D 1.4.1v1 Technology RoadMap

Coordinator: Roberta Cuel (UniTn)

with contributions from
Alain Leger (France Telecom);
Fausto Giunchiglia (UniTn);
Anna V. Zhdanova (UIBK);
Diana Maynard (USFD)

Abstract.
EU-IST Network of Excellence (NoE) IST-2004-507482 KWEB
Deliverable D1.4.1v1 (WP1.4)
The technology roadmap activities aim at reporting on an overall account of semantic web tools and potential impacts in industry, business and society. In order to clearly identify the technology locks (or obstacles) that Knowledge Web is resolving and trying to overcome, the final version of the Knowledge Web Technology Roadmap (KWTR) document approximately should contain: current trends on semantic web tools, general organizational needs (drivers and requirements), technology solutions and main characteristics, costs of implementation, expected results and future evolution of the semantic web.
This document "D1.4.1v1 Technology Roadmap" describes the first step of technology roadmap activities and contains the skeleton of the final version of the KWTR document, the methodologies that are used in these activities, and some very preliminary results.

Document Identifier:	KWEB/2005/D1.4.1v1/v1.2
Class Deliverable:	KWEB EU-IST-2004-507482
Version:	v1.2
Date:	August 01, 2005
State:	Final
Distribution:	Public

Knowledge Web Consortium

This document is part of a research project funded by the IST Program of the Commission of the European Community as project number IST-2004-507482.

University of Innsbruck (UIBK) – Coordinator
Institute of Computer Science,
Technikerstrasse 13
A-6020 Innsbruck
Austria
Contact person: Dieter Fensel
E-mail address: dieter.fensel@uibk.ac.at

École Polythechnique Fédérale de Lausanne (EPFL)
Computer Science Department
Swiss Federal Institute of Technology
IN (Ecublens), CH-1015 Lausanne.
Switzerland
Contact person: Boi Faltings
E-mail address: boi.faltings@epfl.ch

France Telecom (FT)
4 Rue du Clos Courtel
35512 Cesson Sévigné
France. PO Box 91226
Contact person : Alain Leger
E-mail address: alain.leger@rd.francetelecom.com

Freie Universität Berlin (FU Berlin)
Takustrasse, 9
14195 Berlin
Germany
Contact person: Robert Tolksdorf
E-mail address: tolk@inf.fu-berlin.de

Free University of Bozen-Bolzano (FUB)
Piazza Domenicani 3
39100 Bolzano
Italy
Contact person: Enrico Franconi
E-mail address: franconi@inf.unibz.it

Institut National de Recherche en Informatique et en Automatique (INRIA)
ZIRST - 655 avenue de l'Europe - Montbonnot
Saint Martin
38334 Saint-Ismier
France
Contact person: Jérôme Euzenat
E-mail address: Jerome.Euzenat@inrialpes.fr

Centre for Research and Technology Hellas / Informatics and Telematics Institute (ITI-CERTH)
1st km Thermi – Panorama road
57001 Thermi-Thessaloniki
Greece. Po Box 361
Contact person: Michael G. Strintzis
E-mail address: strintzi@iti.gr

Learning Lab Lower Saxony (L3S)
Expo Plaza 1
30539 Hannover
Germany
Contact person: Wolfgang Nejdl
E-mail address: nejdl@learninglab.de

National University of Ireland Galway (NUIG)
National University of Ireland
Science and Technology Building
University Road
Galway
Ireland
Contact person: Christoph Bussler
E-mail address: chris.bussler@deri.ie

The Open University (OU)
Knowledge Media Institute
The Open University
Milton Keynes, MK7 6AA
United Kingdom.
Contact person: Enrico Motta
E-mail address: e.motta@open.ac.uk

Universidad Politécnica de Madrid (UPM)
Campus de Montegancedo sn
28660 Boadilla del Monte
Spain
Contact person: Asunción Gómez Pérez
E-mail address: asun@fi.upm.es

