuously refined and updated according to environment and strategic evolutions. Through various versions of technology roadmaps, a clear vision of future applications, products and services should be provided, and new business values should be foreseen. In particular, a clear scenario and its evolutions has to be predicted, and the current and future trends on semantic web tools, technology solutions and their characteristics have to be drawn to unveil some research challenges and to provide some recommendations for the future activities.

1.1 KWTR desiderata

It is important to consider that the KWTR is not developed for a single organization. It aims at discovering future trends on research activities within a Network of Excellence, a whole semantic web area and across other business sectors (financial, education, logistics, healthcare, etc.). Thus, the KWTR final document should give indications on how various autonomous institutions, spread all over Europe, might address their research activity, but it cannot impose a designed process of activity implementation. Therefore, KWTR will be focused only on the forecasting process, the planning process and a part of the decision making process. It will give, in a principled way some insights and indications on how semantic web technologies will develop, and which research gaps should be covered in the future. Specifically, the KWTR final document would be a report, which:

- summarizes a common agreement among experts in multidisciplinary sectors from both industry (e.g., health care, food, logistic) and academia (e.g., researchers in organization studies, computer science, linguistics, logics) ;
- captures the environmental landscape, threats and opportunities for a particular group of stakeholders in a technology or application area;
- provides a connection between technology and business strategy, as well as strategies of short/medium/long term planning for both research and industrial initiatives.

The roadmapping process should be carried out according to the following steps:

- Analysis of current, short/medium/long term trends in semantic web research, with a point of attention on:
    - theories and methods that have been/are to be studied,
    - tools, services and applications that have been/are to be developed.
- Analysis of market and social trends. For example, the socio-economic trends should be analyzed in order to understand how consumers' preferences, attitude towards technology applications, practices and usage of technology will change.

Also, trends on knowledge flows should be analyzed in order to understand how semantic web applications might be applied in daily work.
- Analysis of products and services that will be developed and used by consumers.
- Analysis of gaps among research trends, product and services development, and consumers' needs.
- The identification of challenges that research should focus on.
- Recommendations for short, medium and long term on the future development of semantic web.

Notice, the recommendation activity, is a crucial stage of the roadmapping process, where customisation issues need to be considered. It should fit the particular aims of autonomous researchers and developers spread all over Europe. In particular, careful analysis and discussion at this stage will significantly improve the chances of success in adopting KWTR. In other words, the KWTR final result should be considered as an artefact shared and commonly understood by the majority of the KW NoE members, who commit to the vision depicted within the technology roadmap. In this sense the technology roadmap might be considered as an agent of change that allows members of the NoE to stress and invest resources on a common and shared vision.

Besides, one of the decisive aspects of the KWTR is the definition of an appropriate balance between markets/products and products/technologies, and technologies/research activities, which should guarantee an effective analysis of current state of the art and trends in technology, business and research activities. Thus, a valuable mechanism for knowledge flow should be adopted according to the following levels:

– **research/technology level:** analysis of the theories, methods and technologies, identification of engineering and science skills, definition of technology management processes required for maintaining the technology base;
– **product level**: analysis of the product and service portfolio and platforms that will be developed in the near future, identification of manufacturing and operations functions, together with innovation in new products development;
– **business level**: analysis of the organization and associated networks, recognition of successful business portfolios, detection of marketing and financial functions, together with the strategy development and implementation processes required to deliver value to the business in the future.

Finally, the methodologies and techniques take up the KWTR activity are the T-Plan and the COCONET methodologies and the Delphi technique. Thus, workshops, conference calls, meetings, and Delphi questionnaires have to be used in the roadmapping process.

The KWTR results should be disseminated among all the NoE partners and should constitute a common agreement on how knowledge society might change in the next future. Therefore every researcher involved in the KW NoE, every industrial partner, and everyone interested in the semantic web technology should be able to use and consult KWTR. For that reason the previous and future results will be made available on the Knowledge Web portal (http://knowledgeweb.semanticweb.org/), and will be presented in conferences, workshops, technology show meetings, summer schools, etc.

1.2 Some improvements over D 1.4.1v1

D1.4.1v1 provided general concepts of roadmap and roadmapping processes, main features of technology roadmaps, methods and tools that allow researcher to develop technology roadmaps such as the T-Plan Guide and the COCONET roadmap method, and finally the Delphi techniques. Some of the activities already carried out and described in the D1.4.1v1 are:

- the initiation process of KWTR;
- the definition of the aims that the technology roadmap should stress;
- the identification of a first step in the definition of a common scenario that allows experts to define the 'first-cut' of the KWTR. This aim seems quite difficult to achieve. In fact, just looking at the answers received from experts, it seems that specialized groups answer according to their vision, without taking into account the general scope of KWTR. For instance, if one group works on metadata annotation, all the answers are provided only according to this perspective;
- the identification of some challenges that will be deeply analyzed in the next versions of KWTR.

Below, we describe the activities done within the D 1.4.1v2.
According to the COCONET roadmap method the following analyses have been started:

- **the analysis of the current state of the art:** through this analysis a general definition of the Knowledge Web environment has been depicted, focusing on semantic web research activities, technologies, and services;
- **the analysis of trends and developments in technologies and user work environments:** the first draft of foreseen domains on research, technologies, tools and services that will be developed and utilized by users has been defined.

Finally, several important factors have been considered prior to the KWTR start-up process:

1. **Identification of appropriate participants:** we consider it very relevant to involve partners from both research institutions and industry. In particular, their views should be merged in order to clearly identify the technology locks that Knowledge Web is resolving and trying to overcome, and the foreseen solutions that might be valuable in the market. The size of the group should be manifestly governed by two considerations: it should not be so large as to be unwieldy or to preclude adequate participation by most members, nor should it be so small that it fails to provide substantially greater coverage than that of an interview with one individual. Thus, industrial partners of Knowledge Web NoE and members of WP 1.4. have been identified as participants of KWTR. All the WP leaders have been asked to participate or to indicate researchers on semantic web that will contribute to this activity.
2. **Identification of available information:** a small group of researchers (for now composed of Roberta Cuel and Alain Léger) has been devoted to conduct the technology roadmap analysis. These researchers come from industry and business studies, and have a biased view on knowledge web applications, tools and

research activities. Thus, the active involvement of appropriate participants has been requested in two steps: (i) through a first questionnaire that has been distributed among all the members of the KW NoE and industry partners of the project. After the identification of available information we have organized a workshop activity in which experts have expressed their viewpoints on specific topics unveiled from the first questionnaire. (ii) through a second request of contribution on short/medium/long term trends of semantic web research and visions on specific and relevant research topics. We obtain only a few contributions, that will be presented in this deliverable. Although few contributions, we have obtain enough information to start our debate.

3. **Required resources and scheduling of workshops:** experts should be enabled to meet in a face to face mode. In this way experts are expected to share knowledge and understand each other more effectively. Members have to deal with a carefully planned discussion [Kreuger, 1988, p.18] in which the interviewer asks group members very specific questions about a topic [Denzin and Lincoln, 1994, p.365]. The workshops are organized at least twice in a year in line with the Knowledge Web plenary meeting events. During the Knowledge Web General Assembly in Heraklion, Crete the June 1st 2005, a special meeting for KWTR has already taken place. Next meeting is scheduled for January 16th - 17th 2006 during the KW Plennary Meeting in Trento.
4. **Definition of the unit of analysis**: it has been identified that some specific problems should be addressed and stressed in order to delimit the effort of interviews and experts' participation. In the next versions of the KWTR specific units of analysis will be identified and deeply analyzed.
5. **Clear articulation of objectives for the process**: the roadmapping processes have been defined, and the schedule has been planned.

1.3 The KWTR skeleton

As from D 1.4.1v1, a tentative skeleton of the KWTR final document had the following structure:

1. **Introduction**
   1.1. Roadmap: a definition
   1.2. Roadmapping: the process
   1.3. Functions of technology roadmaps
2. **Methodology**
   2.1. General theory
   2.2. Delphi technique
   2.3. Planning activities
3. **Aims of the Technology Road Map in the KW NoE**
4. **Current trends in Semantic Web Research**
   4.1. Trends on theories and methods
   4.2. Trends on tools
   4.3. Trends on infrastructure services and applications
5. **Market and Social Trends**

In this deliverable some changes occurred in the KWTR skeleton. In particular, general definitions of roadmaps, roadmapping processes, methodologies and tools are described in section 2 (Preliminaries). The aims of the KWTR are described in section 1 (Introduction). This new structure allows the reader to focus more on the KWTR aims and results than on the methodology we adopted to achieve them. Finally we have presented a more detailed structure for the section 3 (Current Trends in Semantic Web Research and beyond), focusing the attention on short/medium/long terms of trends.

Tentatively, the KWTR final document (month 48) will be structured as follows. Section 1 describes the general KWTR aims. Section 2 provides general concepts of technology roadmap and roadmapping, its methods and tools. Sections 3 and 4 depict the current trends in semantic web research, market and society. Section 5 outlines threats and opportunities that are unveiled by comparing industry and academia trends. Section 6 describes some challenges that might be resolved by realizing recommendations provided in Section 8. Section 8, also, discusses strategies of short/medium/long term planning for both research and industrial activities/initiatives.

2. Preliminaries

In this section, some basic notions of roadmaps, roadmapping processes, and methodologies will be analyzed in order to provide a common understanding about some basic principles used in the KWTR.

2.1 Roadmaps

In general a roadmap is an artefact (a shared report) that reflects a common vision in a particular field and for a desired objective. This vision is usually provided and created by an interdisciplinary group of experts, composed of representatives from different sectors coming from different backgrounds, aims and visions**.**
Also, a roadmap can be considered as Robert Galvin, former CEO of Motorola, said:

> "[...] an extended look at the future of a chosen field of inquiry composed from the collective knowledge and ***imagination*** of the brightest ***drivers of change*** in that field […] the inventory of possibilities for a particular field" [Li and Kameoka, 2003, pp.1].

Another definition can be unveiled by a review of science and technology roadmaps, authored by Kostoff and Schaller. They pointed out that:

> ‘‘[…] the single word 'roadmap' has surfaced as a popular metaphor for planning S&T [science and technology] resources'' [Vojaka and Chambers, 2004, pp.2].

A technology roadmap is a useful instrument that supports strategic technology management and planning. It provides a framework for supporting integrated and aligned multifunctional strategic planning, in terms of both 'market pull' and 'technology push', achieving a balance between market requirements and technological capability, with a key benefit being the communication associated with both the roadmap and road mapping process. Thus roadmaps create a bridge between new discoveries in science to operational engineering processes, with a time frame span from a maximum of twenty years to monthly check-up. The approach was originally developed and promoted by Motorola in the late 1970s, with the stated purpose of

> "encouraging business managers to give proper attention to their technological future, as well as to provide them with a vehicle with which to organise their forecasting process."

Even if the concept of roadmap is well described in literature, it has different meanings depending on the industry sector in which authors and organizations are involved, the level of maturity of sectors, the usage that experts will develop, etc. For instance, industries involved with emerging technologies and dynamic markets, consider roadmaps as useful planned connections between technology and business strategy. Industries that work in a relatively mature business consider roadmaps (such as supply chain roadmaps, or value chain roadmaps) as useful instruments that allow experts to unveil and visualize the main gaps of technology, process, or organizational capability along the value chain. In this sense roadmaps help officers to align knowledge and focus resources on forecast services.

2.1.1 The roadmapping process

Roadmapping is a process in which a roadmap is discussed, charted, and periodically revised by groups of roadmappers - people from different functions or organizations for potential future objectives. This activity is periodically carried out because R&D, product designs, production processes, markets, competitors and consumers' preferences, are rapidly changing and increasing their complexity. Thus technology forecasting and planning should be continuously revised [Li & Kameoka, 2003, pp.1; Groenveld, 1997].

Based on the centre of attention of roadmapping in practice, Kappel [2001] classified general roadmapping processes into four large categories:

- Roadmapping as forecasting process;
- Roadmapping as planning process;
- Roadmapping as decision-making process;
- Roadmapping as design process.

2.1.2 Main features of technology roadmaps

Technology roadmaps typically provide a time-directed representation of relationships between technologies, products, services, and in this case research activities. It is important to note that roadmaps do not represent a prescriptive or linear view of the forecasted processes, because the future is uncertain and the path forward depends on the actions that are taken by both employees and researchers.

Technology roadmaps can be used at various levels of granularity (such as benchmarking or monitoring competitors' activities, or as the major vehicle of strategic planning). They can be developed to both:

- support collaboration, decision making and actions. In other words to coordinate efforts of the departments within a single company and to align their efforts with the overall objectives of the firm;
- support sector-level foresight initiatives [Phaal, 2002]. For example, a recent report by the Dutch Ministry of Economic Affairs highlights the benefits of the approach for 'supra-company level' applications, such as national technology foresight programmes, where the proactive nature of roadmapping is identified as a key advantage, compared to other foresight techniques [Phaal, Farrukh and Probert, 2004, pp.2].

One of the main aims of technology roadmaps is to represent, communicate, plan, and coordinate technology forecasting, selections and visions focusing the attention on various periods of time. For that reason a technology roadmap could be considered as:

- An agent of change. Namely the technology roadmap constitutes a common and shared artefact that allows people to share information, to create common sense or to compromise on actions reasoning achieving a general consensus on major objectives (even tentatively).
- An integrated management tool, that allows people to prioritize some strategic tasks [Li and Kameoka, 2003, pp.2].

The quality of the technology roadmap results depends on:

- the number of participants;
- the multidisciplinary backgrounds and competences of experts involved in the definition of forecasts;
- the level of legitimacy in adopting a vision and using solutions depicted within the technology roadmap.

2.2 Methods and tools for technology roadmaps

There are a lot of methods and techniques that have been used among departments of an organizations, or across firms[1]. Let us consider:

- two of the most important methods: the T-Plan Guide and the COCONET Roadmap Approach [Phaal, Farrukh and Probert, 2000; Kappel 2001; Cuhls, 2003; Clar, 2003];
- the Delphi techniques.

2.2.1 The technology roadmap methods

The **"T-Plan guide"** [Phaal, Farrukh and Probert, 2004, pp.4-5] describes how to develop roadmapping activities within organisations, guaranteeing a rapid and cheap process. The T-Plan allows experts to:

- support the initiation of specific Technology Roadmap processes;
- establish key linkages among R&D, technology resources, and business drivers;
- identify important gaps in markets, technology tools, research activities;
- develop a 'first-cut' technology roadmap;
- support technology strategy and planning initiatives in the organisation;
- support communication among R&D offices, technical departments and commercial offices.

The T-Plan Guide suggests that people should organize workshop activities in order to bring together key stakeholders and experts, capture, share and structure knowledge about

[1] For in depth analysis see [Denzin and Lincoln, 1994; Groenveld, 1997; Kappel, 2001; Li and Kameoka, 2003; Phaal, 2002; Phaal, Farrukh and Probert, 2004; Rinne, 2004; Vojaka and Chambers, 2004]

the issue being addressed, identify strategic issues and plan the way forward [Phaal, Farrukh and Probert, 2004, pp.3].
Even if experts do not completely agree on the forecasted environment, products and applications, the T-Plan allows the production of a 'first-cut' roadmap. This constitutes a first agreement on a shared knowledge construction, that permits them to discuss the remaining open issues. The 'first-cut' provides a first draft version of roadmap as economically and quickly as possible. This offers an opportunity for the organisation to assess how best to take the approach forward, prior to committing significant resources and effort.

This method allows us to develop a first cut of KWTR since it is difficult to manage debates among experts who work all over Europe.

The **"COCONET Roadmap"** method is based on iterative and interactive processes of scenario construction, identification of core technologies and competencies (researches), roadmap design, roadmap agenda definition, and strategy development.

This method provides a process that is based on a series of workshops, which are devoted to the aims at different stages of the roadmap construction: (i) start-up; (ii) elaboration and construction; (iii) validation and finalisation.
The COCONET roadmap method establishes various links between industries and research communities providing useful inputs on foreseen technologies and applications, evaluations on possible research activities that should be carried out to sustain the inputs, and validations of a planning activity that should be designed to address the research activities. In Figure 1, a typical COCONET roadmap process is depicted.

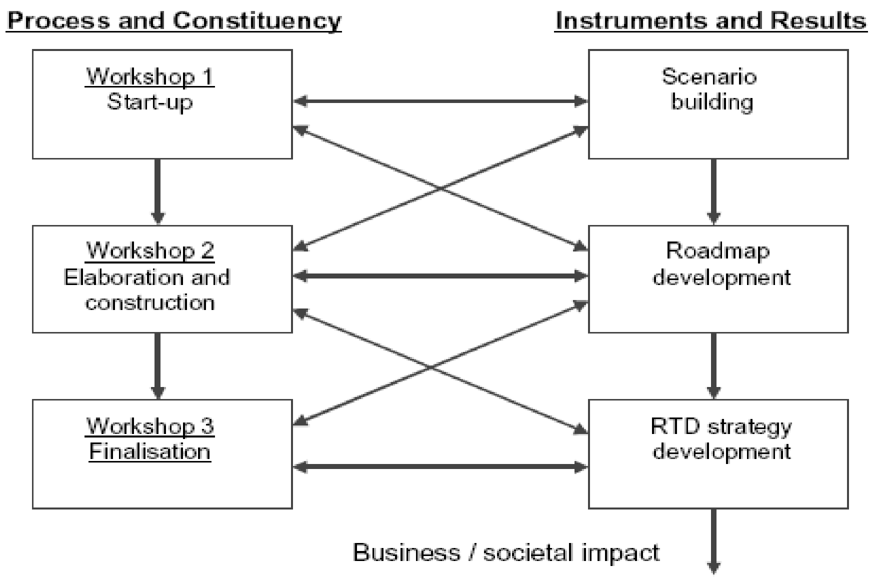


Figure 1. The COCONET Roadmap Process. (Source: Ribak and Schaffers, 2003, pp. 5)

This method, based on the COCONET Roadmap process, allows experts to create a technology roadmap that constitutes a strategic artefact and that is highly comparable with a process of strategy development [Ribak and Schaffers, 2003]. In particular the technology roadmap developed according to the COCONET method integrates four types of analysis that are described in Figure 2.

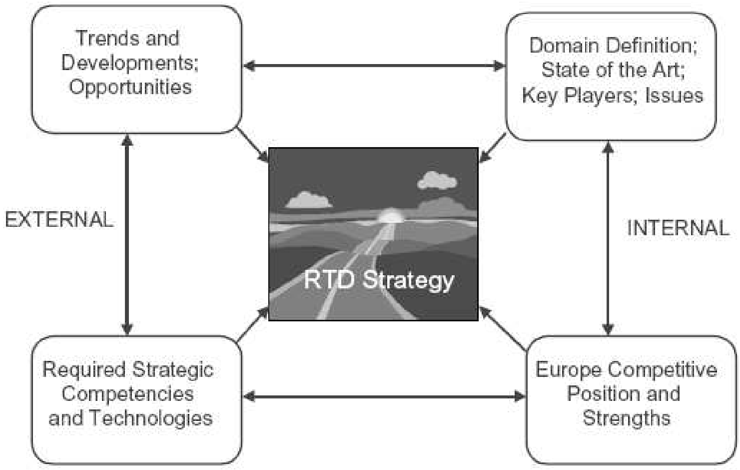


Figure 2. Four types of analysis developed according to the COCONET Roadmap Process

These analyses are the following:

1. **Analysis of the current state of the art in cooperative environments.** This aims at defining the domain, the state of the art of cooperative work environments, and the existing key industry and players;
2. **Analysis of trends and developments in technologies and user work environments.** This stresses the definition of foreseen domains on technologies, tools and services that will be developed and utilized by users;
3. **Analysis of the European position, and assessment of strengths and weaknesses on innovation**. This focuses on the foreseen competitive advantages that organizations might obtain providing technologies, tools, and services, in particular taking into consideration both social cooperative environments and markets;
4. **Identification of the critical strategic competencies and technologies.** This aims at defining the main characteristics that allow organizations and sectors to maintain leadership positions in cooperative environments.

All the above items refer to challenges that might be transformed into strong opportunities for organizations, and threats or problems that should be overcome within both organizations and sectors. As explained above, the results of this method constitute an agent of change, that allows organizations to elaborate foreseen options towards strategies. In other words, the COCONET Roadmap process is an elaborate method that enables the construction of an organizational strategy in terms of choices to pursue over a time horizon.

Even if the workshops and interviewing activities are carefully planned and designed to obtain perceptions in a defined area of interest in a permissive, non-threatening environment [Kreuger, 1988, p.18], they are

> "...limited to those situations where the assembled group is small enough to permit genuine discussion among all its members" [Smith, 1954, p.59 cited in Stewart & Shamdasani, 1990, p.10].

Finally the COCONET method allows us to develop a more in depth analysis of KWTR identifying the current state of the art, the trends of technologies and business solutions, the strengths and weaknesses of European research and industry, critical and strategic competences and technologies of semantic web researches and applications.

2.2.2 The Delphi technique

The Delphi technique is a very widespread tool that allows researchers to obtain group consensus. The Delphi method is based on a structured process for collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback. As described by [Phaal, Farrukh and Probert, 2004] Linstone and Turoff say that:

> "Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem."