University of Karlsruhe (UKARL)
Institut für Angewandte Informatik und Formale Beschreibungsverfahren – AIFB
Universität Karlsruhe
D-76128 Karlsruhe
Germany
Contact person: Rudi Studer
E-mail address: studer@aifb.uni-karlsruhe.de

University of Liverpool (UniLiv)
Chadwick Building, Peach Street
L697ZF Liverpool
United Kingdom
Contact person: Michael Wooldridge
E-mail address: M.J.Wooldridge@csc.liv.ac.uk

University of Manchester (UoM)
Room 2.32. Kilburn Building, Department of Computer Science, University of Manchester,
Oxford Road
Manchester, M13 9PL
United Kingdom
Contact person: Carole Goble
E-mail address: carole@cs.man.ac.uk

University of Sheffield (USFD)
Regent Court, 211 Portobello street
S14DP Sheffield
United Kingdom
Contact person: Hamish Cunningham
E-mail address: hamish@dcs.shef.ac.uk

University of Trento (UniTn)
Via Sommarive 14
38050 Trento
Italy
Contact person: Fausto Giunchiglia
E-mail address: fausto@dit.unitn.it

Vrije Universiteit Amsterdam (VUA)
De Boelelaan 1081a
1081HV. Amsterdam
The Netherlands
Contact person: Frank van Harmelen
E-mail address: Frank.van.Harmelen@cs.vu.nl

Vrije Universiteit Brussel (VUB)
Pleinlaan 2, Building G10
1050 Brussels
Belgium
Contact person: Robert Meersman
E-mail address: robert.meersman@vub.ac.be

Work package participants

The following partners have taken an active part in the work leading to the elaboration of this document, even if they might not have directly contributed writing parts of this document:

University of Trento
France Telecom
University of Innsbruck
University of Sheffield
National University of Ireland Galway
University of Manchester
University of Liverpool
The Open University

Changes

Version	Date	Author	Changes
0.1	31-03-2005	Roberta Cuel	Creation, index of the document, executive summary
0.2	25-05-2005	Roberta Cuel	Deliverable skeleton
0.4	8-06-2005	Roberta Cuel	Previews changes and results
0.6	15-06-2005	Roberta Cuel	Methodologies and first questionnaires
0.8	25-06-2005	Roberta Cuel	Questionnaire previews results
1.0	30-06-2005	Roberta Cuel	Questionnaire analysis
1.1	3-07-2005	Roberta Cuel	Conclusion and final remarks
1.2	1-08-2005	Roberta Cuel	Final revision after the quality control

Executive Summary

One of the main goals of the Knowledge Web Network of Excellence (KW NoE) is the institution of a profitable relationship from academic institutions to strategic industries and vice versa from industry partners to researchers.
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.
2. to understand real needs of organizations and the market society, unveiling new needs and trends that the KW NoE should try to overcome.

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 possible applications;
- semantic web tools and potential impacts in industry, business and society.

Several topics should be discussed, such as:

(i) purposes of the technology roadmap activities for the network of excellence;
(ii) current trends on semantic web research;
(iii) current and future trends on 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 the short, medium, and long term;
(vii) and finally an action plan and some overall recommendations.

This document "D1.4.1v1 Technology Roadmap" contains only a first version of the KWTR document, reporting the first agreements on the skeleton of the deliverable, the methodologies that are used in this activity, the series of questionnaires that have been submitted to researchers and practitioners, and finally some very preliminary results.

The current main action is to collect the finest expertise in both academy and industry (in particular taking into consideration the opinions of the Knowledge Web Industry Board organized by the KW NoE) to get the most up-to-date near term and longer vision of the technology roadblocks on focus to realize the semantic web.

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

Contents

1. Introduction....1

1.1. Roadmap: a definition....1
1.2. Roadmapping: the process....3
1.3. Main features of technology roadmaps....5

2. Methods and tools for technology roadmaps....1

2.1. The technology roadmap methods....1
2.2. The Delphi technique....9

3. Aims of the Knowledge Web Technology Roadmap....10

4. Our actions....12

4.1. Some prior roadmapping steps....12
4.2. Our action plan....13
4.3. Dissemination activity....13

5. Some preliminary results....14

5.1. The current state of the art and other available information....14
5.2. From the analysis of the questionnaire and the workshop activity....14

6. Final remarks and future challenges....25

References....27

Annex 1....29

Annex 2....34

1. Introduction

Technology roadmaps are widely used within and across organizations to identify some economics, market and social trends, namely technology methods, instruments, and applications that will be largely used in the near future. Through the various versions of the technology roadmap, 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 described. All these descriptions should anticipate numbers of trends such as costs of implementations, % of market rises, etc.
In the following paragraphs, clear descriptions of technology roadmap, roadmapping and its functions are provided, with the aim of sharing a common understanding of the concept of technology roadmap and the purpose of our work.

1.1. Roadmap: a definition

In this paragraph a general definition of roadmap is provided, as 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 composed of representatives from different sectors coming from different backgrounds, aims and visions**.**
In other words 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 on 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].

Finally a technology roadmap is a useful instrument that supports strategic technology management and planning, and 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. 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.

Generally speaking the concept of roadmap, as a synonym of guideline, refers to a detailed plan or explanation to guide people in setting standards or determining a course of action [wordnet.princeton.edu, 2005]. In an organizational setting, roadmaps allow technology developments, integration with business planning, and analysis of the impacts of new technologies in the market developments. 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.

In order to clearly identify the concept of roadmap used within this activity, it is important to underline the fact that the KWTR final document would be a report, which:

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

Taking into consideration these items, the KWTR final document (that will be finalized at the end of the activity 1.4 on month 48) would be organized approximately according to 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 services and applications
5. Market and Social Trends
5.1. Trends on markets and society
5.1.1. The socio-economical trends
5.1.2. The knowledge trends
5.2. Trends on products
4.3. Trends on services and applications
7. GAP analysis (between 4 and 5)
7.1. Industry and Knowledge Web Research
7.2. Industry and Semantic Web Research
8. Challenges
9. Research roadmap
9.1. Short term
9.2. Medium term
9.3. Long term
10. Action Plan – Recommendations
11. Final remarks

In other words the KWTR final document will be composed by the following chapters. Chapter 1 in which the concept of roadmap, the processes and general aims that a technology roadmap should satisfy will be described. Chapter 2 in which the specific methodology for the KWTR will be unveiled and Chapter 3 in which the aims of the KWTR of the KW NoE will be described. In chapters 4 and 5 a state of the art of current trends in semantic web research, market and society will be depicted. In Chapter 7 threats and opportunities for a particular group of stakeholders in a technology or application area will be pointed out, and in Chapter 8 some challenges that might be resolved will be stressed and described. Finally in Chapter 9 and 10 a useful planned connection between technology and business strategy will described, supporting strategies of medium and long term planning for both research and industrial activities/initiatives.

1.2. Roadmapping: the process

The roadmap should be the result of a roadmapping process which is defined as:

> ‘‘[…] a process that contributes to the integration of business and technology and to the definition of technology strategy by displaying the interaction between products and technologies over time […]’’ [Groenveld, 1997]

In other words 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 and Kameoka, 2003, pp.1].

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.

In the roadmapping processes we should consider that the KWTR is not developed for a single organization, but is aimed at discovering future trends on research activities within a whole sector (computer science) and across other business sectors (financial, education, logistics, healthcare, etc.). 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 the KWTR will be focused only on the forecasting process, the planning process and a part of the decision making process. It will give only useful insights and indications on how semantic web technologies will develop, and which research gaps should be covered in the next future.

Moreover, according to the structure of the KWTR final document (described in the previous paragraph), the roadmapping process should be carried out according to the following steps:

- Analysis of current trends in semantic web research, namely to focus the attention on trends in:
  - theories and methods that have been studied and will be studied by researchers,
  - tools, services and applications that could be developed; testing and applying theories and methods.
- Analysis of market and social trends. In other words, 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. In the KWTR final document, trends on knowledge flows should be analyzed in order to understand how ontology and 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.