This technique is designed to allow effective interactions among experts, taking advantage of participants' creativity in determining, predicting and exploring group attitudes, needs and priorities. The Delphi technique requires a coordinator (a single individual or a multidisciplinary group) that addresses the experts' activities in contributing to the main topics of the Delphi questionnaires. The coordinator has to communicate with experts asking for contribution, collecting information, organizing all the received information in a common and understandable framework. All these processes allow people to capitalize on the merits of group problem-solving and minimize the liabilities of group problem-solving.

Some critical aspects are:

- the identification of experts in the topics of interest;
- an effective communication channel;
- constructive participation of members:
- a charismatic coordinator;
- the identification of a common and understandable framework;

- reiteration of communications and participation processes;
- the effective elaboration of received contributions;
- the composition of a multidisciplinary group of experts.

As depicted in Figure 3. a typical Delphi process is based on the following steps:

1. identification of a small group of experts;
2. proposal on a specific topic of common interest (view formulation);
3. definition of an explorative questionnaires;
4. exposition and dissemination of the questionnaires;
5. feedback of experts' contributions of information and knowledge;
6. assessment of the group judgment or view (analysis).

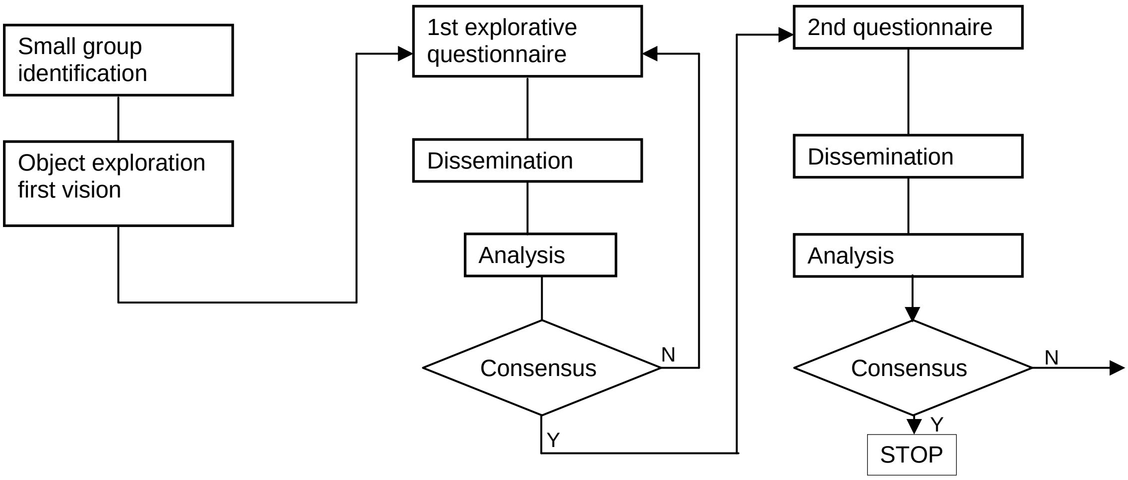


Figure 3: A typical Delphi process

The steps from 3 to 6 are repeated allowing experts to review their view until common consensus is obtained.

Finally the Delphi technique allows us to analyze firstly very general issues, and secondly more in depth features of semantic web. Also, it supports the identification of a common and understandable framework as the result of the reiteration of communications and participation processes. Therefore the KWTR final document will be the results of collaboration, decision making and actions among a group of Knowledge Web experts.

3. Current trends in Semantic Web Research and beyond

Semantic Web[2] research intends to create a universal medium for information exchange by giving meaning (semantics), in a manner understandable by machines, to the content of documents on the Web.
Currently, the WWW is based primarily on documents written in HTML and XML that are useful to describe structured text and multimedia objects, such as images, videos, music and interactive forms. Although, WWW uses standards, markup languages and related processing tools, it can not harness the enormous network of information and services on the web. For instance, it is now not possible to automatically find the nearest dentist to where a WWW user lives and book an appointment for her/him that fits in with her/his agenda. Besides, it is important to consider that a lot of the things that could be done with the Semantic Web could be also done without it, and indeed already are done in some cases. However, the Semantic Web provides standards and tools of RDF, RDF Schemas, OWL, etc. to perform more accurate services.

Some example of Semantic Web applications.

Swoogle (http://swoogle.umbc.edu/) is a crawler-based indexing and retrieval system for the Semantic Web -- RDF and OWL documents encoded in XML or N3. Swoogle extracts metadata for each document, and computes relations among them. Documents are also indexed by an information retrieval system which can use either character N-Gram or URIrefs as keywords to find relevant documents and to compute the similarity among a set of documents. Swoogle's database currently has information on 337,182 semantic web documents which contain 47,568,299 triples and define 97,369 classes, 54,631 properties and 7,279,476 individuals. Only 4,171 of these documents are 'ontologies' that mostly define classes and properties as opposed to mostly asserting facts about individuals. Currently, the most popular kinds of documents are FOAF files and RSS files.

Really Simple Syndication (RSS) is used in a huge number of web sites. RSS is a lightweight XML format designed for sharing headlines and other Web content. Originated by UserLand in 1997 and subsequently used by Netscape to fill channels for Netcenter, RSS has evolved into a popular and effective means of sharing content between sites. RSS solves myriad problems webmasters commonly face, such as increasing traffic, and gathering and distributing news. RSS can also be the basis for additional content distribution services.

An implementation of a Semantic Web Browser is the BigBlogZoo (http://www.bigblogzoo.com/).
The BigBlogZoo is a rich source of current categorized information from all over the world. Blogs, press releases, news, stock reports, and forums can be semantically analyzed with MediaMiner. SearchView is a free search tool which allows users to search multiple search

The Semantic Web addresses this shortcoming, using the descriptive technologies RDF and OWL, and the data-centric, customizable markup language XML. These technologies are combined in order to provide descriptions that supplement or replace the content of

[2] Wikipedia

Web documents. The machine-readable descriptions allow content managers to add meaning to the content, thereby facilitating automated information gathering and search by computers.

As a result of the pervasive and user-friendly digital technologies emerging within our information society, web content is increasingly multiform, inconsistent and very dynamic. Such content is unsuitable for machine processing, and necessitates human interpretation and its respective costs in time and money for business. To remedy this, approaches aim at abstracting of this complexity (e.g. by using ontologies) and offering new and enriched services able to process those abstractions (e.g., by mechanized reasoning) in a fully automated way. This abstraction layer is the subject of a very dynamic activity in research, industry and standardization which is usually called "Semantic Web" (see, for example, DARPA, European IST Research Framework Program, W3C initiative). The initial application of Semantic Web technology has focused on Information Retrieval (IR) where access through semantically annotated content, instead of classical (even sophisticated) statistical analysis, aimed to give far better results (in terms of precision and recall indicators). The next natural extension was to apply IR in the integration of enterprise legacy databases in order to leverage existing company information in new ways.

From a social and economic perspective, these emerging technologies should contribute to growth in economic wealth, but they must also show clear cut value for everyday activities through both effectiveness and efficiency. The uptake of Semantic Web technology by industry is progressing slowly. One of the problems is that academia is not always aware of the concrete problems that arise in industry. In contrast, industry is not often well informed about the academic developments that can potentially meet its needs.

On a large scale, industry awareness of Semantic Web technology has started only recently, e.g. at the EC level with the IST-FP5 thematic network Ontoweb (2001-2004) which brought together around 50 motivated companies worldwide. Based on this experience, within the IST-FP6 network of excellence KnowledgeWeb (2004-2007) an in-depth analysis of the concrete industry needs in the key economic sectors has been identified as one of the next steps towards stimulating the industrial uptake of Semantic Web technology.

3.1 The state of the art: an overview

Some of the core emerging problems in the semantic web are depicted in [Euzenat, Pin and Ronchaud, 2002], and can be summarized as follow:

- resource identification and their localization through annotating and computing systems. In particular, it refers to how users can identify the right information, how two identifiers can be compared or equated in terms of effectiveness, and on how web resources can be localized for processing. This involves various disciplines, such as linguistics, computer science, logics, etc.;

- heterogeneity as an intrinsic feature of the web and the semantic web have to deal with the fact that no language will be suitable for all purposes, no model will be applicable to all the cases and no ontology will cover the infinity of potential applications. This involves various research activities, such as modular representation languages, interoperability and semantic matching, articulation and composition of web services, etc.;
- a variety of reasoning methods that deal with different applications (from fetching to theorem proving) and the quality of their required results will vary;
- end users have to use semantic web in a very easy and transparent way. Human and computer interfaces, automatic annotation systems, ontology libraries, text mining tools, metadata learning processes, should be developed.

As we can unveil from the previous points, knowledge and semantic web cannot be identified with a particular technology (search engine, knowledge representation, natural language processing, etc.) or language (XML, RDF, DAML+OIL, OWL, etc.), but should be analyzed according to several layers of developments: (i) client device; (ii) application services; (iii) resources; (iv) languages; and (v) infrastructure [Euzenat, Pin and Ronchaud, 2002].

Although semantic web retrieval and services can be enhanced by some basic reasoning support, semantic web research topics are often focusing on information retrieval. The current state of the arts in such areas is trying to use metadata to provide a more accurate web searching. So it comes with several steps and efforts going on:

1. to build up easy-to-use metadata, such as FOAF, RSS, DublinCore;
2. to provide the easy-to-adopt way to convince people to use it to annotate their web information. There are various ways to achieve this, such as webblog, wiki, and social networking tools;
3. to provide efficient semantic web search engine to provide services, in particular when there are a lot of semantic web data available.

Finally, semantic web technology takes its roots in the cognitive sciences, machine learning, natural language processing, multi-agent systems, knowledge acquisition, automated reasoning, logics, decision and organizational theories. It can be separated into two distinct – but cooperating fields - one adopting a formal and algorithmic approach for common sense automated reasoning (automated Web), and the other one “keeping the human being in the loop” for a socio-cognitive semantic web (automated social Web).

3.2 Results of the first Delphi questionnaire

According to the Delphi questionnaire, semantic web is an interdisciplinary study that considers some emerging research fields such as:

- Tools and methodologies for semantic web data;
- Semantic annotation of data;
- Ontologies (creation, management, and evaluation);
- Ontology matching (e.g. mapping, alignment, merging, mediation and reconciliation);

- Ontology learning and metadata generation (including e.g. HLT and ML approaches);
- Multimedia and semantic web;
- Database technologies for the semantic web;
- Tools and methodologies for web agents;
- Peer to peer systems;
- Semantic integration and interoperability;
- Semantic web mining;
- Semantic web services (description, discovery, invocation, composition);
- Semantic web trust, privacy, security and intellectual property rights;
- Semantic web rules and query languages;
- Semantic web for e-business and e-learning;
- Semantic web-based knowledge management (e.g. semantic desktop, knowledge portals);
- Searching, querying and viewing the semantic web;
- User interfaces;
- Visualization and modelling;
- Personalization, users and groups modelling behaviour (socio-cognitive and statistical analysis), impacts of the human factor in data networks (collective intelligence);
- Temporal logics and temporal databases, computational logics.

The most important business fields and organizational roles in which interviewees are involved are:

1. IT consulting, software development;
2. Information systems, design of semantic web tools and integration with legal software;
3. Knowledge management, business process integration, information integration;
4. Website promotion and public relations methods through web technologies: conventional and unconventional systems and methods of marketing and advertising;
5. E-government projects: knowledge management approaches, systems providing information to citizens and enterprises.

From the workshop activity it has emerged that other related areas of interest should be considered in the semantic web research:

- artificial intelligence, in particular knowledge representation;
- data mining;
- interdisciplinary research activity;
- KDD (Knowledge discovery from data);
- ambient intelligence, sensor networks, embedded systems;
- bioinformatics and bio-nets.

During the workshop activity some practitioners pointed out that industry is not yet considering the semantic web as a proper system of tools that contribute to the following general areas.

- knowledge management;
- technology management;
- information retrieval systems and methods;
- digital archives;
- integration of heterogeneous information;
- artificial intelligence.

Thus in the KWTR, it should clearly emerge that the semantic web radically improves tools, applications and solutions in all the above mentioned areas.

In the following sections trends in research on theories, methods, tools, and applications will be described. They are unveiled analyzing contributions that researchers have given to Knowledge Web NoE, through Delphi questionnaires, deliverables results, and personal insights.

3.3 Trends in theories and methods

Knowledge Web NoE analyzes a number of theories and methods, thus it is very difficult to identify and classify all the various theoretical contributions. In order to allow people to share a common vision on the project, a taxonomy has been developed[3]. This taxonomy is continuously updated due to contribution of senior researchers. Also, it might be used to identify some of the most important topics that KWTR should analyze.

- 1 Foundations
    - 1.0 Knowledge Engineering / Ontology Engineering
        - 1.0.1 Methodologies
        - 1.0.2 Ontology population / generation
        - 1.0.3 Maintenance and versioning (dynamics)
        - 1.0.4 Mapping / translation / matching / aligning (heterogeneity)
        - 1.0.5 Validation
        - 1.0.6 Interoperability / Integration
        - 1.0.7 Modularization and Composition
        - 1.0.8 Tools
    - 1.1 Knowledge Representation and Reasoning
        - 1.1.1 Logics:
            - 1.1.1.1 Predicate Logic
            - 1.1.1.2 Description Logics
            - 1.1.1.3 F-logic
            - 1.1.1.4 Modal Logics
            - 1.1.1.5 First-order Logic
        - 1.1.2 Logic Programming
            - 1.1.2.1 Horn Logic
            - 1.1.2.2 Datalog

[3] The taxonomy is presented in: https://wiki-sop.inria.fr/wiki/bin/view/Acacia/KnowledgeWeb

1.1.2.3 Prolog
1.1.2.4 Hilog
1.1.3 Reasoning
1.2 Information Management
1.2.1 Data Modeling (Conceptual models; ontologies, UML, Relational data model, Semistructured data, Object-oriented model)
1.2.2 Database systems
1.3 Basic Web information technologies
1.3.1 XML (Namespaces, Schema languages, XML query and, transformation languages, XML programming techniques)
1.3.2 Web data integration
1.3.3 Security
1.3.4 Web services
1.3.5 Personalization techniques
1.3.6 Web data extraction / information extraction
1.3.7 Architecture of Web Information Systems
2 Semantic Web Special Topics
2.1 Natural language processing / human language technologies
2.4 Peer-to-peer and Semantic Web
2.5 Agents and Semantic Web
2.6 Semantic Grid
2.8 Benchmarking and scalability
2.9 Semantic community portal and social networking
2.10 Semantic browsing and learning

In this deliverable only a few of them will be analyzed, according to the following periods of time 0-3, 3-6, 6-12 years.

3.3.1 Trends in theories and methods: short term (0-3 years)

Some semantic web trends in theories and methods, identified by the Delphi questionnaires and discussed during the meeting hold in Crete in June 2005, are the following:

- semantic web and knowledge retrieval, light-weight semantics, distributed systems;
- representing, discovering, and using mappings;
- integration with other fields (natural language, databases, machine learning);
- ontology evaluation and re-use;
- human factor, customer relationship management, user centred data management, collaborative filtering, learning and narrative;
- make alignment practicable: fast (couple of minutes) and accurate (tens of mistakes);
- help taking "context" into account: having a general purpose notion of context that covers existing applications;

- advanced graphical display and adaptive interaction with learners;
- extensions of description logics with reasoning and query support;
- benchmarking of ontology based technology.

In the following part of this paragraph only few of these themes have been deeply analyzed, and some contributions will be presented. In particular (i) Knowledge Engineering / Ontology Engineering; (ii) Mapping / translation / matching / aligning (heterogeneity); (iii) Agents and Semantic Web; (iv) Semantic Web services; (v) Semantic browsing and learning; (vi) Semantic community portal and social networking will be presented. Also, notice that trends which are discussed in the short (medium) term, in general, remain valid for the forthcoming periods, though, their perfection is expected.

Knowledge Engineering / Ontology Engineering
More metadata has been added to the web. Data is formalized and classified based on ontologies. Also, lightweight annotation of data based on widely acceptable ontologies, such as FOAF, DublinCore, RSS make it easier to carry out searching and integration.
In the coming 1-3 years, widely accepted ontologies (efforts from standardization bodies) are increasing and the mapping of the key ontologies is provided and can be partially automated. As a consequence, annotated data based on these ontologies will increase.

Mapping / translation / matching / aligning (heterogeneity)
Heterogeneity is typically reduced in two steps (see, for recent surveys on the topic [Shvaiko and Euzenat, 2005; Noy, 2004; Doan, Halevy, 2005; Kalfoglou and Schorlemmer, 2003; Rahm and Bersnstein, 2001]): (i) match two ontologies, thereby determining the *alignment* (mappings) and (ii) process the alignment according to an application needs (e.g., query answering, web service integration). Also, the number and variety of solutions to the matching problem keep growing at a fast pace. In particular, Figure 4 shows (approximately) how many works devoted to diverse aspects of matching have been published at various conferences all over the world in the recent years.

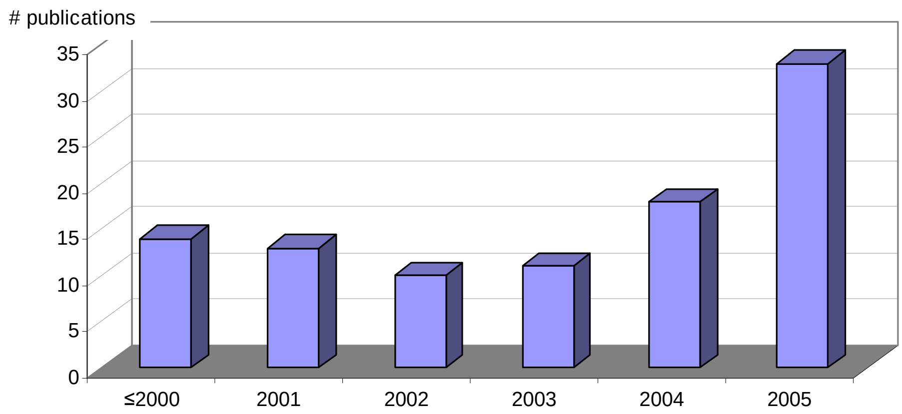


Figure 4. Dynamics of publications devoted to matching
(source: http://www.ontologymatching.org)

In the future, we expect a continuing growth of works on matching due to the constantly increasing interest in intelligent solutions for semantic heterogeneity problem from both academia and industry.

Disregarding the timelines, there are some general trends to be mentioned:

- gradual and incremental improvement of the existing approaches;
- emergence of the new approaches by modifying existing ones (usually performed by different group(s) of people with respect to the original approaches);
- emergence of the completely new approaches.

In the following part of this section, we discuss first matching approaches and then their evaluations. Matching approaches, in turn, are analyzed according to the input, process, and output dimensions.

Algorithms can be analyzed taking into consideration different aspects. First of all, let us consider data / conceptual models in which ontologies are expressed. There are a lot of tools and systems such as the Artemis [Castano, Antonellis, De Capitani di Vimercati, 2001] system which supports the relational, OO, and ER models; Cupid [Madhavan, Bernstein, Rahm, 2001] supports XML and relational models; QOM [Ehrig and Staab, 2004] supports RDF and OWL models. Also, looking at the kind of data that the algorithms exploit, different approaches exploit different information of the input, some of them rely only on schema-level information (e.g., Cupid [Madhavan, Bernstein, Rahm, 2001], COMA [Do and Rahm, 2001]), others rely only on instance data (e.g., GLUE [Doan, Madhavan, Domingos, and Halevy, 2003]), or exploit both schema- and instance-level information (e.g., QOM [M. Ehrig and S. Staab, 2004]). Even with the same data models, matching systems do not always use all available constructs, e.g., S-Match [Giunchiglia, Shvaiko, Yatskevich, 2005] when dealing with attributes discards information about datatypes (e.g., string, integer), and uses only the attributes names.

Some trends are:

- Most of the approaches tend to be more and more generic, i.e., handle multiple input data/conceptual models.
- New types of input, such as plain text and query interfaces from the Deep Web should enter intensively into practice.
- Approaches will try to suitably handle more and more constructs available from the input (e.g., constraints).
- Finally different (new) internal representations of the input data, e.g., descriptors of the entries for the learning algorithm, should appear.

Considering the general properties of the matching process, and in particular, the *approximate* or *exact* nature of its computation, another distinction can be done. It is based on the components of the matching process and their organization, namely distinguishing between *basic (elementary) matchers* and *matching strategies*, i.e., how the elementary matchers can be combined.