- The definition of the planning actions for short, medium and long term and finally recommendations on the future development of technology roadmap.

This last step, the planning activity, is a crucial stage of the roadmapping process, where customisation issues need to be considered. Planning is important if the roadmap architecture and roadmapping processes are to be adapted to fit the particular aims of researchers and developers. In particular, careful analysis and discussion at this stage will significantly improve the chances of success in adopting the KWTR.

1.3. 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 token by both employees and researchers. In any case it should be considered as a relevant resource for thinking about the future, and a framework for supporting collaboration, decision making and actions [Phaal, 2002].

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:

- coordinate the efforts of departments within a single company and to align their efforts with the overall objectives of the firm;
- support sector-level foresight initiatives. 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]. Another example occurs with the semiconductor roadmap, maintained by Sematech, which allowed experts to communicate and coordinate the efforts of the members of the consortium.

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.

It is important to remark that, in this activity, a strong effort should be made to enable scientific debates within a stable network of experts from both industry and academia. Thus the final KWTR document should be the result of in-depth discussions and agreements on how the future of semantic web will be foreseen.

2. Methods and tools for technology roadmaps

2.1. The technology roadmap methods

In literature there are a lot of methods and techniques that have been used within and among organizations[1]. In this paragraph two of the most important methods will be described: the T-Plan Guide and the COCONET Roadmap Approach [Phaal, Farrukh and Probert, 2000; Kappel 2001; Cuhls, 2003; Clar, 2003]

The **"T-Plan guide"** [Phaal, Farrukh and Probert, 2004, pp.4-5] describes how to develop roadmapping activities within organisations, guaranteeing a rapid and economic process. The T-Plan allow 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 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 common and shared knowledge construction, that permits them to discuss the remaining open issues. In other words 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.

[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 **"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 [Ribak and Schaffers, 2003, pp. 5].

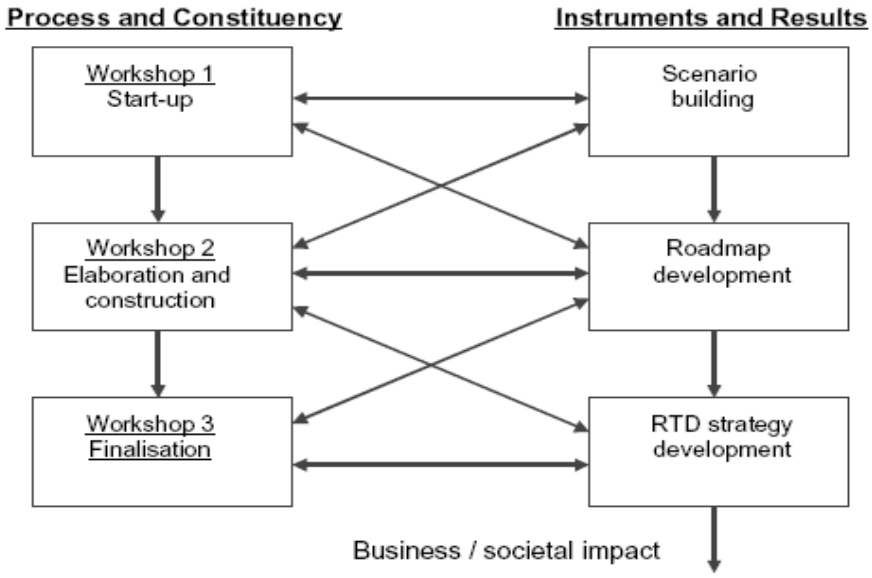

Figure 1. COCONET Roadmap Process.

This method, based on the COCONET Roadmap process, allow 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.