Below, we discuss the expected trends first in basic matchers, then in matching strategies, and finally, generally, in matching approaches. Thus, the expected short term trends are:

- New types of basic automatic matchers addressing a larger variety and more sophisticated situations with respect to the current state of affairs. Some possibly emerging examples are:
  - Methods for matching glosses (comments) against entities;
  - Methods for matching processes;
  - Methods for alignment reuse (e.g., by reasoning with the given mappings to deduce the new mappings, verify if the mappings are still correct, and repair them if necessary);
  - Methods exploiting various (new) external resources, e.g., upper level ontologies, such as DOLCE [Gangemi, Guarino, Masolo, Oltramari, 2003], domain specific corpuses [Madhavan, Bernstein, Doan, Halevy, 2005];
  - Approximate (e.g., semantic-based) methods.
- New libraries of matchers (or extensions of the existing libraries), which group together the basic automatic matchers based on their common characteristics, e.g., name-based matchers.
- New approaches to automate the combination of individual matchers and libraries of matchers. Some existing solutions here can be found in [Doan, Domingos, Halevy, 2001], [Ehrig and Sure, 2004]. Some possibly emerging examples are:
  - Methods for learning the optimal weight assignments, given a set of basic matchers;
  - Combining different techniques (e.g., collaborative filtering, genetic algorithms, statistics) for the optimal/near optimal weight assignments.
- New general matching solutions or default combinations of basic matchers which prove themselves equally good for most of the tasks.
- New approaches to tune automatically matching solutions in general (e.g., thresholds, weights, coefficients, which basic matchers to use). An existing example is [Sayyadian, Lee, Doan, Rosenthal, 2005].
- Various application specific approaches, which are particularly tailored to the input/output characteristics.
- New matching approaches investigating the quality vs. efficiency trade off.
- New ways of viewing/resolving the matching problem by reducing it to the other, already known problem. Some existing examples of these translations are graph matching [Melnik, Garcia-Molina, Rahm, 2002; Euzenat and Valtchev, 2004], propositional validity [Bouquet, Serafini, Zanobini, 2003; Giunchiglia, Shvaiko, 2003], probabilistic inference [Pan, Ding, Yu, Peng, 2005; Mitra, Noy, Jaiswal, 2005].

In view of graded answer, equivalence between entities can be expressed through: (i) the confidence measure in each correspondence, usually in [0,1], range, see, for example, [Euzenat and Valtchev, 2003, Madhavan, Bernstein, Rahm, 2001]; (ii) the kind of relations between entities. Most of the systems focus on equivalence, while a few others are able to provide a more expressive result (e.g., equivalence, subsumption, incompatibility), see for details [Bouquet, Serafini, Zanobini, 2003; Giunchiglia, Shvaiko, Yatskevich, 2004]). We expect the following short term trends:

- Translations between alignments specified with the help of coefficients in [0,1] range and logical relations;
- Expressiveness of alignment (atomic vs. complex);
- Language(s) for alignment;
- Formal semantics of alignment;
- Alignment format;
- Scalability of alignment;
- Framework(s) for characterizing the alignment;
- Application specific alignment.

Finally, we expect the following trends in evaluation of matching approaches in the short term:

- Continuous (at least annual) ontology matching contests[4];
- Improvements of the ontology matching evaluation methodology;
- New dataset construction methodologies:
    - New large real-world datasets;
    - New systematic (artificial) tests, e.g., robustness to data noises.
- New quality measures:
    - Combinations of precision and recall;
    - Application specific measures.

Agents and Semantic Web

AI and knowledge representation must rise to the occasion to work with decentralized representations, imprecision and incompleteness [Spector, 2005]. Thus several methods should be developed in the following years. In Figure 5 the relations between artificial intelligence and semantic web are depicted [Goble, 2005].

The trends identify all the theoretical studies that allow the development of collective and artificial intelligence. Building and develop methodologies that enable decision making processes, knowledge discovery, and (automatic or semi-automatic) ontology building through the elaboration of a huge amount of documents and information. At the same time it occurs methods and techniques that enable intelligence information linking, and web services.

[4] Matching contests of years 2004 and 2005 can be found following the links below:
2004: http://www.atl.external.lmco.com/projects/ontology/i3con.html;
2004: http://oaei.inrialpes.fr/2004/Contest/;
2005: http://oaei.inrialpes.fr/2005/.

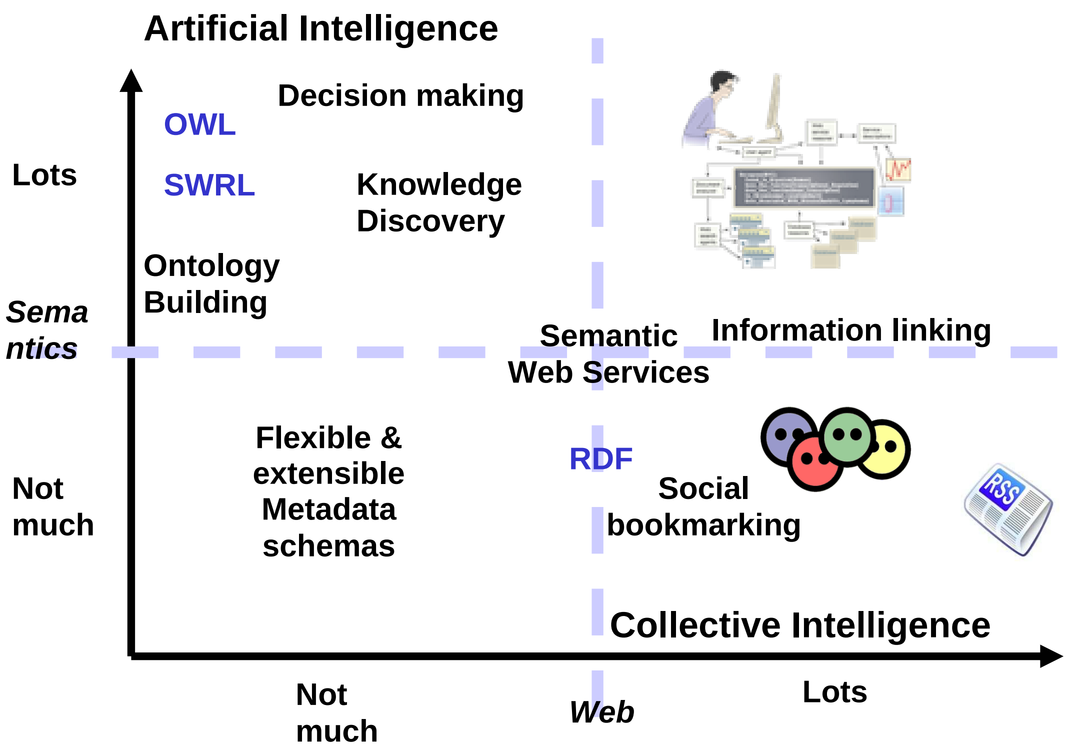


Figure 5. Relations between semantic web and artificial intelligence (source Goble, 2005)

Semantic Web services

The objective of Semantic Web Services is to provide knowledge to a distributed device of computation. This should allow large scale machine processing. Thus in the short term, a markup language must be descriptive enough that a computer can automatically determine its meaning.

There are two different research approaches involved:

- Behavioural approach. It clearly tries to address the service flow and the service composition issues, rather than other aspects. The main idea is that we need to know exactly how web services operate in order to: (i) use semantic web services in a composite process, (ii) obtain combined results from valid processes. Theories and methods as Petri Nets, Workflow, Process Algebras and task planning have been used to augment the semantic of these behavioural aspects.
- Static approach. It exploits semantics for the basic Web Service stack (description, publishing, discovery). The main idea is that we need a more flexible framework including: (i) effective abstractions of business information, (ii) adoption of semantic web languages such as OWL-S or WSMO. They define classes and properties that form an extended service description.

Also first prototypes of automated web services and intelligent searching facilities should be developed in order to analyze how user can easily way in, via Internet.

Semantic browsing and learning
As the search technology on the Web becomes more robust, the access to information in general, and to learning resources in particular, is improving. It is an old cliché that we are now facing information overload and new means are needed to reduce the amount of information we are interacting with. If we want to peruse the existing web technologies in the educational domain, we need to make a shift towards the “web is for exploration” paradigm. More specifically, we see two distinct modes of exploratory learning: (i) convergent, ‘spotlight’ browsing of internal resources, and (ii) divergent, ‘serendipitous’ browsing in an open web space.

The spotlight browsing approach to supporting exploratory learning is based on a cycle involving the *selection* of a collection of resources, the *organization* of this collection into pedagogically effective presentations, and the *exploration* of those presentations by the learner. It is suitable for the learning situation where the learner has a specific, well-defined objective. The concept in question becomes the centre of the spotlight, and the ‘shadow’ cast by the spotlight leads to semantically close or similar concepts.

On the other hand, the serendipitous approach to exploratory learning relies on the learner engaging in a different cycle: the presentation of an arbitrary, serendipitous resource, the discovery of domain-specific anchors in this resource, and the exploration of a range of other resources starting from the anchors. This model is more suitable for a learner who wants to have an overview of a domain or to learn something about the structure of a particular domain without any specific objectives.

Both models of exploratory learning lend themselves rather well to the emerging semantic web technologies. The common ground shared by both models is their flexibility, extensibility, and their potential for customization.

Moreover, the semantic web should be treated as an enabling and enriching technology, which can sit alongside and add value to the existing technologies (such as web browsers or digital libraries). However, in addition to developing rather passive extensions to the standard tools, an important aspect of the Semantic Web is the capability to put users/learners into a more active role, for example, as annotators of web content.

We also envisage that approaches to semantic browsing will go beyond the current single-ontology paradigm, to provide dynamic, opportunistic views of semantic content, to support browsing and exploration on the web. To achieve this goal several problems need to be addressed. For instance, it will be necessary to ensure that the user is not overwhelmed by the potentially huge amount of semantic information, which can in principle be relevant to the current web resource. It will also be necessary to develop reasoners able to assess the relevance of semantic information residing in distributed ontologies with respect to the current web resource and make decisions about which information to present and to what level of detail. These reasoners will be able to reason about the provenance of the information to assess its value with respect to the current browsing context and to perform mappings on the fly to integrate information derived from distributed, heterogeneous ontologies.

Semantic community portal and social networking
There is a strong connection between social networking services and semantic community portals. The Friend of a Friend[5] (FOAF) Semantic Web ontology has been utilised by a number of SNS sites including Tribe and Ecademy for describing member profiles and their relationships. The use of the FOAF ontology is leading to interoperability between the various standalone social networking spaces. This will in turn increase the number of "happy chances" or serendipity occurring between people using these online worlds by bringing them all together in a universal social network (as a sum of its SNS parts). For this to become a reality, more SNS sites will be required to use FOAF, SIOC (Semantically-Interlinked Online Communities) and other related ontologies, making the data within them distributed and decentralized as opposed to being locked into proprietary sites or applications.

3.3.2 Trends in theories and methods: medium term (3-6 years)

As the Delphi questionnaire indicates, in the medium term, the semantic web should take into account some emerging research fields:

- distributed systems, scalability of systems;
- semantics-oriented research;
- standardization of semantic web and certification of ontologies;
- massive popularization of semantic data;
- personalization;
- social networks, web communities;
- deeper context based applications;
- editing and reasoning methods for uncertain rule representation;
- semi-automatic annotation methodologies of general multimedia content;
- alignment of multimedia ontologies;
- automated web services and intelligent searching;
- involvement of economics, cognitive science, and human sciences aspects.

As in the previous paragraph, only few of these themes have been deeply analyzed, and some contributions will be presented. In particular (i) Knowledge Engineering / Ontology Engineering; (ii) Mapping / translation / matching / aligning (heterogeneity); (iii) Semantic browsing and learning; (iv) Semantic community portal and social networking will be presented. Also, notice that trends which are discussed in the short (medium) term, in general, remain valid for the forthcoming periods, though their perfection is expected.

[5] The *Friend of a Friend* (FOAF) project is about creating a Web of machine-readable homepages describing people, the links between them and the things they create and do. http://www.foaf-project.org/

Knowledge Engineering / Ontology Engineering

The success of SW is based on two legs: the efforts from standardization bodies and the efforts of massive popularization of data. If both legs walk together, SW is not that far. Web data are much cleaner (based on annotation effort and standardization effort) and therefore searching can be more accurate. Also, heavy logic will dominate the SW. A thumb rule for IT: simple and easy to use guarantee the success.

Mapping / translation / matching / aligning (heterogeneity)

Regarding matching approaches, standard(s) for the internal representations of the input data/conceptual models are required.

Also, concerning process dimensions within industrial contexts, new methods should tackle the following topics:

- *Knowledge incompleteness.* Recent industrial-strength evaluations of matching systems, see, e.g., [Avesani, Giunchiglia, Yatskevich, 2005; Euzenat, Stuckenschmidt, Yatskevich, 2005], show that lack of background knowledge, most often domain specific knowledge, is one of the key problems of matching systems. In fact, most state of the art systems, for the tasks of matching thousands of entities, perform with lower values of *recall* (~30%) than in cases of *toy* examples, where the recall was most often around 80-90%. Thus, we expect emergence of the frameworks leveraging the knowledge incompleteness problem, ultimately in a fully automated way.
- *Performance*. Following the above mentioned examples from the industrial-strength evaluations, besides the effectiveness of the results, there is an issue of performance. In fact, there are applications which require at least some weak form of real time performance (to avoid having a user waiting too long for the system to respond). *Execution time* indicator shows scalability properties of the matchers and their potential to become industrial-strength systems. Also, referring to the above mentioned evaluations, the fact that some systems ran out of memory on some test cases, although being fast on small and medium test cases, suggests that their performance time was achieved by using a large amount of main memory. Therefore, usage of *main memory* should also be taken into account. We expect significant improvements of the matching approaches with respect to their performance characteristics.
- *Interactive approaches (semi-automatic matching)*. As from above, automatic ontology matching usually cannot be performed with high quality, especially on huge datasets. We believe that semi-automatic matching is a plausible way to improve the effectiveness of the results. There are tasks at which machines are good, and others at which human users are good. An important point here is to involve the user only when his/her input is maximally useful.
- *Explanations and transparency*. Mappings produced by matching systems may not be intuitively obvious to human users, and therefore they need to be explained (see [Shvaiko, Giunchiglia, Pinheiro da Silva, McGuinness, 2005; Dhamankar, Lee, Doan, Halevy, Domingos, 2004]). In fact, if Semantic Web users are going to trust the fact that two terms may have the same meaning, then they need to understand the reasons leading a matching system to produce

such a result. Explanations are also useful in semi-automatic matching, especially when matching (large) applications with thousands of entities (e.g., business catalogues, such as UNSPSC and eCl@ss). In these cases automatic matching solutions will find a number of plausible mappings, hence some human effort for performing the rationalization of the mapping suggestions is inevitable. Generally, the key issue here is to represent explanations in a simple and clear way to the user.

- *Social aspects.* The impact of social networks, web communities and direct involvement of humans (in a distributed fashion) on ontology matching has to be analyzed and distilled. Let us consider one example. Eventually, once an alignment has been determined, it can be saved, and further reused just like any other data on the Web. Thus, on the one hand, a (large) repository of mappings has the potential to increase the effectiveness of matching systems by providing yet another source of domain specific knowledge. On the other hand, users can publish different and even contradicting alignments. Hence, one of the open problems here is how to manage the contradictory mappings in the repositories.

In addition to this, other research on output dimensions, in particular annotations (codifying social aspects) of the alignment, and standard(s) for expressing the alignment should be addressed.

Regarding the evaluation of matching approaches in the medium term, we expect the following trends:

- Extensive experiments across different domains with multiple test cases from each domain:
  - New hard and large real-world datasets.
- More accurate evaluation measures:
  - User-related measures.
- Automating acquisition of expert mappings, especially for large applications.

Semantic browsing and learning

Graphically oriented representations of domain knowledge such as argumentational networks, narrative structures or causal models will allow users to navigate both textual and graphical representations and provide access to complex models as well as alternative pages. As part of this work we envisage the development of a range of services associated with the building, maintenance and navigation of these complex representations. We also envisage a further range of community-oriented services and tools which will allow communities to express and transmit their community knowledge via these complex representations.

We also expect that by this stage the semantic web will be a reality, with very large amounts of semantic markup available to support learning, interpretation and personalization. Hence, in addition to the issues of visualization and ontology mapping described earlier, issues of scalability and trust will also come to the forefront, as semantic information will be readily available and the tools will also be there to make use of it.

Semantic community portal and social networking
On the (Semantic) Web, the large number of community Web sites and social networks make it difficult to choose and find the ones a community member needs to take part in. To assist community discovery algorithms, ontology matching techniques, and ways to aggregate and visualize information about communities need to be developed. Flink [Mika, 2005] is an example of current Semantic community portals addressing the challenge of aggregation, visualization and presentation of community information.

Once the people, objects and processes are being annotated, and the Semantic Web is being easily extended by the communities of users and developers, delivery of massive volumes of Semantic content and workflows to the community members is a major challenge. The solution is expected to stem from the active research fields in the Semantic Web area. For example, Decker and Frank [Decker and Frank, 2004][6] address this problem by combining the current Semantic Web developments in a Social Semantic Desktop, which will let individuals collaborate at a much finer-grained level than is currently possible, and save time on filtering out marginal information and discovering vital information. Delivery of community-driven Web content will also interoperate at a Semantic level with mobile devices, as first projects start to appear, e.g., Semapedia[7]: an application of Web-based Wikipedia to mobile environments.

3.3.3 Trends in theories and methods: long term (6-12 years)

It is hard to forecast methods in the long term, because the semantic web is radically improving and a lot of changes are affecting the whole discipline. In any case, as from the Delphi questionnaire and the meeting in Crete, the semantic web will take into account the following research fields:

- multimedia semantics;
- industry strength security and trust solutions;
- automatic annotation of general multimedia content;
- automatically adapted knowledge;
- semantic grid;
- ambient intelligence merged with distributed knowledge management.

Knowledge Engineering / Ontology Engineering
One perspective is that, if we are spending too much time applying heavy logic to SW, the success of SW will be difficult to see. If people get used utilizing standardized ontologies just as they are using Windows everyday, and the data which are not annotated based on standardized ontologies cannot be published to the Web, then the success of SW can be seen overnight.

[6] An EU Integrated Project NEPOMUK around the topic of Semantic Desktop will run in the next 3 years

[7] The Physical Wikipedia: www.semapedia.org

Mapping / translation / matching / aligning (heterogeneity)
In the long term we expect the appearance of multilingual matching approaches, i.e., those matching across multiple languages, such as English, Italian, and French. Also, a substantial progress in the field should have been done by that time in general, which in turn should cause some paradigm shifts. Thus, new visions and requirements of matching should appear.
Addressing the multilingual matching approaches, we expect the following trends in evaluation of matching approaches in the long term:

- Evaluation methodology for multilingual matching approaches;
- Multilingual datasets;
- Quality measures for multilingual matching approaches.

Semantic browsing and learning
It is difficult to envisage what form the Semantic Web will have taken as we approach 2020. However, on the assumption that it will succeed, it is likely that it will remain composed of two essential features – ontologies and services – since these provide the means for capturing factual/relational and procedural knowledge respectively. It is likely that ASPL/Magpie [Domingue, Dzbor, Motta, 2003; Domingue, Dzbor, Motta, 2004; Dzbor, Motta, Domingue, 2005] will continue to expand its range of services and that these will become both more complex, user- or community-specific and supported by a plethora of novel computational and display technologies. We would hope that as these services become more and more usable (e.g., via voice activated, ubiquitous computational devices with holographic screens) they also become more firmly grounded in well-tested theoretical foundations. Thus, we would expect that services oriented to learning would combine a range of information retrieval technologies with the means for sifting, sorting and rearranging knowledge and expressing the results as part of some clear and clearly supported educational task while being fully and seamlessly integrated into the learner's day to day activities.

Semantic community portal and social networking
The content of Semantic community portals is easier to aggregate, reuse and misuse than the content of conventional Web portals. Therefore, additional trust and security policies and practices need to be established for Semantic community portals. Within such practices, ontology-based algorithms can be applied to describe, analyse and adequately render aggregated information. For example, after analysis of social networks of trust [Golbeck et al., 2004], information from less trusted sources can be automatically displayed in a less highlighted manner compared to the information from more trusted sources.

3.4 Trends in tools

In this section a description of trends on semantic web tools will be described according to the periods of time 0-3, 3-6, 6-12 years. In particular we will focus only on a few of the topics defined in the Knowledge Web taxonomy, as follows.

1. Semantic Web: Core topics
    - 1.0 Infrastructure
        - 1.0.1 Architecture
        - 1.0.2 Semantic Web Services
    - 1.1 Resource Description Framework / RDFSchema
    - 1.2 Languages
        - 1.2.1 Query Languages
        - 1.2.2 Update Languages
    - 1.3 Ontologies
        - 1.3.1 Ontology representation / Ontology languages / OWL
        - 1.3.2 Ontology Engineering
    - 1.4 Rules + Logic
        - 1.4.1 Rule languages
        - 1.4.2 Rule Markup
        - 1.4.3 Reasoning languages
        - 1.4.4 Reasoning Engines
    - 1.5 Proof
    - 1.6 Security / trust / privacy

2 Semantic Web Special Topics
- 2.1 Natural language processing / human language technologies
- 2.4 Peer-to-peer and Semantic Web
- 2.5 Agents and Semantic Web
- 2.6 Semantic Grid
- 2.8 Benchmarking and scalability

3.4.1 Trends in tools: short term (0-3 years)

Knowledge Engineering / Ontology Engineering
The main tools in this area at the moment are social networking tools, such as wikis and blogging. Most of these tools are free. Of course there are some commercial ones on the market with a reasonable price. There are some ontology engineering tools available freely (such as Protégé) and commercially (such as Ontostudio). But most of them can still only handle a limited amount of data.

Mapping / translation / matching / aligning (heterogeneity)
Below, we discuss the future trends in tools, distinguishing between (relevant) commercially available ones and research prototypes.
Most of the commercially available matching tools focus on visualization of the input ontologies expressed in e.g. XML, database, flat file formats, and the correspondences between them. It is also possible to specify (over the correspondences) some data transformation operations (e.g. by means of functoids) such as adding, multiplying, and dividing the values of fields in the source document and storing the result in a field in the target document. However, the matching operation itself is not automated at all, namely all the correspondences have to be specified manually. Some examples of these tools are

Altova MapForce[8], BizTalk Schema Mapper[9], Cape Clear XSLT Mapper[10], Stylus Studio XSLT Mapper[11]. In the short term we expect an increase in the number of such tools.
Obviously, contrary to the commercial tools, research matching prototypes focus on automating the correspondence discovery operation and related themes. In general, the majority of the research tools focus only on one of the steps of reducing the heterogeneity, namely on matching ontologies, fewer on processing the alignments, and only some of them can be called infrastructures, since they consider match as one (among others) operation. Since the quality of match in general still has to be improved, there is an effort on design and development of the matching testbed environment [Euzenat, 2004]. It is early to speak about software quality in research tools. However, some positive trends are worth mentioning, such as modularity and extensibility of the architectures in most of the research prototypes. We expect gradual and incremental improvements along the lines mentioned above in the short term.

Semantic browsing and learning
There are some ontology engineering tools available freely (such as Protégé) and commercially (such as Ontostudio). Another example is Oyster (which can be freely downloaded at http://oyster.ontoware.org) is a Java-based system that exploits semantic web techniques in order to provide an innovative and useful solution for exchanging and reusing ontologies, providing facilities for managing, searching and sharing ontology metadata in a P2P network, thereby implementing the OMV* (Ontology Metadata Vocabulary) proposal for the standard set of ontology metadata (http://ontoware.org/projects/omv/). In any case, most of them can still only handle a limited amount of data. Finally, the main tools in this area at the moment are social networking tools, such wikis and blogging. Most of these tools are free, even if some commercial ones are sold on the market at reasonable prices.

> As we have already indicated, ASPL/Magpie operates as a learning support tool for learners wanting to familiarize themselves with the Semantic Web Studies domain. An earlier version of Magpie has already been successfully deployed as part of the Climateprediction project (http://www.climateprediction.net/) and is being used as part of the educational infrastructure for an Open University course on climate change. We have also had interest from online journal providers.

3.4.2 Trends in tools: medium term (3-6 years)

Knowledge Engineering / Ontology Engineering

8 http://www.altova.com/features_xml2xml_mapforce.html

9 http://msdn.microsoft.com/library/en-us/introduction/htm/ebiz_intro_story_jgtg.asp

10 http://www.capescience.com/education/tutorials/index.shtml#mapper

11 http://www.stylusstudio.com/xslt_mapper.html

There should be some efficient tools available to provide support for ontology engineering, such as efficient ontology management tools (see www.omwg.org). Wikis and blogging tools will grow with good performance. Searching engine tools will implement semantic features.

Mapping / translation / matching / aligning (heterogeneity)

We expect the following trends in the medium term:

- Scalability of visualization of the alignment between input ontologies;
- User interfaces;
- Configuration/customizing technology;
- Industrial-strength research prototypes, including tools for matching ontologies, processing the alignment, and infrastructures.

Semantic community portal and social networking

Identity itself is fairly straightforward but in the online world it can be fairly ambiguous and far more complicated. A digital profile is a representation of an individual that grows over time. Many online communities require a user to register and a digital profile is created from this registration. If the user's profiles are machine processable then systems can be used for extracting meaning from online content improving the power of searches. Most community sites are standalone and many individuals struggle to remember the passwords for the number of accounts or struggle with the lengthy registration of logging into yet another social network. Tools to handle the problem are starting to appear, e.g., Sxip[12].

Another issue will be the Community-driven ontology management. A fully fledged framework for community-driven ontology management would go beyond simple tagging and merge community portals with established practices for ontology management. The areas involved would be ontology development and population, storage, matching and versioning. The objective of community-driven ontology management is to provide means and motivations for a large number of users to "weave" and adopt the Semantic Web via ontology management practices.

Semantic browsing and learning

Extended semantic browsing tools (such as ASPL/Magpie) with a fully service based architecture with multiple ontology-supported services provide access to and navigation through graphical as well as textual resources. It is likely that the advanced platform for learning (ASPL) will be able to access any material available via the internet and to provide a personalized display of this material via fully tailorable web pages or other programmable display types. What is more, when we refocus the attention of the Semantic Web community on capturing the users' statements rather than expecting users to do formal annotation, this opens a wide array of possibilities. One particular strand we are exploring at the OU concerns the role of mobile devices such as PDAs or telephones in learning. Since these devices are with the learners almost all the time, it is possible to start exploration/annotation e.g. through a mobile phone and later continue on desktops. Hence, a learner does not need to make a note of an interesting object (say a painting) to

[12] SXIP Network: http://www.sxip.com

explore it at home. S/he can simply trigger the exploratory processes straight on the spot – in the gallery, in the café or in a train. This would obviously open further opportunities, e.g. embedding domain knowledge with geographic and positional knowledge, so that it becomes possible to customize the presentations of resources truly to the level of individual learners.

The People's portal infrastructure [Zhdanova, 2004] allows end users to define the content structure (i.e., develop ontologies), populate ontologies and define the ways the content is managed on Semantic Web community portals where the People's portal infrastructure is applied. Content management features on the People's portal include ontology matching support, personalization support (at the personal and community levels) and dynamic reaching of a consensus on the basis of heterogeneous ontologies.
The People's portal was deployed as a part of an intranet at DERI – Digital Enterprise Research Institute [Zhdanova et al., 2005] and as an extension to the portal of a Semantic Web community (knowledgeweb on the people's portal: http://people.semanticweb.org). The ontology matching part of the People's portal was deployed as a Web application open to everybody on the Web (OWL Ontology Aligner: http://align.deri.org).
In this respect, the People's portal environment appeared to be planned from the very beginning to make a contribution to a trend that now proves to dominate in acquisition of the Web structures. Ontology acquisition from regular community members has not yet become a common practice on the Web, but current trends convince us that it will become among most common practices.

3.4.3 Trends in tools: long term (6-12 years)

Although researchers consider these trends very hard to imagine, some contributions have been provided.

Knowledge Engineering / Ontology Engineering
It might be that an effective Swoogle will be used all over the industrial world. Of course some commercial ones will pop up as well which can handle better searching and data integration issue

Mapping / translation / matching / aligning (heterogeneity)
In the long term, we expect emergence of good quality matching tools: in the sense of system characteristics, e.g., complexity, design features, performance, quality, and process characteristics, e.g., maintenance.
Finally, it is worth noting that, for example, engineers of information integration systems would rather use existing matching systems than build their own. However, it is quite difficult to connect state of the art matching systems to other systems or embed them into the new environments. They are usually packaged as stand alone systems, designed for communication with a human user. In addition, they are not provided with an interface described in terms of abstract data types and logical functionality. We expect some substantial progress on the frameworks for integration of different matching systems into the new environments in the long term.

Semantic community portal and social networking
The merging of Semantics, Communities, Multimedia, Web and Ubiquitous Computing. Tools which support the efficient integration of all the existing and near future developments in mobile, real life environments will appear. Many scalability and context problems will be resolved.

Semantic browsing and learning
ASPL descendants will be able to access, reason about, manipulate and (re)display any available web information. They will have immediate access to a range of ontology repositories as well as a range of mapping tools or services. ASPL itself will become a more pro-active environment in which communities continue to use ontology-oriented tools to express their knowledge. Indeed, since they are pro-active, ASPL and its descendants will become an integral part of these communities as they access, process, filter and suggest changes to ontologies, services, domain representations and content. ASPL or ASPL-like systems will become indispensable as a means of countering the massive amounts of information, misinformation and disinformation available via the Internet.

3.5 Trends in services and applications

In this section a description of services and application will be described according to the periods of time 0-3, 3-6, 6-12 years. In particular we will focus only on a few of the topics defined in the Knowledge Web taxonomy, as follows.

1. Semantic Web: Core topics
    - 1.7 Applications
        - 1.7.1 Knowledge Management
        - 1.7.2 E-Learning
        - 1.7.3 Bioinformatics
        - 1.7.4 Multimedia
        - 1.7.5 Health
        - 1.7.6 e-Business
        - 1.7.7 Law
        - 1.7.8 Engineering

2 Semantic Web Special Topics
- 2.1 Social impact of the Semantic Web
- 2.2 Social networks and Semantic Web
- 2.3 Outreach to industry

Other interesting topic has been defined by the Delphi questionnaire and the meeting held in June. These are applications on:

- product and service design and analysis
- workflow management system
- storekeeping and logistics
- cost and risk management
- human resources management
- customer relationship management

Finally some concrete examples and trends will be identified by the next KWTR version from WP 1.1.

3.5.1 Trends in services and applications: short term (0-3 years)

Mapping / translation / matching / aligning (heterogeneity)
Matching is an important operation in traditional applications, such as schema integration, data warehousing, enterprise information integration (EII), and so on. Some examples of commercially available, e.g., EII tools, are IBM Information Integrator, Liquid Data for WebLogic from BEA systems, SAP NetWeaver, and EII platform from Denodo Technologies. However, it is worth mentioning that, even in these tools, a support for handling the semantic heterogeneity problem is still in its early stages.
Let us describe a concrete example of a traditional application, which is catalogue integration. In B2B applications, trade partners store their products in electronic catalogues. Catalogues are tree-like structures, namely concept hierarchies with properties. Typical examples of catalogues are product directories of www.amazon.com, www.ebay.com, etc. In order for a private company to participate in the marketplace (e.g., eBay), it is used to determine correspondences between entries of its catalogues and entries of a single catalogue of a marketplace. This process of mapping entries among catalogues is referred to the catalog matching problem, see [Bouquet, Serafini, Zanobini, 2003]. Having identified the correspondences between the entries of the catalogues, they are further analyzed in order to generate query expressions that automatically translate data instances between the catalogues (see, for example, [Velegrakis, Miller, Mylopoulos, 2005]). Finally, having aligned the catalogues, users of a marketplace have a unified access to the products which are on sale. We expect the above mentioned applications to play as crucial a role in the short term as in the medium and long term. For example, according to Aberdeen Group, the EII market will grow by 60% annually with around $250M in revenue in 2005[13]. Notice, below, we discuss only the new applications as an addition to those already mentioned.

[13] http://www.denodo.com/english/news/2005/08_06_05.html

Semantic Web services

The web services technology can propose some solutions to the problems of interoperability. We describe now a new approach based on a "patient envelope" and we conclude with the implementation of this envelope based on the web services technology

The patient envelope is a proposition of the Electronic Data Interchange for Healthcare group (EDI-Santé) with an active contribution from the ETIAM society.
The objective of the work is on filling the gap between "free" communication, using standard and generic Internet tools, and "totally structured" communication as promoted by CEN or HL7. After the worldwide analysis of existing standards, the proposal consists of an "intermediate" structure of information, related to one patient, and storing the minimum amount of data (i.e. exclusively useful data) to facilitate the interoperability between communicating peers.
The "free" or the "structured" information is grouped into a folder and transmitted in a secure way over the existing communication networks [Cordonnier, Croci, Laurent, Gibaud, 2003]. This proposal has reached widespread adoption with the distribution by Cegetel.rss of a new medical messaging service, called "Sentinelle", fully supporting the patient envelope protocol and adapted tools. After this milestone, EDI-Santé is promoting further developments based on ebXML and SOAP (Simple Object Access Protocol) in specifying exchange (see, items 1 and 2 below) and medical (see, items 3 and 4 below) properties: (i) Separate what is mandatory to the transport and the good management of the message (e.g., patient identification from what constitutes the "job" part of the message. (ii) Provide a "container" for the message, collecting the different elements, texts, pictures, videos, etc. (iii) Consider the patient as the unique object of the transaction. Such an exchange cannot be anonymous. It concerns a sender and an addressee who are involved in the exchange and who are responsible. A patient can demand to know the content of the exchange in which (s)he is the object, which implies a data structure which is unique in the form of a triple {sender, addressee, patient}. (iv) The conservation of the exchange semantics. The information about a patient is multiple in the sense that it comes from multiple sources and has multiple forms and

3.5.2 Trends in services and applications: medium term (3-6 years)

Mapping / translation / matching / aligning (heterogeneity)

There is an emerging line of applications which can be characterized by their dynamics (e.g., agents, peer-to-peer systems, web services). Such applications, on the contrary to traditional ones, require a run-time matching operation and take advantage of more "explicit" conceptual models. Let us discuss some of them.

P2P Databases. P2P networks are characterized by an extreme flexibility and dynamics. Peers may appear and disappear on the network, their databases are autonomous in their language, contents, how they can change their schemas, and so on. Since peers are autonomous, they might use different terminology, even if they refer to the same domain of interest. Thus, in order to establish (meaningful) information exchange between peers, one of the steps is to identify and characterize relationships between their schemas. Having identified the relationships between schemas, the next step is to use these relationships for the purpose of query answering, for example, using techniques applied in data integration systems, namely Local-as-View (LAV), Global-as-View (GAV), or

Global-Local-as-View (GLAV) [Lenzerini, 2002]. However, P2P applications pose additional requirements on matching algorithms. In P2P settings an assumption that all the peers rely on one global schema, as in data integration, cannot be made, because the global schema may need to be updated any time the system evolves (see [Giunchiglia, Zaihrayew, 2002]). Thus, if in the case of data integration schema matching operations can be performed at design time, in P2P applications peers need a means of coordinating their databases on the fly, therefore requiring a run time schema matching operation.

Agents and Semantic Web

Agent Communication. Agents are computer entities characterized by autonomy and capacity of interaction. They communicate through speech-act inspired languages which determine the ”envelope” of the messages and enable agents to position them within a particular interaction context. The actual content of messages is expressed in knowledge representation languages and often refers to some ontology. As a consequence, when two autonomous and independently designed agents meet, they have the possibility of exchanging messages, but little chance to understand each other if they do not share the same content language and ontology. Thus, it is necessary to provide the possibility for these agents to match their ontologies in order to either translate their messages or integrate bridge axioms in their own models (see [van Eijk, de Boer, van de Hoek, Meyer, 2001]). One solution to this problem is to have an ontology alignment protocol that can be interleaved with any other agent interaction protocol and which could be triggered upon receiving a message expressed in an alien ontology. As a consequence, agents meeting each other for the first time and using different ontologies would be able to negotiate the matching of terms in their respective ontologies and to translate the content of the message they exchange with the help of the alignment.

Semantic Web services

Web Services Integration. Web services are processes that expose their interface to the web so that users can invoke them. Semantic web services provide a richer and more precise way to describe the services through the use of knowledge representation languages and ontologies.Web service discovery and integration is the process of finding a web service able to deliver a particular service and composing several services in order to achieve a particular goal (see [Paolucci, Kawmura, Payne, Sycara, 2002]). However, semantic web service descriptions have no reason to be expressed by reference to exactly the same ontologies. Henceforth, both for finding the adequate service and for interfacing services it will be necessary to establish the correspondences between the terms of the descriptions. This can be provided through matching the corresponding ontologies. For instance, if some service provides its output description in some ontology and another service uses a second ontology for describing its input, matching both ontologies will be used for (i) checking that what is delivered by the first service matches what is expected by the second one, (ii) verifying preconditions of the second service, and (iii) generating a mediator able to transform the output of the first service in order to be input to the second one.

We expect these applications to play an important role starting from the medium term, since the necessary technologies (e.g., run-time matching) will not mature or converge earlier to support scalable solutions in, e.g., B2B, supply chains.

Semantic community portal and social networking
A recent trend comprises very popular portals allowing communities to create their own vocabularies and tag the items/information they want to exchange with arbitrary tags from their vocabularies. The following applications fall in category of such portals:

- http://del.icio.us – This community portal allows communities to tag, share and search their bookmarks;
- www.43things.com and www.43places.com – These community Web portals allow description by community-created tags and sharing information about the things people do (www.43things.com) and about the places where people travel or want to travel (www.43places.com).
- www.flickr.com – This community portal allows community members to tag with arbitrary tags, search for and share photos.
- http://base.google.com – This community application was recently launched (in November 2005) and provides the most advanced community-driven functionalities among the portals mentioned above. The application allows regular Web user to contribute their arbitrary items (pictures, text, ads, web-sites) for searching and sharing and to annotate these items using pairs of an arbitrary attribute and an arbitrary value. Most popular/shared attributes and attribute values come up in the upper level of Google search interfaces and are proposed to be used for searching and browsing the available items.

Though none of the portals above is directly based on Semantic Web technologies, they clearly show the massive trend of the Web in becoming more structured and annotated in a community-driven manner, via social processes and contributions of regular Web users. Certain portals also start to employ semantic technologies to reach their communities. For example, www.43places.com provides RSS feeds to get updates on the information appearing at the portal, e.g., on entries about a particular place, entries from a particular user, etc.

Semantic browsing and learning
Semantic browsing and learning portals will continue to be an invaluable means of providing computational assistance to learners, whether they are following a prescribed course or not, and to anyone battling the seemingly unstoppable flood of available information. For instance, they may be used by course developers as a means of accessing and arranging a set of resources into some narrative thread with central pathways and interesting but elusive byways. We are currently looking at how to abstract the structure of learning narratives in order to produce a high-level layer of semantics reusable within different domains. We are designing an application that allows the semantic annotation of philosophical resources, with the aim of supporting the automatic creation of learning narratives through the inserted material. As part of this framework, we are building a domain ontology covering fundamental philosophical concepts. The semantic relationships between these domain concepts will allow the formalization of

specific learning narratives in a second ontology. So, for example, ways to browse this semantic space can be (at a high level):

- the *critical explanation* of a concept/theory (a learning path that highlights opposing theories, and the problems on which they are focused);
- the *contextualization* of a concept/theory (a learning path that shows associated information about an author, or the historical period, or other contemporary important theories in different research areas);
- the *production* of an author (a learning path that collects all the activities and results of an author, and organizes them according to user's preferences);
- the *intellectual lineage* of a concept/theory (through a learning path that follows the influence of ideas across different areas and historical periods).

In a second phase, these results will be generalized and the framework extended to other subjects of educational courses, in order to define what the abstract features of a learning narrative are.

3.5.3 Trends in services and applications: long term (6-12 years)

Mapping / translation / matching / aligning (heterogeneity)
It is hard to see what is going to happen in the long term, since semantic web in particular and computer science in general are very dynamic and continuously evolving fields. Of course, in the long term, we expect different variations (e.g., P2P trading grid) of the applications mentioned so far. However, as one of the new possible scenarios, we could see embedding of the semantic matching services inside operation systems.

Semantic community portal and social networking
Semantics and Communities will get to Physical Worlds. Semantics and communities will be merged with robotics and mobile communication. This trend will take away routine tasks from a person by delivering many helpful gadgets, e.g. kitchen appliances acting on your behalf. For example, your fridge will be online finding out from fridges of your friends and friends of your friends which nice food is available around. Then your fridge will order needed food for you with a minimum of expenses, via a Web agent working with food distributors.

Semantic browsing and learning
Semantic browsing and learning systems descendants, in addition to their pedagogic role, will increasingly form part of all interactions with information. ASPL-like systems will initially be incorporated into ALL web browsers. However, as computing becomes ubiquitous and computational machinery becomes part of the everyday world with on-demand interfaces for input and display, ASPL-like systems will form an essential component of their infrastructure in providing contextualized, tailored information in a contextualized, tailored form. We will no longer interact with raw information – we will interact with the representations provided by ASPL-like services in a Gibsonian cyberworld which is at once pleasurable, productive and pedagogically sound.

4. Market and Social Trends

The practical web is about automating the assignment of semantics to unstructured content to realize the vision of the semantic web. If well done, the results will be synergistic with the motors of web expansion: user value and commercial value [Spector, 2005].

Thus, the aim of this section is to describe the changes in societies and the world economy that result from dramatically increased international trades and cultural exchanges. In particular the falling of economical, commercial and social barriers among countries have transformed business in a global market, supported by improved technology, information and communications systems.

In dynamic markets (characterized by specialization of work, outsourcing processes, just in time and distributed productions, etc.) firms have moved to intra-organizational networks among strategic units, divisions, groups, and so on; and inter-organizational networks, such as industrial districts, outsourcing, offshoring [Hamel and Prahalad, 1990]. Therefore the production is based on the coordination of a constellation of units, some of which are part of the organization (administration, R&D, etc.) and others refer to different companies (such as specialized outsourcing production, logistics, etc.). All these units might not totally be controlled by a unique subject, and might grow and differentiate their activities in an autonomous way, coexisting as in a bio-functional system [Maturana and Varela, 1980] and creating unexpected combinations of processes, products, and knowledge [Chandler, 1962; Ashby, 1956; Numagami, Ohta, Nonaka, 1989; Purser and Pasmore, 1992].

From a knowledge management point of view, the need for sharing knowledge among units in a very complex organization, or among networked organizations, increases the importance of introducing new information communication technologies and effective knowledge management systems. Considering technology as a non-neutral organizational asset [Giddens, 1984; Orlikowski, 1991], the distributed nature of knowledge should be taken into account. Coordination among autonomous units (i.e. community or an informal social group [Lave and Wenger, 1991, Wenger, 1998, Starbuck, 1992; Brown and Duguid, 1991]. should satisfy two different needs:

- supporting the creation of specialized knowledge within a unit. Knowledge is created in a social and cultural environment which has impact on the beliefs and behaviours of the community's members [Wenger, 1998]. Knowledge is reified within physical, mental, and cultural artifacts, which stem from members participation. These artifacts are not a neutral organization of information but reify and reflect specific community perspectives [Boland and Tenkasi, 1995], and cognitive paths [Weick, 1979; 1993].
- enabling the coordination of knowledge (and activities through which knowledge is exchanged) among units. In dynamic and very specialized markets, units need to preserve their competitiveness through the coordination of their work and business processes. This requires the ability of sharing knowledge across units (with boundary objects and knowledge brokers [Bowker and Star, 2000; Wenger, 1998]), and using this knowledge to achieve complex results in a coordinated way.