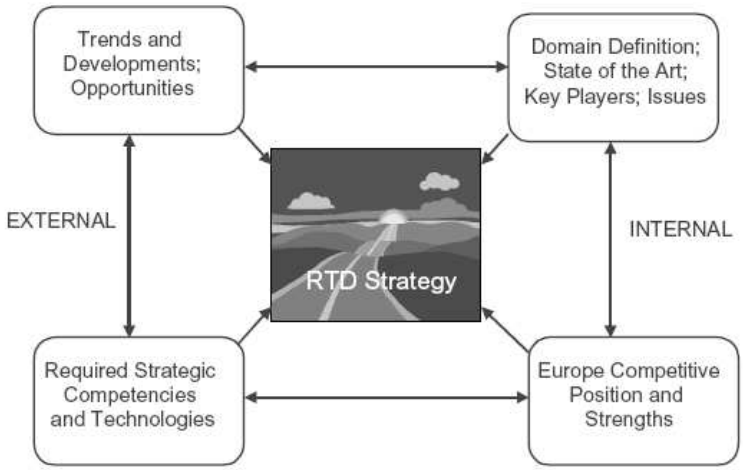

Figure 2. Four types of analysis developed according to the COCONET Roadmap Process

These analyses are the following:

1. **Analysis of the current state of the art in cooperative environments.** This analysis is aimed 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 analysis 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 analysis 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 analysis is aimed at defining the main characteristics that allow organizations and sectors to maintain leadership positions in cooperative environments.

All these analyses 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 the 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. The Delphi technique

The Delphi technique is a very widespread tool that allow 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 in the article "Collaborative technology roadmapping: network development and research prioritisation" 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." [Phaal, Farrukh and Probert, 2004]

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 address 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 received, 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).

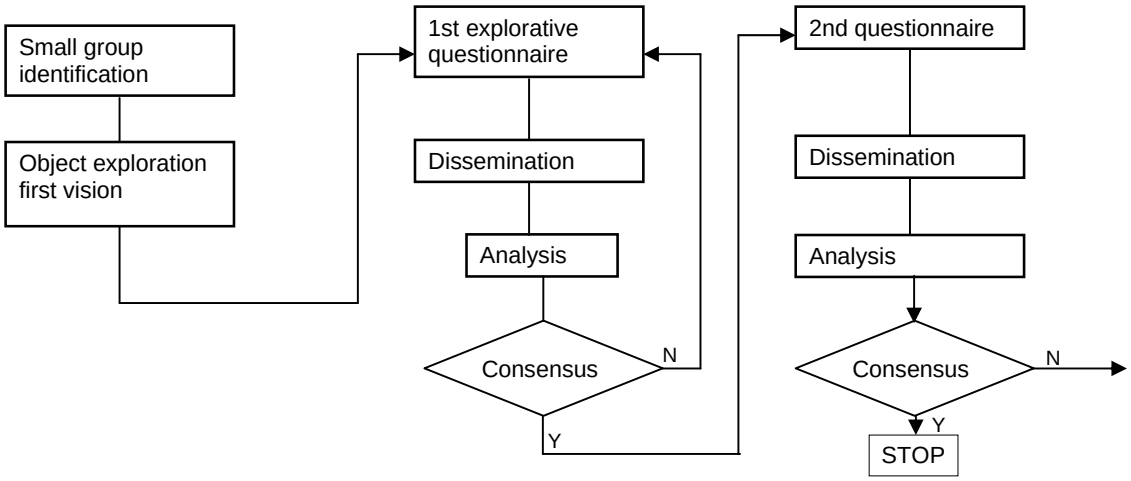

Figure 3: A typical Delphi process

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

3. Aims of the Knowledge Web Technology Roadmap

In order to guarantee an effective KWTR, our activity should allow experts to merge their views, and discuss how their future research may unveil a common and shared vision of a possible future in semantic web applications and research.

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.