These dual needs reflect the tension between the necessity for both highly specialized organization of work and flexible inter-group cooperation within and outside the organizations. This is reflected in the duality between the need for highly articulated local perspectives that make up the communication and knowledge creation tissue of each community, and the need for sharing cultures and instruments that allow communication across different units [Mark et al., 2002].

In this section the argumentation is adressed by the nature of industries that will use semantic web services and applications. In particular the focus will be on worldwide organizations, because they need to share knoweldge across the whole world.
The classification adopted in this section refers to the economical nature of organizations. Although the primary sector (i.e. agricolture, cultivation) is not considered, the secondary sector (e.g. production) and the service sectors are considered very relevant. Specifically the following sectors are considered in the KWTR. In this deliverable only a few of them are analyzed:

- secondary sector (production):
    - food industry;
    - aerospace;
    - vehicles and cars;
    - constructions (building industry);
    - computers and electronics;
    - energy;
    - luxury goods;
    - health care and pharmaceutical;
    - software vendors;
- tertiary sector (services)
    - banking and finance;
    - transportation and logistics;
    - public services and administration (e-procurement, e-governement);
    - media and telecommunications;
    - business consultants;
    - law domain (such as copyright problems, crimes, cyber-crimes etc.);
    - web and public relation domain;
    - consultancy (knowledge management, business processes reingeneering).

4.1 Trends in markets and society

In this section we describe some aspects on globalization and organizational networks.
Globalization[14] (or globalisation) describes the increase of trade and investing due to the falling of barriers and the interdependence of countries. Usually it refers almost exclusively to the liberalization or "free trade". Between 1910 and 1950, a series of political and economic upheavals dramatically reduced the volume and importance of international trade flows. But starting with the First World War and continuing through

[14] Source Wikipedia.

Second World War, globalization trends have been fostered by international economic institutions and rebuilding programs. With the 1970s, the effects of this trade became increasingly visible, both in terms of daily benefits and disruptive effects.

Although all three aspects are closely intertwined, it is useful to distinguish economic, political and cultural aspects of globalization. The other key aspects of globalization are changes in technology, particularly in transport and communications. In this deliverable only a few of them will be deeply analyzed.

4.1.1 The socio-economical trend

In this section, a few socio-economical trends are described. In particular, the deliverable focuses on: (i) the social impacts of Net-Economy, (i) ethical problems of the net-economy paradigm, (iii) the relationships between users and network, and (iv) the relationship between organizations and networks.

Net-Economy: the convergence of the new business needs.
Due to the complexity of both human activities and knowledge growth, firms are driven to find new organizational and business models based on the socio-technical infrastructure of the network. Firms connect to a network involved in multiple-interactions where they could share their business experiences [Rullani, 2001].
The Internet and the inter/intra firms relationship management ties the industrial and information economies together to create the Net-Economy, an environment with a brand new set of operating principles underscored by a whole new set of economic realities. It is the virtual arena in which: (i) business is conducted, (ii) value is created and exchanged, (iii) transactions occur, and (iv) one-to-one relationships mature. These processes may be related to, but are nevertheless independent of, similar activities occurring in the conventional marketplace.
In other words the value chains are becoming more virtual and technological-informational integrated (e-procurement systems), electronic relationships are emerging between users and vendors (business to consumer systems) and producers and sellers (business to business systems). As depicted in the Figure 6, thanks to Net-Economy smart methods, products and services are proliferating (VoIP tools, Messenger tools, Bolgs and WebBlogs Figure 7).

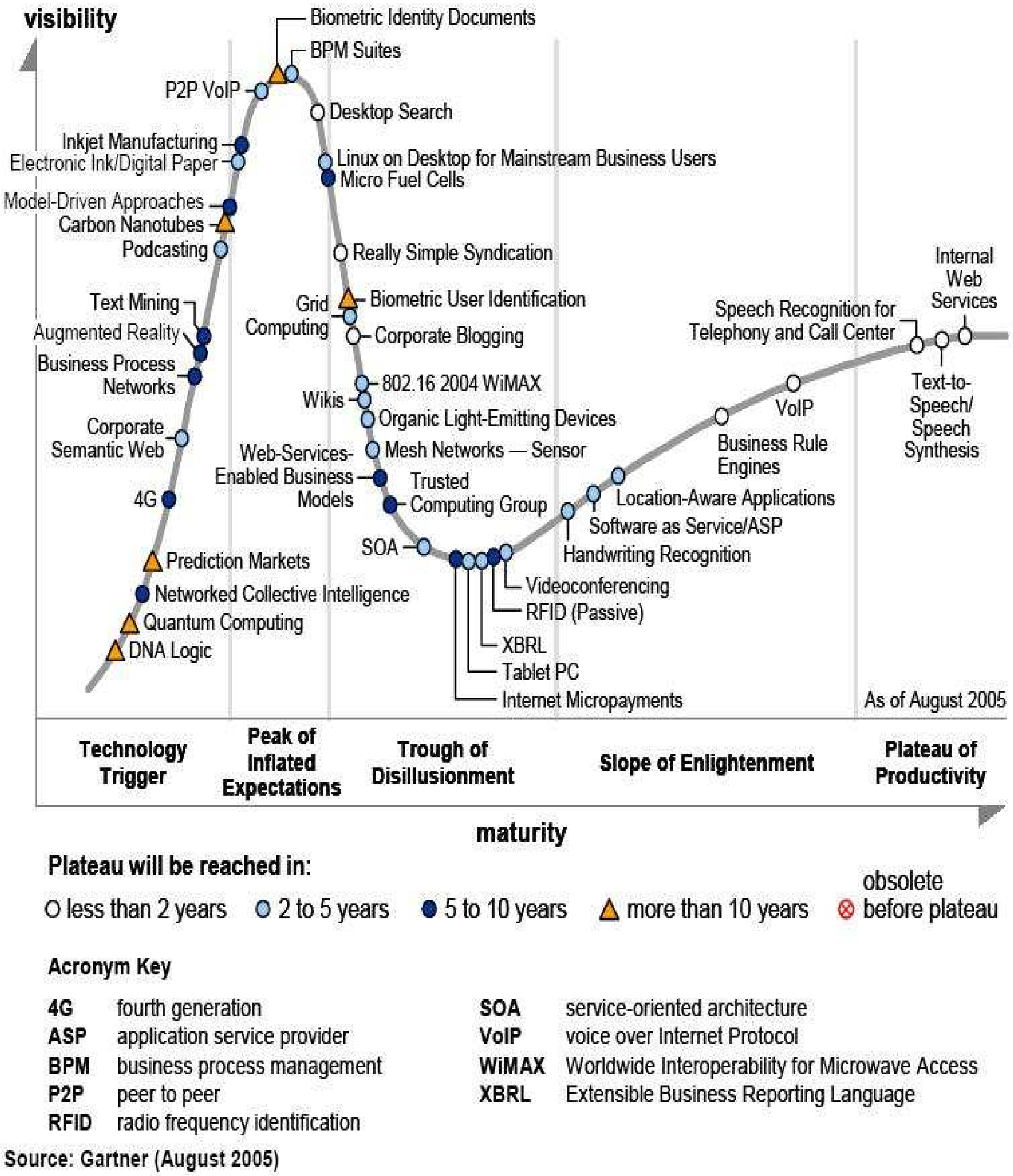


Figure 6. Trends of products and services (source Gartner Group, Hype Cycle for Emerging Technologies, 3 August 2005)

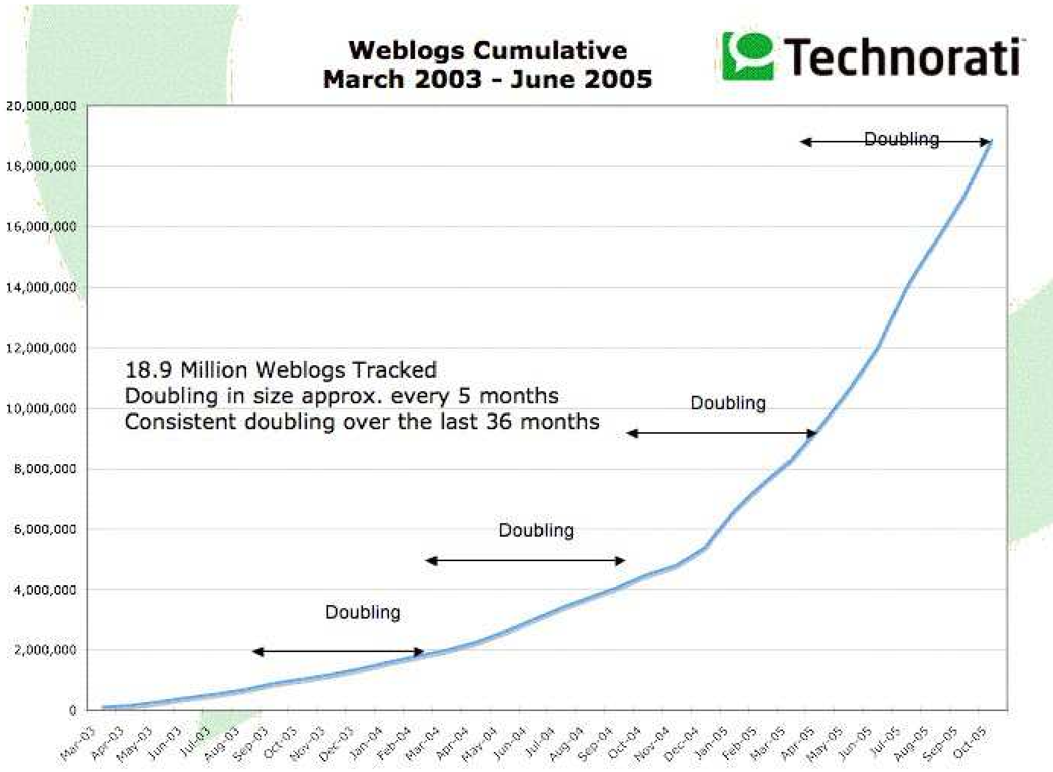


Figure 7. Trend of Blogs and Weblogs (source Technoarti, 2005)

Ethical problem in Net-Economy paradigm

E-democracy[15] is a neologism meaning "of electronic democracy", in other words it refers to the use of electronic communications technologies in enhancing democratic informative processes. The Internet is viewed as a platform that helps people to eliminate some of the distance constraints in direct democracy. Consider, for instance, the multimedia communication services that only very recent and expensive radios, televisions and telephones are offering.

The term e-democracy is both descriptive and prescriptive. Typically, the kinds of enhancements sought by proponents of e-democracy are framed in terms of making processes more accessible; making citizen participation in public policy decision-making more expansive and direct so as to enable broader influence in policy outcomes (i.e., more heads involved could yield smarter policies); increasing transparency and accountability; and so on. Concluding some of the answers that w-democracy tries to overcome are: "*Nowadays a firm should compete in a business global system and to understand that its performances depended by its network. How does it support its network? What kind of technology? In this context how is user role? What are changes in user interaction?*"

[15] Source Wikipedia.

Some important industries and fields in which changes are forecasted are: e-government, cyber-law, e-security, health care, and e-learning.

Users and Network

Eric von Hippel [2002] asserts that innovation developement, production, distribution and consumption networks can be built up among actors. Namely, user innovation networks can function entirely independently of manufacturers when (1) some users have sufficient incentives to innovate, (2) some users have an incentive to voluntarily reveal their innovations, and (3) diffusion of innovations by users is low cost and can compete with commercial production and distribution [von Hippel, 2002]. These user-centic innovations have a great advantage over the traditional manufacturer-centric innovation development systems. They enable each user, or group of users, to develop exactly what he/she wants rather than being restricted to available marketplace choices. Moreover, users do not have to develop everything they need on their own: they can benefit from positive network externality (innovation developed by other members and freely shared within user network) [von Hippel, 2002].

DBin is a novel kind of personal application which enables users to experience the Semantic Web by participating in P2P "discussion groups" and exchanging metadata and annotations about common
topics of interest. The p2p transport layer is provided by the RDFGrowth algorithm which has characteristics of scalability and sustainability even in large real world communities. DBin is fully based on the syntax, semantics and philosophy of the W3C Semantic Web initiative and accommodates both a novel, domain scriptable user interface and a number of experimental modules to deal with specific kinds of metadata and information sources (audio metadata extraction, textual analysis,
desktop integration). DBin includes an RDF subgraph digital signature facility enabling personalized trust policies to provide filtering out unwanted information. Maximum extendability is guaranteed by the use of the Eclipse Rich Client platform and by the Open Source model.
Source : The DBin platform: toward a personal tool to experience the Semantic Web Giovanni Tummarello, Christian Morbidoni, Francesco Piazza, Paolo Puliti in Proceedings of SWAP 2005, the 2nd Italian Semantic Web Workshop, Trento, Italy, December 14-16, 2005, CEUR Workshop Proceedings, ISSN 1613-0073, online http://ceur-ws.org/Vol-166/67.pdf.

Networked Users:
Virtual Communies, communities of practices and network of practices

The term "virtual community[16]" [Rheingold, 1993] is traditionally considered a group of people that share knowledge, ideas, prectices through computer-mediated communication such as: Usenet, MUDs (Multi-User Dungeon) and their derivatives MUSHes and MOOs, IRC (Internet Relay Chat), chat rooms and electronic mailing lists. Today, "virtual community" is loosely used and interpreted to indicate a variety of social groups connected in some ways by the Internet. It does not necessarily mean that there is a strong bond among the members. The explosive diffusion of the Internet into some countries

[16] Source Wikipedia.

such as the United States was also accompanied by the proliferation of virtual communities. The nature of those communities and communications is rather diverse, and the benefits are not necessarily realized, or pursued, by many. At the same time, it is rather commonplace to see anecdotes of someone in need of special help or in search of a community benefiting from the use of the Internet.

> An email distribution list on Star Trek may have close to one hundred members, and the communication which takes place there could be either one-way (the list owner making announcements) or merely informational (questions and answers are posted, but members stay relatively strangers and uninterested to each other). The membership turnover rate could be high. This is in line with the liberal use of the term community.
>
> In the next version of the KWTR a case study about linked-in, orkut, or flink will be provided.

The concept of a Community of Practice[17] (often abbreviated as CoP) refers to the process of social learning that occurs when people who have a common interest in some subject or problem collaborate over an extended period to share ideas, mental models, practices, find solutions, and build innovations. The term “community of practices” was first used in [Lave and Wenger, 1991]. The authors used it in relation to situated learning as part of an attempt to "rethink learning" at the Institute for Research on Learning. In 1998, the theorist Etienne Wenger (website) extended the concept and applied it to other contexts, including organizational settings.
The members of a CoP build up an agreed set of communal resources is over time. This "shared repertoire" of resources represents the material traces of the community. Written files can constitute a more explicit aspect of this common repository although more intangible aspects such as procedures, policies, rituals and specific idioms may also be included [Wenger, 1998]. All this documentation is presented and organized according the community’s perspective. More recently, Communities of Practice have become associated with knowledge management as people have begun to see them as ways of developing social capital, nurturing new knowledge, stimulating innovation or sharing existing tacit knowledge within an organization. It is now an accepted part of organizational development.

The strength of the Network of Practice (NoP) model is that these networks can extend beyond the organization where the individual is situated. Brown and Duguid (2000) propose that the network of reps could be extended to include technicians in other companies, though they suggest that these links may be weaker, with less ground for common understanding. These links reflect the flow of knowledge that exist through the surrounding knowledge ecology [Brown and Duguid, 2000].
The network of practice is a sort of model for fast knowledge diffusion and assimilation over a wide network. The CoP model also provides a home for the identities of the

[17] Source Wikipedia.

members through the engagement in the combination of new types of knowledge and the maintenance of a stored body of collective knowledge.

> EduOntoWiki
>
> The main functions of EduOntoWiki provide a community tool kit to create/modify ontological structures. There is an "ontology moderator" who tries to mediate between people, in order to carefully implement the ontology concepts. This kind of figure is required because it can assure a shared vision, so ontologies reveals important *sideeffects*: first a definition of a common lexicon [Wenger, 1998], second to enable the explicitation of tacit knowledge, and last, a shared meta-model with relations between concepts. The functions are related to: Instances of Ontology, Relationship among Concepts and Social Networks.
> Each person subscribed to EduOntoWiki can fill in a personal description form, along the lines of the FOAF semantic standard, which allows you to declare your affiliation to more than one community of practice and/or learning.
>
> Source: EduOntoWiki: The Evolution of an Ontology on Educational Sciences Towards a Socio-Relational Environment Luciano Galliani, Corrado Petrucco, Anna Nadin, in Proceedings of SWAP 2005, the 2nd Italian Semantic Web Workshop, Trento, Italy, December 14-16, 2005, CEUR Workshop Proceedings, ISSN 1613-0073, online http://ceur-ws.org/Vol-166/62.pdf.

Organizations and Networks

In both intra and inter-organizational networks, the production is based on the coordination of a constellation of units, some of which refer to different companies. All these units might not totally be controlled by a unique subject, and might grow and differentiate their activities in an autonomous way.
In facts a firm aims at the success of its core business and develops its relationships with other business actors by collaboration systems on the value chain.

Networked organizations

The Networked Organization is a term that is used to describe a variety of new emergent organizational structures such as virtual and learning organizations. In this case we view the networked organization as an organizational structure that relies on multiparty co-operative relationships between people across structural, temporal and geographic boundaries based on the existence of dense networks of flexible communications [Ashkenas, Ulrich, Jick, Kerr, 1995].
This can be organized in different ways as: industrial district, virtual corporation, network of practices, outsourcing relationships, virtual supply chain, etc.
The industrial district is a local area characterized by high level of industrial concentration with high level of labour specialization into the same value chain and distributed productions.
The virtual corporation[18] is a firm that outsources the majority of its functions. The term was a buzzword in the 1990s, and became popular during the dot-com era, when demand

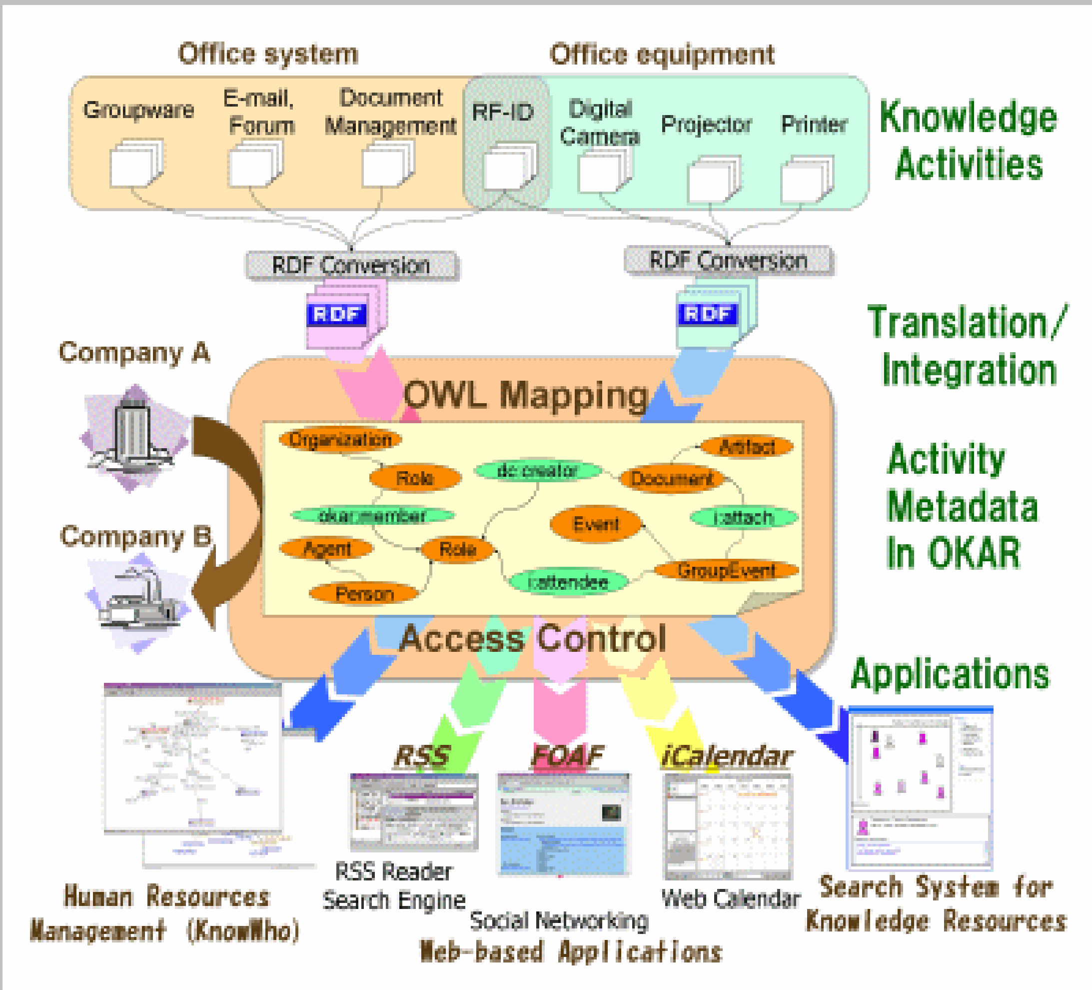
[18]Source Wikipedia.

was high for a new kind of services that traditionally organized companies relied on outsourcing to perform. Thus, the existence of the Internet helped facilitate communication and cooperation across this web of contracts.
Typically, a small group of executives will contract out and then coordinate the designing, making, and selling of products or services. In theory, this allows small groups of knowledgeable executives to find the lowest supplier for any given service, and to concentrate solely on the "big picture". In theory, it also allows firms to be nimble, rapidly ramping up production without having to slowly develop people and competencies. In practice, virtual firms are scarce due to the difficulties in constructing elaborate contracts that specify the distributions of profits, and because the short-term profit-centered relationships implied by the virtual structure discourage co-operation among the parts of the organization. Moreover, the contracts often fail to effectively measure the ephemeral quality. As a result, there is a tendency for suppliers to defect (in prisoner's dilemma parlance) by providing products that are "up to specs", but that fall short of rigorous quality standards.