Considering the fact that the KWTR should support sector-level foresight initiatives, it is necessary that members of the KW NoE merge their efforts to represent, communicate, plan, and coordinate technology forecasting and visions.
They will do it relating both the methodologies depicted above the T-Plan and the COCONET methodologies using the Delphi technique. In particular they will use some of their main features and indications with the aim at defining a technology roadmap for

various partners (independent research institutions) spread all over Europe. In particular, some processes have already been carried out and others are planned in the next months. In the next paragraphs will be described some of the activities already finished such as:

- the initiation process of the 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 reported in paragraph 5 it emerges that specialized groups answer according to their vision, without taking into account general scope of the KWTR. For instance if one group works on metadata annotation, all answers are provided only according to this perspective.

In addition, according to the COCONET roadmap method the following analysis 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 researches, technologies, tools and services that will be developed and utilized by users has been defined;

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 trend 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, etc.
- **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 into the future.

In particular, the roadmapping processes have to encourage communication and discussion within a creative workshop environment and the roadmap will provide a framework for continuing this more broadly in the future [Phaal, 2002]. Therefore workshops (as suggested by the T-Plan and the COCONET methodologies) and Delphi questionnaires have been used (and are planned to be used) in the roadmapping processes.

4. Our actions

The KWTR is a living document, and the roadmapping process is ongoing. Thus this deliverable reflects the initial efforts of the roadmapping team in developing a framework and outlining key directions and messages that have been elicited to date.

4.1. Some prior roadmapping steps

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 sold in the market. In any case the size of the group should manifestly be 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.
2. **Identification of available information:** a small group of researchers, devoted to conducting the technology roadmap analysis, should provide a first vision on foreseen solutions, tools, technologies and research activities.
3. **Required resources and scheduling of workshops:** experts should be enabled to meet in a face to face mode. In this way experts are allowed to share knowledge and understand each other more effectively. The workshops are organized at least twice in a year in line with the Knowledge Web plenary meeting events. 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].
4. **Definition of the unit of analysis**: some specific problems should be addressed and stressed in order to delimit the effort of interviews and experts' participation.
5. **Clear articulation of objectives for the process**: the roadmapping processes have been defined, and the schedule should be planned.

The identification of available information (item 2) has been depicted 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 point of view on specific topics unveiled from point 2.

Although points 4 and 5 refer to problems that are roughly described in the Delphi questionnaires results, they should be deeply discussed in a smaller group that will conduct the roadmapping process through other rounds of Delphi questionnaires and workshops.

In paragraph 5 some very preliminary results are described, in particular the results of the first round of Delphi questionnaires, and the very general results of the first workshop which took place in Crete in June 2005 during the Knowledge Web plenary session.

4.2. Our action plan

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 will address the Delphi and roadmapping processes in the next periods.

- September 2005:
  a second round of the Delphi questionnaire will be submitted to a committed group of experts (senior research practitioners involved in the Knowledge Web project).

- October/November 2005:
  the Delphi questionnaires should be elaborated and a third round of the Delphi questionnaire should be submitted.

- November/December 2005:
  previews results of Delphi questionnaires should be provided in the first version of the 2nd version of D 1.4.1

4.3. Dissemination activity

The results of the KWTR should be disseminated among all the NoE partners and should constitute a common agreement on how knowledge society will change in the next future. Therefore every researcher involved in the KW NoE, every industrial partner, and every one interested in the semantic web technology should be able to use and consult the KWTR. For that reason the previews and future results will be made available on the Knowledge Web portal, and will be presented in conferences, workshops, and technology show meetings, summer schools, etc.
We hope that the technology roadmap will constitute a useful artifact for Knowledge Web experts, who will use it to effectively address research and applications in the Knowledge Web field.

5. Some preliminary results

In this section some preliminary results on current trends in Knowledge Web will be described. In particular some useful insights unveiled from background literature (paragraph 5.1) and from the first round of the Delphi questionnaire will be depicted. In particular the first round of Delphi questionnaire did not allow us to give a complete vision of the semantic web scenario, and new rounds should be organized in order to allow experts to debate on the KWTR scenario.

5.1. The current state of the art and other available information

Taking into account some background literature, a lot of useful ideas about the state of the art and the current trends on knowledge and the semantic web can be unveiled.
In particular 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 semantic web. Semantic and knowledge web have to deal with the fact that no language will be suitable for all purposes, no model will be applicable to all 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;
- final users have to use knowledge and semantic web in a very easy and transparent way. Human and computer interfaces, automatic annotation systems, ontology libraries, text mining tools, metadata learning processes, etc, 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].

5.2. From the analysis of the questionnaire and the workshop activity

Although the first round of Delphi questionnaire tried to reach the largest number of researchers and practitioners involved in the KW NoE and other external experts, we received back only 19 questionnaires (6 from industry and 13 from research). Thus, even if the number of questionnaires does not allow us to obtain complete results, the remarks obtained allow us to unveil some useful insights, at least at this stage of research activity.

The questionnaire addressed to researchers was aimed at understanding the following topics:

- Research fields (in KW NoE and other semantic web projects);
- Research trends (in KW NoE and other semantic web projects);
- Problems that should be solved;
- Solutions, methodologies, tools that may solve these problems;
- Impacts of semantic web based solutions within and among organizations, and between organizations and clients.

The questionnaire addressed to practitioners was aimed at understanding the following topics:

- Industry fields and business interests related to semantic web methods, technologies, and tools;
- Business trends of organizations and competitors (related to semantic web based systems, tools and solutions);
- Business problems that organizations try to overcome (organizational visions, and competitive analysis sectors and solutions related to semantic web);
- Solutions and tools that may solve organizational problems and provide competitive advantages in products and services innovation;
- Impacts of semantic and knowledge tools/services within and among organizations.

5.2.1. Question 1.
"What are your research fields?" and
"What are your fields of interest and business activities?"

From the questionnaire it emerged that research fields in which researchers are mostly involved are the following:

1. computer science, artificial intelligence;
2. human language technology and the semantic web;
3. users and groups modelling behaviour (socio-cognitive and statistical analysis), and impacts of the human factor in data networks (collective intelligence);
4. knowledge representation, semantic web, ontologies and conceptual modelling, ontology alignment, semantic interoperability;
5. knowledge-based matching, context;
6. web mining, multimedia content analysis, intelligent multimedia;
7. XML family languages and applications, metadata, meta-models;
8. temporal logics and temporal databases, computational logics;
9. peer-to-peer database systems, distributed knowledge management;
10. security.

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

1. IT consulting, software development;
2. designing of web applications which allow experts to integrate web applications 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 in artificial intelligence;
- statistics-based approaches;
- 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 areas.

5.2.2. Question 2. "What are the most important trends in your research or business activities?"

From the question "What are the most important trends in your research or business activities?" researchers answered providing observations for short (1-3 years), medium (3-6) and long terms (6-12 years) as follow:

Short term, from 1 to 3 years

- semantic web and knowledge retrieval research, light-weight semantics, distributed systems;
- representing, discovering, and using mappings;
- integration with other fields (natural language, databases, machine learning;
- ontology evaluation and re-use;
- development of ontology-based automatic techniques for metadata creation;
- 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.

Medium term, from 3 to 6 years
- distributed systems, scalability of systems;
- semantics-oriented research;
- standardization of semantic web and certification of ontologies;
- massive popularization of semantic data;
- more accurate models of the user;
- deeper context based applications;
- editing and reasoning tools for uncertain rule representation;
- tools for semi-automatic annotation of general multimedia content
- alignment of multimedia ontologies;
- automated web services and intelligent searching;
- involvement of economics, cognitive science, and human sciences aspects.

Long term, from 6 to 12 years
- multi-media semantics;
- industry strength security and trust solutions;
- making semantic web tools widely used by non-experts in the same way as they nowadays can edit web pages without knowing HTML nowadays;
- tools for automatic annotation of general multimedia content;
- automatically adapted knowledge;
- semantic grid;
- ambient intelligence merged with distributed knowledge management.