RAP (Remote Assistant for Programmers) is a Web and multi-agent based system to support remote students and programmers during common projects or activities based on the Java programming language. RAP helps users to solve problems proposing information extracted from dedicated repositories and forwarding answers received from other users, recommended as experts. Its peculiar characteristic is the integration of the agent technology with the semantic Web technology. In fact, in order to improve filtering and recommendation techniques, RAP takes advantage of an ontological approach to user and document profiling. A RAP system is not a closed system, instead it is based on a dynamic network of RAP platforms managing groups of geographically localized users and documents. Therefore, recommendations should take into account of the accessible experts and documents. For this purpose, RAP users and documents profile management subsystems providing a mechanism that dynamically adapts the relevance of each profile. An initial prototype of the RAP System is under development by using JADE.

Source: Ontology-Based Remote Collaboration for the Development of Software System, M. Mari, A. Poggi, P. Turci in Proceedings of SWAP 2005, the 2nd Italian Semantic Web Workshop, Trento, Italy, December 14-16, 2005, CEUR Workshop Proceedings, ISSN 1613-0073, online http://ceur-ws.org/Vol-166/20.pdf.

OKAR (Ontology for Knowledge Activity Resources) is a format to describe knowledge activity information. Fujitsu Laboratories and Ricoh have jointly developed the format using Semantic Web technology, the base technology for the next generation Web. The goal of OKAR is to support improved productivity and knowledge creation in the office.
Merits of OKAR: (i) Shared information of knowledge activity based on various systems and equipment. (ii) Automatic information storage of knowledge activity. (iii) Sharing of knowledge among organizations.
OKAR provides (i) Descriptions of knowledge activities OKAR codes basic information and the interrelationships between "people" and "things" that appear to be common to various work activities. (ii) Integration with heterogeneous systems and information equipment OKAR enables storage of information from heterogeneous systems and equipment and relates them mutually, since it is defined using Web Ontology Language (OWL). (iii) Exchanging knowledge activity metadata between different companies OKAR enables the exchanging of knowledge activity metadata between different companies by supporting integration with various systems and describing information that commonly appears in various knowledge activities.



Source: http://www.labs.fujitsu.com/en/techinfo/okar/

Organizational Outsourcing

Outsourcing is defined as the delegation of non-core operations or jobs from internal production to an external entity (such as a subcontractor) that is specialized in that operations. Namely it is the management and/or day-to-day execution of an entire business function by a third party service provider.

Outsourcing always involves a considerable degree of two-way information exchange, co-ordination, trust, and managerial responsibility for running a segment of business. Business segments typically outsourced include information technology, human resources, facilities and real estate management and accounting. Many companies also outsource customer support and call centre functions, manufacturing and engineering.

The logical extension of these decisions was of outsourcing labour overseas to countries with lower labour costs, this trend is often referred to as offshoring of customer service.
An example is outsourcing processes for call centres in India, Pakistan, the Philippines, Canada and even the Caribbean. Many companies, most notably Dell and AT&T Wireless, have obatained effective services, reducing costs. Although, they endure significant negative publicity for their decisions to use Indian and Pakistani based labour for customer service and technical support. One of the most prominent complaints is the expectation that the replacement staff will have more trouble communicating with customers.

Outsourcing generally identifies some other specific transfer of jobs to other countries, either by hiring local subcontractors or building a facility in an area where labour is cheap. As depicted in the Figure 8 the sectors that have outsourced more services are: automotive, machinery, pharmaceutical, publishing, and textile.

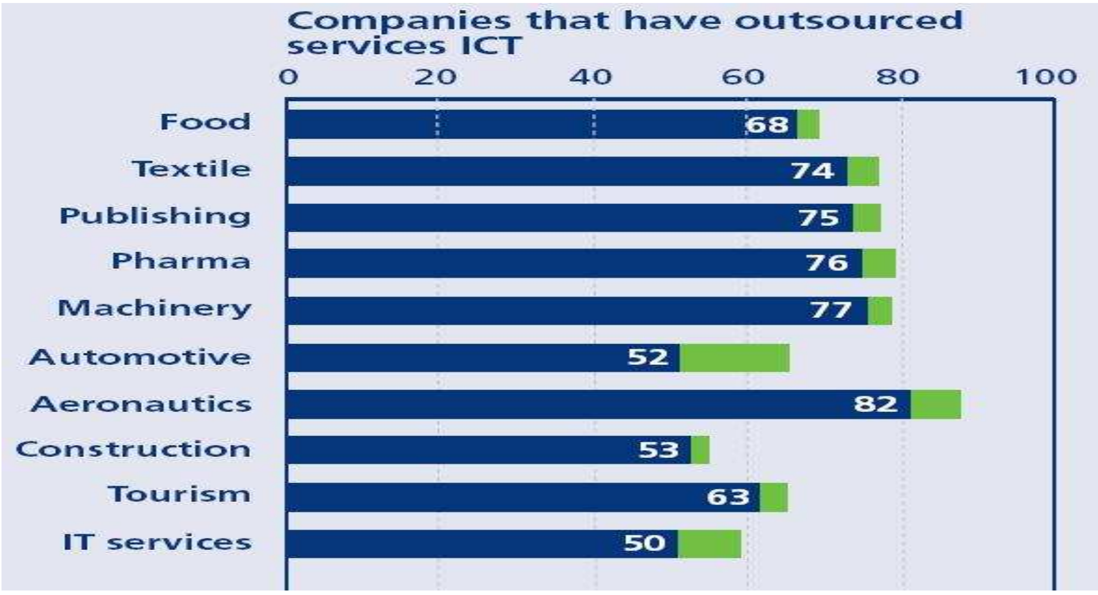


Figure 8. E-Business survey (source *e-Business W@tch,* 2005)

Due to the distances of production units, all the processess of product design, productions, purchasing, logistic are managed online. In the following paragraph the e-commerce is discussed.

Supply chain and virtual supply chain

The traditional supply chain[19] is a system of linear links among suppliers, manufacturers, warehousing, logistics, retailers and the end customer. Its aim is to aggregate skill and resource pool with the goal of delivering a product or service. It encompasses all activities and the flow of information both up and down the chain and is associated with the transformation of a product from raw materials through to a finished product, and post selling services.

Nowadays, outsourcing processes, networked design and productions, radically change the supply chain. It becomes a virtual supply chain, through which different sources of information are integrated in order to sustain a complex and distributed flow of prodution.

Supply chain management (SCM)[20] is the process of planning, implementing, and controlling the operations of the supply chain with the purpose of satisfying customer requirements as efficiently as possible. Due to radical innovation and changes, the supply chain management must address the following problems:

- manage a distributed newtork of suppliers, production facilities, distribution centers, warehouses, and customers;
- manage a common strategy of distribution due to descentralized storage, direct shipment, third party logistics, etc.;
- manage heterogeneous information: integrate systems and processes through the supply chain including demand signals, forecasts data, inventory information;
- manage the storekeeping: quantity and location of products, including raw materials, work-in-process, and finished goods. All these information are typically managed according to different languages and semantics which depend on the vendors system of information.

Usually, supply chain management systems are not semantic based. However they are widely used in a lot of sectors (as depicted in Figure 9)

[19] Source Wikipedia

[20] Source Wikipedia.

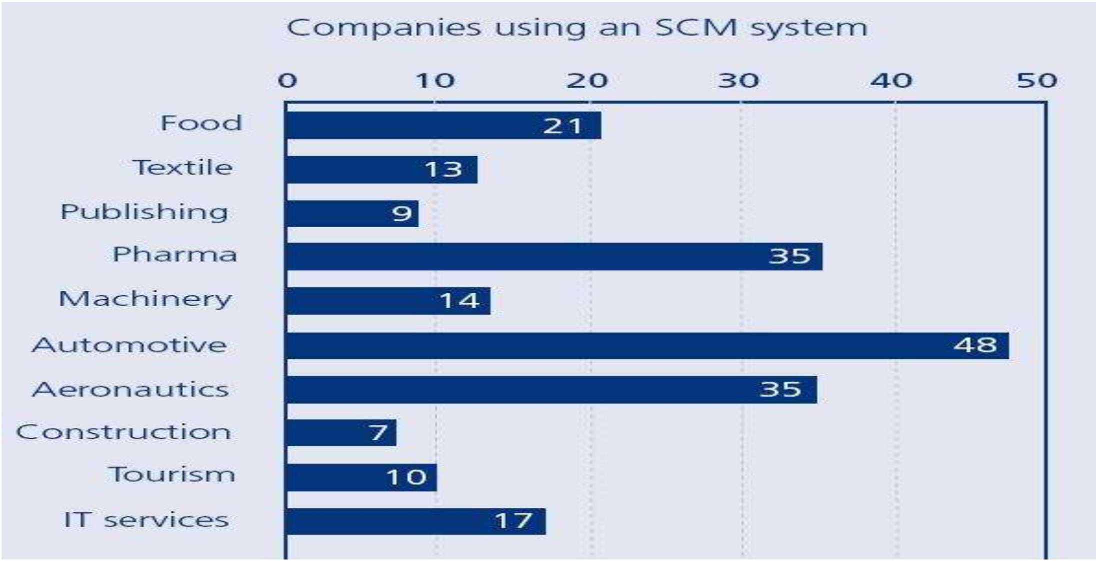


Figure 9. Companies using SCM systems (source *e-Business W@tch*, 2005)

E-business

The intensity of electronic business (in its different forms, business to business, business to consumer, business to government, etc.) differs widely between sectors, particularly between manufacturing and service sectors (primary and seconday sectors). As depicted in Figures 10 and 11, the e-Business Index 2005 shows that (among the 10 sectors surveyed) e-business activity is most advanced in information technology services, the automotive, aeronautics and pharmaceutical industries.

As discussed above, the rapid development of e-business in the leading manufacturing sectors is mostly driven by their large international companies. Virtual supply chains (supply chains integrated with networked organizations) are forcing the adoption of e-business solutions.

	Make online purchases		... of those: Online purchases <5%		Online purchases 5-25%		Online purchases 26-50%		Online purchases >50%		Use specific ICT systems for e-sourcing	
Weighting	firms	empl	firms	empl.	firms	empl.	firms	empl.	firms	empl.	firms	empl.
Total (EU-7)	**44**	**51**	**42**	**47**	**34**	**34**	**11**	**11**	**13**	**8**	**11**	**19**
By sector (EU-7)												
Food & beverages	22	43	67	62	28	29	4	5	1	4	5	18
Textile & clothing	30	44	62	65	31	29	4	3	3	4	8	14
Publishing & printing	48	57	41	44	41	39	11	6	7	12	8	16
Pharmaceutical	38	48	50	40	32	44	8	8	11	8	14	32
Machinery & equipment	36	53	50	59	39	32	7	7	4	2	10	18
Automotive	41	60	58	44	30	52	7	<1	5	3	13	39
Aeronautics	65	43	44	12	39	83	7	<1	10	4	16	63
Construction	36	43	53	59	40	32	3	5	4	3	9	16
Tourism	49	57	40	38	32	32	16	20	12	11	14	14
IT services	81	76	21	22	26	30	18	25	36	24	19	29

Figure 10. European companies that use e-business solutions
(source *e-Business W@tch*, 2005)

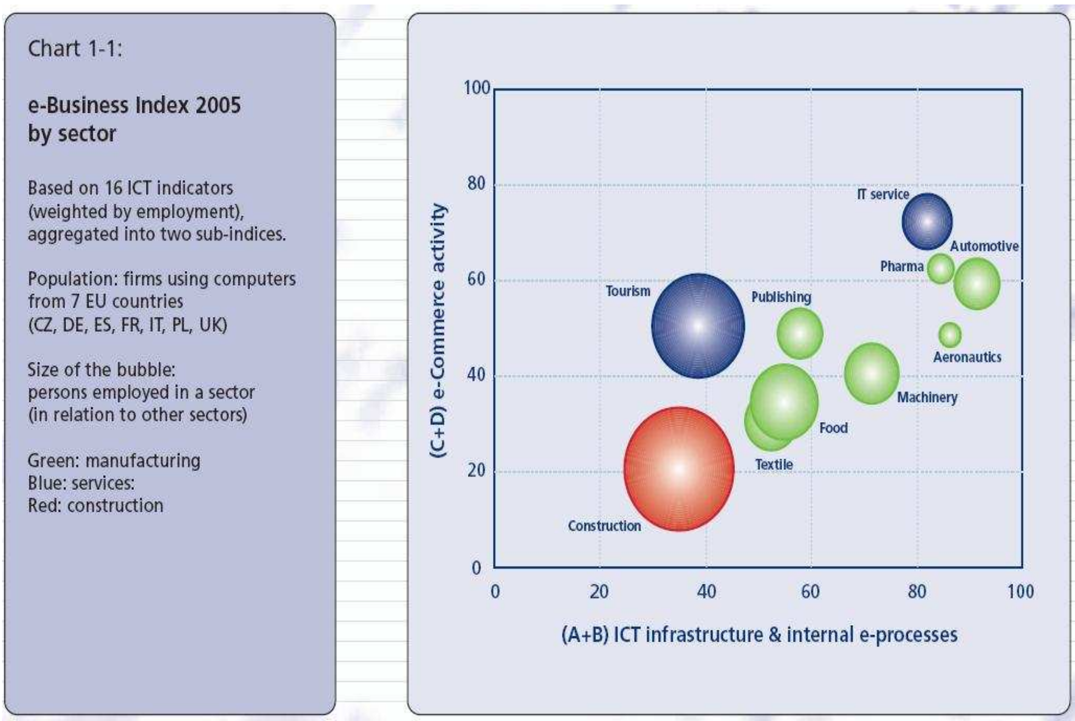


Figure 11. European companies index by sector (source *e-Business W@tch*, 2005)

Electronic business is mainly based on the exchange of information between involved stakeholders using a telecommunications infrastructure. There are two main scenarios: Business-to-Customer (B2C) and Business-to-Business (B2B), Business-to-Government, etc.. In particular B2C applications enable service providers to promote their offers, and for customers to find offers which match their demands. By providing unified access to a large collection of frequently updated offers and customers, an electronic marketplace can match the demand and supply processes within a commercial mediation environment. As depicted in Figure 12 some information technologies can be used to analyze consumers' needs. They are called customer relationship management (CRM) systems.

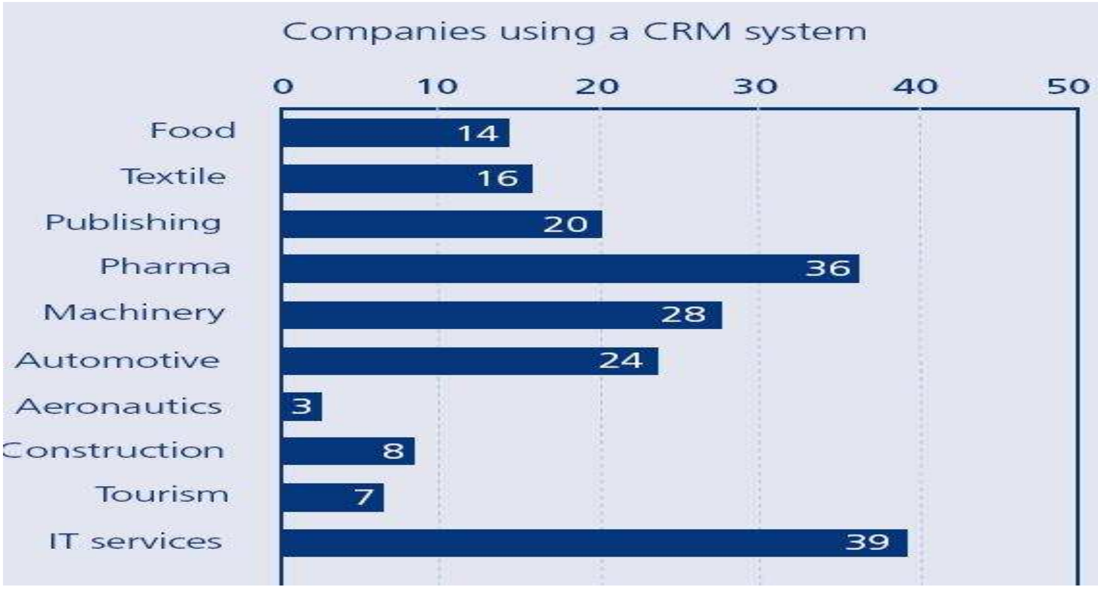


Figure 12. European companies using CRM systems (source *e-Business W@tch*, 2005)

Or as described by Figure 13, information technologies can be used for maketing processes, such as one to one marketing, etc.

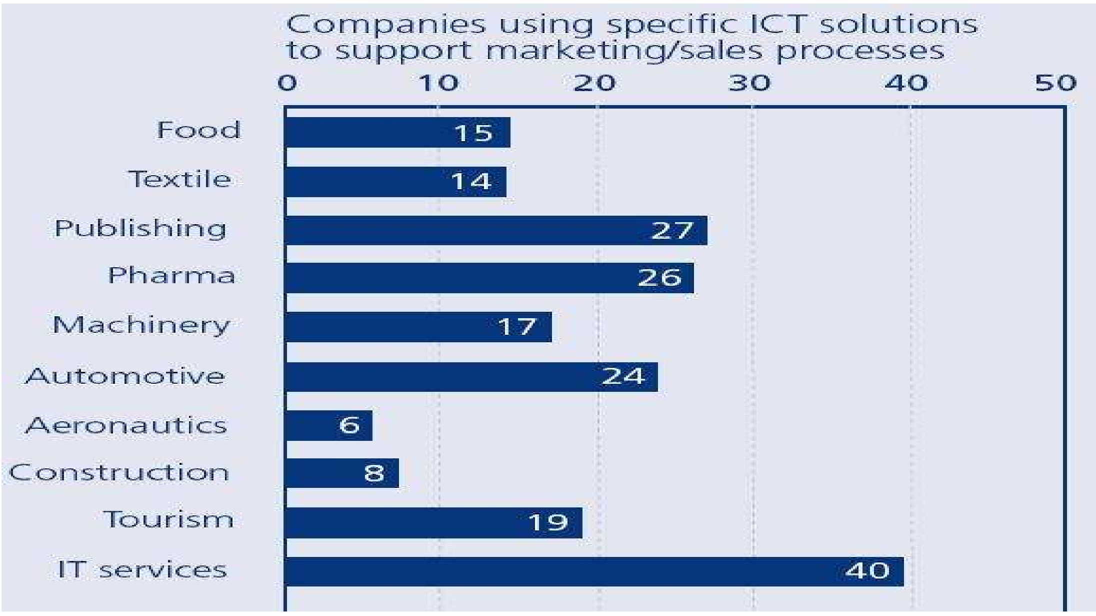


Figure 13. European companies using specific ICT solution for marketing/sales processes (source *e-Business W@tch*, 2005)

In all these areas, the semantic web approach seems very relevant. In particular organizations have to manage personalized information, in order to address effective strategies of selling.

A semantic based approach has the potential to significantly *enable interoperability at the business level*, reducing the need for standardisation at the technical level. This will enable services to adapt to the rapidly changing online environment. The following uses for ontologies and classification schemes that could be defined using ontologies have been noted within electronic commerce applications:

- Categorization of products within catalogues;
- Categorization of services (including web services);
- Production of yellow page classifications of companies providing services;
- Identification of countries, regions and currencies;
- Identification of organizations, persons and legal entities;
- Identification of unique products and saleable packages of products;
- Identification of transport containers, their type, location, routes and contents;
- Classification of industrial output statistics.

Distributed cost and risk management

Distributed costs and risk management aim to reduce total cost of ownership in a distributed system of production. It is made up of cost management and risk management solutions. Cost management[21] is the process whereby companies use cost accounting to report or control the various costs of doing business.

Cost management methods and processes have been largely used and studied within organizations, and their complexity has increased. Consider for instance the increasing amount of methodologies, tools and norms for effective organizational processes [Berliner and Brimson, 1988; Kaplan, 1990; Cooper, Slagmulder and Drucker, 1999]. This complexity increases the need for specialized expertise on products and cost management methods, tools and organizational processes. This scenario is characterized by the proliferation of consultants and experts in cost reduction and management that

> Talea example.
>
> It is a platform aimed at supporting the development of web-based e-business applications. Talea supports a flexible matching between service provision and request. The platform can be easily customized thanks to XML-based communication, Semantic Web technologies, and the exploitation of a generator/performer design pattern which greatly simplifies the task of adding new functionality. Moreover, Talea provides multidevice access to both service providers and final users. An ontological description of the application domain, expressed in RDF/RDFS format, is exploited in order to facilitate the customization and to provide personalized navigation as well as semantic-based search. The ontology-driven personalized navigation is particularly useful for limited display devices (like smartphones or PDAs), since it reduces the amount of information displayed. A first evaluation of the current prototype is planned with a restricted number of users and will be carried on by the Local Tourist Organization.
>
> Source: Talea: An Ontology-based Framework for e-Business Applications Development, Guido Levi, Andrea Vagliengo, Anna Goy in Proceedings of SWAP 2005, the 2nd Italian Semantic Web Workshop, Trento, Italy, December 14-16, 2005, CEUR Workshop Proceedings, ISSN 1613-0073, online http://ceur-ws.org/Vol-166/70.pdf.

often are not employed in one unique organization. They collaborate with an increasing number of firms, have strong networks with producers and vendors, and know the new

[21]Source Wikipedia.

production technologies. This new scenario generates the proliferation of outsourcing processes of costs management which increase the need for consultancy firms specialized in different kinds of knowledge on cost management methodologies, technologies, products and services. As a result the role of knowledge becomes a very important matter and problem, unveiled by bounded rationality [March and Simon, 1958] and mainly caused by the information asymmetry between organizations (the outsource) and consultants (outsourcers), that requires solving.

Generally, Risk Management[22] is the process of measuring or assessing risk and then developing strategies to manage the risk. In general, the strategies employed include transferring the risk to another party, avoiding the risk, reducing the negative affect of the risk, and accepting some or all of the consequences of a particular risk. Traditional risk management, which is discussed here, focuses on risks stemming from physical or legal causes (e.g. natural disasters or fires, accidents, death, and lawsuits). Financial risk management, on the other hand, focuses on risks that can be managed using traded financial instruments. Regardless of the type of risk management, all large corporations have risk management teams and small groups and corporations practise informal, if not formal, risk management.

In ideal risk management, a prioritization process is followed whereby the risks with the greatest loss and the greatest probability of occurring are handled first, and risks with lower probability of occurrence and lower loss are handled later. In practice the process can be very difficult, and balancing between risks with a high probability of occurrence but lower loss vs. a risk with high loss but lower probability of occurrence can often be mishandled.

Risk management also faces a difficulty in allocating resources properly. This is the idea of opportunity cost. Resources spent on risk management could be instead spent on more profitable activities. Again, ideal risk management spends the least amount of resources in the process while reducing the negative effects of risks as much as possible.
A distribution management system is also a system of computer-aided tools used by operators of electronic distribution networks to monitor, control, and optimize the performance of the distribution system.

4.1.2 The knowledge trends

This section stresses the role of knowledge management in our society, and focuses on the need of semantic, and semantic web based applications.

Knowledge management an overview

[22] Source Wikipedia.

Knowledge, in its different forms, is increasingly recognised as a crucial asset in modern organisations. Knowledge Management (KM) is referred to as the process of creating, codifying and disseminating knowledge within complex organisations, such as large companies, universities, and world wide organisations [Harris, 1998; Zilich, 2002; Davenport and Prusak, 1997; Nonaka and Takeuchi, 1995; Stewart, 2001; Wenger, 1998].

Knowledge management some traditional technological applications
Most KM projects aim at creating large, homogeneous knowledge repositories, in which corporate knowledge is made explicit, collected, represented and organised, according to a single - supposedly shared - conceptual schema. Such a schema is meant to represent a shared conceptualisation of corporate knowledge, and thus enable communication and knowledge sharing across an entire organisation. The typical outcome of this kind of project is the creation of an Enterprise Knowledge Portal (EKP), a (webbased) interface which provides a unique access point to corporate knowledge [Davenport, 1998; Davenport and Prusak, 1997; Wiig , 1997].

All these activities are based on the common assumption that raw forms of knowledge, called implicit knowledge [Nonaka and Takeuchi, 1995] and tacit knowledge by Polany [1966], can be "cleaned up" from all contextual elements, and that the resulting "objective form" of knowledge can be explicitly represented in an abstract (reified from the original context) and general (applicable to any similar situation) form.

A case study: the KnowledgeBoard Portal (http://www.knowledgeboard.com/)

The European KM Framework is designed to support a common European understanding of KM, to show the value of this emerging approach and help organizations towards its successful implementation. The Framework is based on empirical research and practical experience in this field from all over Europe and the rest of the world. The European KM Framework addresses all of the relevant elements of a KM solution and serves as a reference basis for all types of organizations, which aim to improve their performance by handling knowledge in a better way.
For this reason some important projects and activities have been carried out. One of these is KnowledgeBoard. It is a KM portal funded by the European Commission under the Information Society Technologies Programme (IST). KnowledgeBoard is a growing community of over 9,000 KM professionals throughout Europe and the world, managed by a consortium of partners around Europe. The portal presents the following virtual spaces:

1. events: shows a listing of passed and forthcoming KB events. The list can be updated by each KnowledgeBoard participant;
2. groups as Special Interest Groups (SIGs) and ZONEs: allow people to manage virtual spaces, through which they discuss on specific topics.
3. community: it contains some KnowledgeBoard services such as news, who's who, KM jobs, newsletters, etc.
4. knowledge bank: a system of KM citations such as bibliographies and journals.

Most business operators claim that this traditional approach is the right answer to the needs of managing corporate knowledge. As depicted in Figure 14, they invest a lot of resources (in terms of time and money) in KM applications.

	Information sharing								Planning / controlling			
	Intranet		KM system		E-learning		Share documents		Track work hours		ERP	
Weighting	empl.	firms	empl.	firms	empl.	firms	empl.	firms	empl.	firms	empl.	firms
Total (EU-7)	**47**	**19**	**13**	**5**	**18**	**9**	**30**	**18**	**19**	**8**	**28**	**9**
By sector (EU-7)												
Food & beverages	46	12	11	4	12	6	28	11	28	6	37	6
Textile & clothing	45	17	13	8	9	4	27	13	20	5	34	8
Publishing & printing	52	23	11	8	13	9	29	19	19	5	21	8
Pharmaceutical	75	35	25	8	19	10	43	20	32	9	71	19
Machinery & equipment	54	22	11	6	19	9	37	21	28	11	58	17
Automotive	85	30	25	7	35	9	60	19	34	13	71	18
Aeronautics	98	42	39	14	60	22	26	29	47	17	52	25
Construction	29	14	10	4	11	6	21	11	11	7	13	7
Tourism	41	18	7	3	19	9	23	21	11	5	12	8
IT services	78	50	37	17	39	27	56	50	35	19	39	18

Figure 14. European companies using KM solutions (source *e-Business W@tch*, 2005)

However, many KM systems are deserted by users, who instead continue to produce and share knowledge as they did before, namely through structures of relations and processes that are quite different from those embedded within the corporate wide KM system. For instance workers continue to use non-official tools such as shared directories, personalized and local databases, and so on [Bonifacio et al., 2000, Bonifacio et al., 2002]. In theory, KM systems are sold as systems that combine and integrate functions for the contextualized handling of both explicit and tacit knowledge, throughout the entire organization or part of it. But, in practice, traditional KM systems manage knowledge according to a technology-oriented approach, which considers the “cleaned up” and “objective knowledge” as the “good and sharable knowledge” (best practices, documentations, etc.) within the firm and among companies.

Knowledge management and its distributed nature

Many authors who stressed the subjective nature of knowledge argued also that meanings are not externally given; rather, individuals give meaning to situations through subjective interpretation. Interpretation is subjective, since it occurs according to some “internal” interpretation schema, not directly accessible to other individuals. These schemas have been called, for example, mental spaces [Fauconnier, 1985], contexts [McCarthy, 1993; Ghidini and Giunchiglia, 2000; Benerecetti et al., 2000], or mental models [Johnson-Laird, 1992]. Besides, internal schemas can be made partially accessible to other individuals through language, since language is not just a means to communicate information, but also a way of manifesting an interpretation schema. As a consequence, when interpretation schemas are deeply different, people will tend to give a very different meaning to the same facts. Conversely, in order to produce similar interpretations, people need to some extent to share interpretation schemas, or at least to be able to make some conjectures on what the other people's schema is. For in depth discussion see the notions of paradigms [Kuhn, 1970], socio-technical frames [Goffman, 1974], thought worlds [Dougherty, 1992].

Thus, this approach leads to some significant consequences:

- knowledge is intrinsically subjective, as the meaning of any statement is always dependent on the context or on the interpreter's schema, that can be either explicit or implicit;
- at a collective level, groups of people can assume they share (or have a reciprocal view on) some part of their intrinsically subjective schemas. These "common parts" can emerge from participation and reification processes of community's members, who share (or understand) the other's meanings through practices [Wenger, 1998]. In other word we can say that the intrinsically subjective schema can be shared, or at least coordinated, in the inter-subjective agreements of community's members.

As a result, the notion of knowledge as an absolute concept that refers to an ideal objective picture of the world leaves the place to a notion of "local knowledge", which refers to the different, partial interpretations of portions of the world or domains that are generated by individuals and within groups of individuals (e.g. communities) through a process of negotiating interpretations. According to knowledge network theories – see [Creech & Willard, 2001; Hildreth and Kimble, 2004; Cross and Parker, 2004] — different and specialized actors which coordinate each others, move beyond the information sharing to the aggregation and creation of new knowledge, and obtain benefits from network communications and engagement strategies.

Knowledge management and semantic based applications

The existence of autonomous "local knowledges" requires ontologies and related methods, to accurately manage knowledge. In particular:

- Industrial KM applications have to avoid any kind of overhead as far as possible. A *seamless integration* of knowledge creation (e.g. content and metadata specification) and knowledge access (e.g. querying or browsing) into the working environment is required. Strategies and methods are needed to support the creation of knowledge, as side effects of activities that are carried out anyway. These requirements mean *emergent semantics*, e.g. through *ontology learning*, are needed, which reduce the current time consuming task of building-up and maintaining ontologies.
- Access to as well as presentation of knowledge has to be *context-dependent*. Since the context is set up by the current business task, and thus by the business process being handled, a tight integration of business process management and knowledge management is required. KM approaches can provide a promising starting point for *smart push services* that will proactively *deliver relevant knowledge* for carrying out the task at hand more effectively.
- *Conceptualization* has to be supplemented by *personalization*. On the one hand, taking into account the experience of the user and his/her personal needs is a prerequisite in order to avoid information overload, and on the other hand, *to*

deliver knowledge at the right level of granularity and from the right perspective [Léger, Nixon, Shvaiko, 2005].

KM solutions will be based on a combination of intranet-based functionalities and mobile functionalities in the very near future. Thus, Semantic Web technology is a promising approach to meet the needs of mobile environments, like location-aware personalization and adaptation of the presentation to the specific needs of mobile devices, i.e. the presentation of the required information at an appropriate level of granularity. In essence, employees should have access to the KM application *anywhere* and *anytime*[Léger, Nixon, Shvaiko, 2005].

In all these situations, there are many suppliers and consumers of knowledge and a loose coupling between them - information is used in unanticipated ways by knowledge workers unknown to those who deposited it. Already e-Science has been inspired by the results of the Semantic Web initiative, with a number of pioneering communities using RDF and OWL to enhance their knowledge applications, and even some genuine "Semantic WEB", with the emphasis on Web, examples are also starting to appear. These examples should be an inspiration to the Semantic Web community. However, there is also irritation that the wrong emphasis is being placed on what is important and what is not by the technologists leading to a communication failure between those for whom the Semantic Web is a means to an end and those for whom it is the end [Goble, 2005.].

Some main benefits by smantic based systems within KM applications are:

- *Productivity:* automation of maintenance of the knowledge bases, automation of content indexing, augmented productivity in the publication cycle (commercial proposals, reports), search efficiency (a reduction factor on search time of the order, e.g., 1000 to 1, is claimed to be possible by the use of "semantic search");
- *Quality and operational valorisation of knowledge legacy:* unified management of heterogeneous resources, information relevance, capacity to represent complex knowledge, gains in development and maintenance of knowledge and content management solution, generic and evolvable solution;
- *Human factors* prove to be the key difficulty in reaching a KM solution with full groupware functionality for company employees, so adopt a step-by-step approach;
- *Access to the information portal* must be well designed and must be supported by a group of people dedicated to information filtering and qualifying (P2P is possible). [Léger, Nixon, Shvaiko, 2005]

Technical requirements from industry

In the D1.1.2 some technical use cases have been analyzed and the following important typology of knowledge processing tasks and components have been identified. These are described in Figure 15:

#	Knowledge processing tasks	Components
1	Ontology Management	Ontology Manager
2	Matching	Match Manager
3	Matching Results Analysis	Match Manager
4	Data Translation	Wrapper
5	Results Reconciliation	Results Reconciler
6	Composition of Web Services	Planner
7	Content Annotation	Annotation Manager
8	Reasoning	Reasoner
9	Semantic Query Processing	Query Processor

Figure 15: Typology of knowledge processing tasks and components.
Part 1 - Primary tasks.

#	Knowledge processing tasks	Components
1	Schema/Ontology Merging	Ontology Manager
2	Producing Explanations	Match Manager
3	Personalization	Profiler

Figure 16: Typology of knowledge processing tasks and components.
Part 2 – Secondary Tasks

In this work, 9 primary tasks and 3 secondary tasks are identified. Some tasks are required to be implemented within a single component. For example, (schema/ontology) matching, matching results analysis, and producing explanations of mappings are the functionalities of the match manager component. Thus, the library of high level components contains fewer components than the number of knowledge processing tasks identified. In particular, it consists of 9 components. Let us discuss knowledge processing tasks and components of Table 2 and Table 3 in more detail [Léger, Nixon, Shvaiko, 2005].

- **Ontology Management, Schema/Ontology Merging and Ontology Manager.** These tasks and component aim at (i) ontology maintenance, e.g., editing concepts, resolving name conflicts, browsing ontologies, and (ii) merging (multiple) ontologies, e.g., by taking the union of the axioms, according to evolving business requirements (see [Dou, McDermott, Qi, 2005; Stanford Medical Informatics -Protégé ontology; McGuinness, Fikes, Rice, and S.Wilder, 2000]).
- **Matching, Matching Results Analysis, Producing Explanations and Match Manager.** These tasks and component aim at discovering mappings between the entities of schemas/ontologies which correspond semantically to each other, see [Rahm, Bernstein., 2001; Shvaiko, Euzenat, 2005]. Mappings are typically specified (i) by using coefficients rating match quality in the [0,1] range, see [Billig and Sandkuhl, 2002; Euzenat, Valtchev, 2004; Petrini and Risch, 2004; Zhong, Zhu, Li, and Yu, 2002], or (ii) by using logical relations (e.g., equivalence, subsumption), see [Giunchiglia, Shvaiko, 2004; Giunchiglia, Shvaiko, Yatskevich, 2004]. Depending on the application requirements, some

further manipulations with mappings (e.g., ordering, pruning) can be performed, see [Di Noia, Di Sciascio, Donini, Mongiello, 2003]. State of the art matching systems may produce effective mappings. However, these mappings may not be intuitively obvious to human users, and therefore, they need to be explained, see [Dhamankar, Lee, Doan, Halevy, Domingos, 2004; Shvaiko, Giunchiglia, Pinheiro da Silva, McGuinness, 2005]. In fact, if Semantic Web users are going to trust the fact that two terms may have the same meaning, then they need to understand the reasons leading a matching system to produce such a result. Explanations are also useful when matching (large) applications with thousands of entities (e.g., business catalogs, such as UNSPSC and eCl@ss). In these cases automatic matching solutions will find a number of plausible mappings, hence, some human effort for performing the rationalization of the mapping suggestions is inevitable. Generally, the key issue here is to represent explanations in a simple and clear way to the user.

- **Data Translation and Wrapper.** These tasks and component aim at an automatic manipulation (e.g., translation, exchange) of instances between information sources storing their data in different formats (e.g., OWL, XML), see [Petrini and Risch, 2004; Velegrakis, Miller, and Mylopoulos, 2005]. Usually, for the task under consideration, correspondences between semantically related entities among schemas/ontologies are assumed to be given. They are taken in input, processed according to an application requirements, and are returned in output as executable mappings.
- **Results Reconciliation and Results Reconciler.** These tasks and component aim at determining an optimal solution for returning results from the queried information sources. The problem should be considered at least at two levels: (i) contents, e.g., for discarding redundant information, and (ii) routing performance, e.g., for choosing the best (under the given conditions) plan for delivering results to the user, see [Preguica, Shapiro, and Matheson, 2003].
- **Composition of Web Services and Planner.** These tasks and components aim at an automated composition of the pre-existing web services into new (composed) web services, thereby enabling the latter with new functionalities, see [Benatallah, Hacid, Léger, Rey, and Toumani, 2005]. Technically, composition is typically performed by using automated reasoning approaches (e.g., planning, see [Traverso, Pistore, 2004]).
- **Content Annotation and Annotation Manager.** These tasks and components aim at an automated generation of metadata for different types of contents, such as text, images, audio tracks, etc. (see the AceMedia website http://www.acemedia.org/aceMedia). Usually, an annotation manager has in input the (pre-processed) contents and some sources of explicitly specified domain knowledge and outputs content annotations.
- **Reasoning and Reasoner.** These tasks and components aim at providing a set of logical reasoning services (e.g., subsumption, instance checking tests, see [Haarslev, Moeller and Wessel, 2004]), which are (heavily) tuned to particular application needs. For example, when dealing with multimedia annotations, logical reasoning can be exploited in order to check consistency of the annotations against the set of spatial (e.g., left, right, adjacent, near) and modal (possibility,

necessity) constraints. Thus, ensuring that the objects detected in the multimedia content correspond semantically to the concepts defined in domain ontologies. The key issue here is in the development of optimizations over the standard reasoning techniques tailored to specific application tasks, because, in general, modal/temporal logic reasoning procedures do not scale well.

- **Semantic Query Processing and Query Processor.** These tasks and components aim at rewriting queries by exploiting terms from the pre-existing ontologies, thus, enabling a semantics-preserving query answering (see [Mena, Kashyap, Sheth, and Illarramendi, 1996]).
- **Personalization and Profiler.** These tasks and components aim at an adaptation of functionalities available from a system to the needs of groups of users, see [Antoniou, and all, 2004]. Typical tasks of a profiler include automatic generation and maintenance of user profiles, personalized content management and mining, etc.

4.2 Trends in products

Trents on products should be organized according to the followisng items:

- Ontology based systems;
- Semantic web based portals;
- Knowledge crawlers, spiders, etc.;
- Tools for ontology management (creation, editing, visualization, merging, matching, etc.);
- Intelligent search engines;
- Tools for semantic web services (creation, management, evolution, etc.);
- Tools for semantic normalization and standardization;
- Semantic Tools for project and process management, distributed workflow management systems, etc.

Some examples are:

- Yellow pages and product catalogs are direct benefactors of a well structured representation which, coupled to a multilingual ontology, enhance clearly the precision /recall of products or services in a search engine.
- The ONTOSEEK system (1996- 1998) was the first prototype which operates by associating a domain ontology (encoded in a conceptual graph (CG) knowledge representation (KR) formalism with very limited expressiveness) to a large multilingual linguistic ontology (SENSUS – WORDNET) for natural language search of products [Doan, Domingos, Halevy, 2001]. ONTOSEEK searches products by mapping natural human language requests to entities of the domain ontology. Unlike traditional e-commerce portal search functions the user is not supposed to know the vocabulary used for describing the products and thanks to the SENSUS ontology (s)he is able to express the query using his or her own vocabulary. The main functional architectural choices of ONTOSEEK are: (i) use of a general linguistic ontology to describe products; (ii) a high flexibility in

expressing the request thanks to the semantic mapping offered between the request and the offers; (iii) interactive guided request formulation through generalisation and specialisation links. A conceptual graph KR is used internally to represent requests and products. The semantic matching algorithm is based on simple subsumption on the ontology graph and does not make use of a complex graph endomorphism. ONTOSEEK has not been deployed commercially but through its trial period has fully demonstrated the potential benefits of making use of preliminary semantic web tools.

- The MKBEEM [Doan, Madhavan, Domingos, and Halevy, 2003] prototype and technology (Multilingual Knowledge Based European Electronic Marketplace - IST-1999-10589, 2000 – 2003) concentrated on written language technologies and their use in e-commerce. Within the global and multilingual Internet trading environment, there is an increasing pressure on e-content publishers of all types to adapt content for international markets. Localization – translation and cultural adaptation for local markets – is proving to be a key driving factor in the expansion of business on the web. In particular, MKBEEM focused on adding multilingualism to all stages of the information cycle, including multilingual content generation and maintenance, automated translation and interpretation, and enhancing the natural interactivity and usability of the service with unconstrained language input. On the knowledge technology side, the MKBEEM ontologies provide a consensual representation of the electronic commerce field in two typical domains, such as B2C Tourism and B2C Mail orders, allowing for the commercial exchanges to be transparent in the language of the end user, of the service, or of the product provider.

4.3 Trends in services and applications

At present, ontology and more generally knowledge-based systems, appear as a *central issue* for the development of *efficient and profitable* solutions.

However, it is currently difficult for companies to achieve the promised ROI from knowledge-based e-commerce. This is, because of:

- a current lack of standardization for business models, processes, and knowledge architectures,
- it is difficult to evaluate knowledge. Only theories on Intellectual Capital allow organization to evaluate knowledge and its revenues, but they do not take into account semantic features;
- the co-determination among technologies and organizational processes, can be studied only through ethnography analaysis, and results can not be standardized because they are context dependent.

In this paragraph, some applications will be described according to various interesting industry sectors and the following typology of applications:

- KM applications and consultancy activities;

- Web mining applications and services;
- Intellectual capital measurement;
- Certification authority services on web information;
- Semantic mediation services for legacy DB;
- Network management consultancy activities;
- Semantic web services consultancy activities.

The medical domain is a favourite target for Semantic Web applications just as the expert system was for Artificial Intelligence applications 20 years ago. The medical domain is very complex: medical knowledge is difficult to represent in a computer format, making the sharing of information even more difficult. Semantic Web solutions become very promising in this context. One of the main mechanisms of the Semantic Web - resource description using annotation principles - is of major importance in the medical informatics (or sometimes called bioinformatics) domain, especially as regards the sharing of these resources (e.g. medical knowledge in the Web or genomic database). Through the years, the Information Retrieval area has been developed by medicine: medical thesauri are enormous (e.g., 1,000,000 terms in Unified Medical Language System, UMLS) and are principally used for bibliographic indexation. Nevertheless, the MeSh thesaurus (Medical Subject Heading) or UMLS have been used to provide data semantics with varying degrees of difficulty.

For example the domain of NEUROBASE project [Barillot and all, 2003] attempts to federate different neuro-imagery information bases situated in different clinical or research areas. The proposal consists of defining an architecture that allows the access to and the sharing of experimental results or data treatment methodologies. It would be possible to search in the various databases for similar results or for images with peculiarities or to perform data mining analysis between several databases. The mediator of NEUROBASE has been tested on decision support systems in epilepsy surgery.

5. Gap analysis

The Gap analysis will be done in the next KWTR version on month 30.

5.1 Industry and Knowledge Web NoE

5.2 Industry and Semantic Web research

6. Challenges

Even though the challenges section will be completed in the next deliverables some useful insights are presented here. They will be refined in the next KWTR versions.

The success and potential of the web is leading to the possibility that every information resource, person, organization, and many of the activities related to them will be located on or be driven by the Web. In other words rich descriptions of media and content will allow users to improve search and management tools; rich descriptions of Web Services will permit consumers to personalize their activities through the composition of various web services; common interfaces will be developed in order to simplify integration of disparate systems; and a common language for the exchange of semantically rich information will be supported through integration of various heterogeneous conceptual models and languages [Euzenat, Pin and Ronchaud, 2002]. All these solutions might occur only with access to enhanced "meaning" of all resources and the ability of software on the Web to deal with this enhanced meaning [Sheth and Meersman, 2002].

Technical difficulties in developing and implementing these solutions in business products and services make knowledge and semantic web very challenging. Let us consider, for instance, how tools for semantic matching or web service compositors might be applied in order to sustain purchasing officers in their daily processes: namely to allow officers to select, compare and then buy the more satisfying composition of products and services needed by the organizations. Even the consumers' (or in this case the purchasing officers') behaviours and cultures will radically change using knowledge based products and services.

Even if it has been recognized that bringing semantics to web services is an essential step, there are a lot of research challenges that are still open. We identify three main areas:

- Integration of behavioural approach with the static approach: one of the fundamental challenges is the need for a comprehensive formal semantic model of all the entities – the services, the processes and the environment. This must include a broad framework of semantics including data, functional, non-functional and execution.
- Need of a "lightweight adoption" of the static approach: there is a need to investigate the right level of semantics that can be introduced in a service; if we want a real adoption for the "real life" applications, this must be necessarily a "lightweight" semantic.
- Autonomic vision of semantic web services: the provision of autonomic capabilities to semantic web services is a compelling requirement, since the success of service discovery, selection and composition unavoidably depends on the capability of each service to perform self-configuration, self-healing, self-optimization and self-adaptation with respect to components that are not fully under our own control. The modelling of Autonomic Services needs a comprehensive model of all the different entities, which has still to be identified.

7. Research Roadmap

This paragraph will be done in the next KWTR version on month 30.

7.1 Short term

7.2 Medium term

7.3 Long term

8. Recommendation

The Recommendation paragraph will be done in the next KWTR version on month 30.

9. Final remarks

Although the first and second round of contributions didn't achieve a significant number of answers, we unveiled some useful insights, about both the content and the methods. Summarizing the answers above it has been emerged that:

- about contents: industry is not yet considering the semantic web as a proper system of tools that contribute to daily activities including knowledge management, information retrieval systems and methods, digital archives, etc. Thus in the final document of KWTR it should clearly emerge that the semantic web radically improves tools, applications and solutions;
- about methods: semantic web technologies are not mature fields and a lot of organizations do not have a clear vision on how solutions can be developed using knowledge and semantic web applications. Therefore an asymmetric temporal analysis could be helpful, in particular through a comparison of the answers of research in the short term with those of industry in the long term. Moreover in the next analysis a series of prototype case studies should be taken into consideration. This is based on the idea that more concrete examples, goals and case studies should be analysed, providing contextualized problems and needs. These case studies should be provided by skilled organizations that have a tangible vision of semantic and knowledge web forecasted solutions.

Finally, the results presented here are preliminary and a more detailed deliverable with the shared view of the consortium will be given in month 30 (June 2006). In particular, a more in-depth analysis will provided in order to understand how Knowledge Web technologies, tools and applications will radically influence the social life of individuals, their businesses and their market opportunities.

In conclusion, the D1.4.1v1 (which contains general concepts of roadmap and roadmapping processes, main features of technology roadmaps, methods and tools) has been improved.
Industrial partners of Knowledge Web NoE and members of WP 1.4 have been identified as participants of KWTR. All the WP leaders have been asked to participate or to indicate researchers on semantic web that will contribute to this activity.
Thus, a second call for contribution has been sent to KWTR participants, identifying a "first cut" scenario of the KWTR, and some challenges that will be deeply analyzed in the next versions of KWTR.

Due to the participants' contributions, some changes occurred in the KWTR skeleton allowing us to focus more on the KWTR aims and results than on the methodology we adopted to achieve them. We have also presented a more detailed structure for: (i) section 3 (Current Trends in Semantic Web Research and beyond) focusing the attention on short/medium/long terms of trends; (ii) section 4 (Market and Social Trends) focusing on market and society, products and services/applications. The future KWTR deliverables will provide more in depth discussions on (i) threats and opportunities that are unveiled by comparing industry and academia trends; (ii) challenges that might be resolved by realizing recommendations provided by the technology roadmap and (iii) strategies of short/medium/long term planning for both research and industrial activities/initiatives.

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Annex 1

D 1.4.1 Technology RoadMap (first version) addressed to researchers involved in the Knowledge Web Network of Excellence

Questions for the qualitative interviews

In the deliverable 1.4.1 "Technology roadmap (first version)", a general description of semantic web tools and potential impacts in industry, business and society will be given. In order to clearly identify the technology locks that Knowledge Web might resolve and overcome, the roadmap approximately should contain: (i) purposes of the technology roadmap for the network of excellence, (ii) current trends in semantic web research, (iii) current and future trends in market and society considering both business models and knowledge flows, (iv) problems and gaps generated by these changes, (v) challenges for the future of semantic web research (vi) research roadmap for short, medium, and long term, and finally (vii) an action plan and some overall recommendations.

The Technology roadmap is very used within organizations at different levels:
– ***Technology level****:* analysis of the innovative technology, engineering and science skills and platforms of the firm;
– ***Product level****:* analysis of the innovative product and service portfolio and platforms, manufacturing and operations functions;

– ***Business level:*** analysis of the organization and associated networks, business portfolio, marketing and financial functions, together with strategy development and implementation processes**.**

These three levels should all be analyzed within the KW's technology roadmap. In particular we will analyze:

– ***at technology level:* technologies and processes required for maintaining the technology base.** Such as trend on technologies (algorithms and methods) used within products, trend of the research in Semantic Web and Knowledge Web and all the scientific and industry researches.
– ***at product level:* innovations on product /services and processes.** Such as trend on new products, services, and possible solutions should be defined. Question we should answer are: which kind of products? Which kind of services? Which consumers? etc.
– ***at business level:* required processes to deliver value to the business into the future.** Such as trend of the markets, possible creation of new market niches, business needs for new services and products, a vision of/for the future should be defined, and current trend on Semantic web technologies should be calculated.

The roadmap should be the result of experts' debate about the future trend of semantic web methods and technologies, products (tools and applications) and businesses. For that reason we really appreciate your involvement in filling up the questionnaire above. Please take your time and accurately explain your point of view regarding technologies (theories, methods), innovative products and possible business ideas in the short, medium and long periods. When possible, please provide data (numbers of your forecasts) and justification on your view, and may be some references. In particular for short term (1-3 years) please provide crisp and detailed information, for medium term provide approximate information, and for long term be as visionary as possible.

For in depth analysis see Cunningham, J.B. (1993). Action research and organisational development. London: Praeger and Denzin, N.K., & Lincoln, Y.S. (1994). Handbook of qualitative research. London: Sage.

What are your research fields?

What are the most important trends in your research?

[Please provide your observations for short term (1-3 years)]:

[Please provide your observations for medium term (3-6 years)]:

[Please provide your observations for long term (6-12 years)]:

What are, in your opinion, the most relevant problems in your research fields?

What are the most important trends in other research fields related to Semantic Web and Semantic Web Services?
[Please provide some observations for each KW activity (i.e. scalability, heterogeneity, Dynamics, web services, languages, etc.]

[Please provide your CRISP observations for short term (1-3 years)]:

[Please provide your APPROXIMATES observations for medium term (3-6 years)]:

[Please provide your observations for long term (6-12 years) as visionary as possible]:

Do you know other research fields related to Semantic and Knowledge Web?

[If yes please provide both description of the fields and motivation]

If yes, what are the trends in these research field?

[Please provide your crisp observations for short term (1-3 years)]:

[Please provide your approximate observations for medium term (3-6 years)]:

[Please provide your observations for long term (6-12 years) as visionary as possible]:

What are the core issues and core problems that your research tries to solve?

What are, in your opinion, the core issues and core problems that other important researches try to overcome (please indicate no more than 3/5 problems)?

What are, in your opinion, the tools and solutions that will resolve these problems?

What are, in your opinion, the methodologies and technologies that will be used in the tools and solutions described above?

How will this change the relationships among agents (i.e. organizations, people) in the market/business/society?

How will this change the management of knowledge and information among organizations or between organizations and consumers?

If you want, feel free to add any comment on this questionnaire

Thanks for your effort, we really appreciate your help,
the team of WP 1.4

Annex 2

D 1.4.1 Technology RoadMap (first version) addressed to practitioners (expersts) involved in knowledge web activities

Questions for the qualitative interviews

In the deliverable 1.4.1 “Technology roadmap (first version)”, a general description of semantic web tools and potential impacts in industry, business and society will be given. In order to clearly identify the technology locks that Knowledge Web might resolve and overcome, the roadmap approximately should contain: (i) purposes of the technology roadmap for the network of excellence, (ii) current trends in semantic web research, (iii) current and future trends in market and society considering both business models and knowledge flows, (iv) problems and gaps generated by these changes, (v) challenges for the future of semantic web research (vi) research roadmap for short, medium, and long term, and finally (vii) an action plan and some overall recommendations.

The Technology roadmap is very used within organizations at different levels:
– ***Technology level****:* analysis of the innovative technology, engineering and science skills and platforms of the firm;
– ***Product level****:* analysis of the innovative product and service portfolio and platforms, manufacturing and operations functions;

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These three levels should all be analyzed within the KW's technology roadmap. In particular we will analyze:

– ***at technology level:*** **technologies and processes required for maintaining the technology base.** Such as trend on technologies (algorithms and methods) used within products, trend of the research in Semantic Web and Knowledge Web and all the scientific and industry researches.
– ***at product level:*** **innovations on product /services and processes.** Such as trend on new products, services, and possible solutions should be defined. Question we should answer are: which kind of products? Which kind of services? Which consumers? etc.
– ***at business level:*** **required processes to deliver value to the business into the future.** Such as trend of the markets, possible creation of new market niches, business needs for new services and products, a vision of/for the future should be defined, and current trend on Semantic web technologies should be calculated.

The roadmap should be the result of experts' debate about the future trend of semantic web methods and technologies, products (tools and applications) and businesses. For that reason we really appreciate your involvement in filling up the questionnaire above. Please take your time and accurately explain your point of view regarding technologies (theories, methods), innovative products and possible business ideas in the short, medium and long periods. When possible, please provide data (numbers of your forecasts) and justification on your view, and may be some references. In particular for short term (1-3 years) please provide crisp and detailed information, for medium term provide approximate information, and for long term be as visionary as possible.

For in depth analysis see Cunningham, J.B. (1993). Action research and organisational development. London: Praeger and Denzin, N.K., & Lincoln, Y.S. (1994). Handbook of qualitative research. London: Sage.

What are your fields of interest and business activities?

What are the most important trends in your business activities?

[Please provide your observations for short term (1-3 years)]:

[Please provide your observations for medium term (3-6 years)]:

[Please provide your observations for long term (6-12 years)]:

What are, in your opinion, the most relevant aims of your business activities?

Do you know other markets (or industry sectors) related to Semantic and Knowledge Web?
[If yes please provide both description of the fields and motivation]

If yes, what are the trends in these industries?
[Please provide your crisp observations for short term (1-3 years)]:

[Please provide your approximate observations for medium term (3-6 years)]:

[Please provide your observations for long term (6-12 years) as visionary as possible]:

What are the tools and solutions (related to semantic and knowledge web) that your organization is developing?

What are, in your opinion, the core problems that your organization tries to overcome?

What are, in your opinion, the core issues and core problems that other organizations try to overcome (please indicate no more than 3/5 problems)?

What are, in your opinion, the methodologies and technologies that will be used in the tools and solutions described above?

How will this change the relationships among agents (i.e. organizations, producers, consumers) in the market/business/society?

How will this change the management of knowledge and information in the Porter's value chain (among organizations or between organizations and consumers)?

If you want, feel free to add any comment on this questionnaire

Thanks for your effort, we really appreciate your help,
the team of WP 1.4

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Annex 3

D 1.4.1v2 Technology RoadMap

Dear partners,

as you all know the task 1.4.1 “Knowledge Web Technology Roadmap” has the aim of reporting on an overall account of semantic web tools and potential impacts in industry, business and society.

With the intention of clearly identify the technology locks (or obstacles) that Knowledge Web is solving and trying to overcome, the final version of the Knowledge Web Technology Roadmap (KWTR) document approximately should contain:

1) a description of trends on Semantic Web Researches. (This means, that a description of trends on specific theories and methods, tools and applications should be provided.)
2) a description of Market and Social Trends
3) the identification of research challenges
4) the definition of an action plan and a system of recommendations to researchers and institution for future research

In this work, two critical aspects are emerging:

1) the need of having a strong vision on semantic web research, that obliges us to have contribution from senior researchers
2) the need of having a vision on specific research topics.

Therefore as researchers on semantic web, partners of KW NoE and mainly WP leader or member of the WP 1.4, your involvement is KINDLY requested. Alain and I (as WP and task leaders) ask you to provide a very short document (minimum 2 pages maximum 5) in which you provide your vision on trends of your research interests.

Enclosed to this e-mail you’ll find a form, you should follow while providing your contribution.
The deadline of the contribution is December 11, 2005.

We would really appreciate if you could send an e-mail with your willingness to contribute before Monday 21, November 2005.

Thanks for your effort
Alain and Roberta

Title:
TECHNOLOGY ROADMAP:
CURRENT TRENDS AND CHALLENGES ON
…………
(PLEASE PROVIDE YOUR RESEARCH TOPIC)

Author(s)
Affiliation(s) and contact(s)

1. Current trends in Semantic Web Research

Please provide a short abstract on the state of the art of your specific research topic related to semantic web

2. Trends on theories and methods

Please provide a short description of trends on theories and methods of your specific research topic.
Present this trends according to the following periods of time:

- 0-3 years (theories that are being developed in these years. For instance, mention long period research projects such as European projects already started, etc.)
- 3-6 years (trends on theories and methods that will be developed in the next future)
- 6 -12 years (future challenges for your research topics)

3. Trends on tools

Please write a short description of tools that will be based on your specific research topic.

Try to provide this trends according to the following periods of time:

- 0-3 years (tools that already exist and that are mainly based on your research topic – please try to describe one or two innovative tools that are sold on the market)
- 3-6 years (tools that are designed and planned for future applications – please try to figure out which kind of tools will be produced in the next future)
- 6 -12 years (tools that might be developed in the future – you should have a lot of imagination ;))

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4. Trends on services and applications

Please write a short description of uses (services and applications) in which your specific research topic will be adopted.

For instance natural languages theories might be used in cost reduction services. In particular orders written by purchasing officers (written in natural languages, using acronyms, etc.) might be automatically elaborated through natural languages tools with the aim at classifying products and services that are bought by the organization.

If you can, try to provide this trends according to the following periods of time:

- 0-3 years (applications and services that already exist and that are mainly based on your research topic – please try to describe one or two innovative tools that are sold on the market)
- 3-6 years (application and services that are designed and planned for future uses – please try to figure out which kind of tools will be produced in the next future)
- 6 -12 years (application and services that might be developed in the future – you should have a lot of imagination ;))

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Annex 4

D 1.4.1v2 Technology RoadMap

Title:
TECHNOLOGY ROADMAP:
CURRENT TRENDS AND CHALLENGES ON
…………
(PLEASE PROVIDE YOUR RESEARCH TOPIC)

Author(s)
Affiliation(s) and contact(s)

1. Current trends in Semantic Web Applications (Market and Society)

Please provide a short abstract on the state of the art of your specific industry related to semantic web. For instance try to figure out how semantic web applications, theories and technological infrastructure are changing your market nice.

2. Trends on services and applications

Please write a short description of applications or services (related to your industry) in which semantic web theories will be used.

For instance if you are a cost management consultant you can say that: natural languages theories might be used in cost reduction services. In particular orders written by purchasing officers (written in natural languages, using acronyms, etc.) might be automatically elaborated through natural languages tools with the aim at classifying products and services that are bought by the organization.

If you can, try to provide this trends according to the following periods of time:

- 0-3 years (applications and services that already exist and that are mainly based on your research topic – please try to describe one or two innovative tools that are sold on the market)
- 3-6 years (application and services that are designed and planned for future uses – please try to figure out which kind of tools will be produced in the next future)
- 6 -12 years (application and services that might be developed in the future – you should have a lot of imagination ;))

3. Trends on tools

Please write a short description of tools (used in your business activity) that are based on semantic web theories.

Try to provide this trends according to the following periods of time:

- 0-3 years (tools that already exist and that are mainly based on semantic web theories – please try to describe one or two innovative tools that are sold on the market)
- 3-6 years (tools that are designed and planned for future applications – please try to figure out which kind of tools will be produced in the next future)
- 6 -12 years (tools that might be developed in the future – you should have a lot of imagination ;))

4. Trends on theories and methods

Please try to provide a short description of trends on theories and methods of your specific research topic. In particular try to focus on gaps on semantic web theories, in other words on specific topics that researchers should work on in order to solve some emerging problems.
Present this trends according to the following periods of time:

- 0-3 years (theories that are being developed in these years. For instance, mention long period research projects such as European projects already started, etc.)
- 3-6 years (trends on theories and methods that will be developed in the next future)
- 6 -12 years (future challenges for your research topics)

Annex 5: Schedule of activities

The schedule we have proposed has been mostly observed as follows:

- April 15, 2005:
  the Delphi questionnaire has been sent to all the WP leaders in the Knowledge Web project. In Annex 1 and 2 the completed version of the questionnaire is provided.
- May 15, 2005:
  the Delphi questionnaire has been received.
- June 1st, 2005:
  first previews result has been presented in Crete during the Knowledge Web plenary session. A half day in Crete has been organized with the aim of discussing the aims of the technology roadmap, its table of contents, and most importantly the previews results obtained from the Delphi questionnaire.
- July 2005:
  the identification of a small group of experts who addresses the Delphi and roadmapping processes in the next periods.
- September 2005:
  first results elaboration.
- October/November 2005:
  a second round of request of participation and eventually the Delphi questionnaire will be submitted to a committed group of experts (senior research practitioners involved in the Knowledge Web project).
- November/December 2005:
  previews results of contributions should be provided in the D 1.4.1v2.
- January 2006:
  another action plan should be discussed in order to involve in the KWTR other partners of WP 1.4. It will be discussed at the KW plenary meeting in Trento.
- February/March 2006:
  another Delphi questionnaire should be sent in order to deeply analyze some relevant topics of the KWTR. One of the main idea is to use the KW portal to both allow researchers to easily contribute to the KWTR, and disseminate previews results.
- April/May 2006:
  the questionnaire results should be elaborated.
- May/June 2006:
  the D 1.4.4 “Intermediate version of Technology Roadmap” should be provided.