Practitioners answered with unexpected and very vague descriptions like:
Short term, from 1 to 3 years
- W3B, ontology, web service;
- ontology based systems;
- knowledge management;
- web mining; web technologies, web applications;
- integrated application among organizations;
- automatization of distributed business processes;
- semantic web technologies.

Medium term, from 3 to 6 years
- ontology based community management;
- new ontology based products in the market;
- new methods.

Period of time from 6 to 12 years

- semantic web services.

The vagueness of the answers of practitioners can be attributed to the fact that semantic web technologies are not mature fields and that a lot of organizations do not have a clear vision on how solutions can be developed using knowledge and semantic web applications. 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.

In any case, due to the vague answers we received, in the next analysis a series of prototype case studies should be taken into consideration. Some of them should be based on the idea that large organizations have full vision on various knowledge based systems such as GRID computing and distributed computing, open (virtual) value chains, distributed design products, etc. These more "sensible" organizations should be:

- big industries already involved in KW NoE, because they should have a personal vision of semantic web future applications (i.e. Airbus, France Telecom);
- small and medium enterprises which might have no vision on the semantic web, but could contribute by showing what they think about future semantic applications.

Moreover, during the workshop it came out that a list of companies, consultants and experts should be contacted and involved in the roadmapping activities in order to cover the most important industrial sectors (as classified in the KW Industry Board) such as:

- aerospace;
- vehicles and cars;
- banking and finance;
- computers and electronics;
- food industry;
- transportation and logistics;
- energy and public services;
- government and public administration;
- constructions (building industry);
- luxury goods;
- media and communication;
- health care and pharmaceutical;
- sports;
- telecommunications;
- software vendors;
- business consultants.

5.2.3. Question 3.
"What are the most important trends in your research or business activities?"

All the various answers to the question about the most relevant aims in research fields or business activities generally refer to a universal management of data, information or knowledge contained in documents, taxonomies, classifications, and ontologies. In this sense management mainly refers to navigation services such as publish (on web, intranet, etc), add, match, and modify. In particular researchers answered as follows:

- knowledge retrieval in "localised systems": change, distributed knowledge, dealing with trust and confidence;
- heterogeneity/ontology mapping/semantic integration;
- scalability: ontologies are too complicated and changing too fast (lose control);
- guidelines and tools for ontology development;
- logics are too heavy (only a person with a PhD degree can understand it);
- performance issues;
- lacks of stable tools and standards;
- realistic models are not developed yet (ontology based search can only be achieved in scientific paper);
- creating easy to use and collaborative tools for building ontologies;
- finding ways to deal with multiple narrative systems;
- solving the context-dependent nature of the object recognition problem.

And practitioners answered as:

- to create new generation of applications which enable knowledge management;
- to help customers, improve their information management;
- to extract information in a machine recordable form;
- to get other and own structures;
- to develop web application (e-Goverment);
- to transfer data, information and knowledge from old applications.

5.2.4. Question 4.
"Do you know other research fields markets (or industry sectors) related ore interested to Semantic and Knowledge Web?"

Researchers answered as follows:

- scalability: closer collaboration with database community is needed;
- heterogeneity as a learning issue;
- dynamics: good results are achievable on this timescale;
- large ontologies, e.g. for product description;
- web service based systems, cross-business processes;
- data integration and presentation;
- to study of the tradeoffs between expressivity and efficiency;
- to overcome the problem that users are ready to create and disseminate contents but not ready to describe their content;
- approximate reasoning;

- distributed reasoning, P2P applications;
- ontology versioning;
- agent oriented semantic web engineering;
- new models on the concepts of correctness and completeness. These are unfeasible requests for the web, see for instance the notion of “good enough” or “marginal utility”;
- ambient computing.

Practitioners answer as follows:

- semi-automatic analysis of multimedia content;
- knowledge-assisted automatic annotation of multimedia content;
- semantic interpretation of multimedia content;
- semantic spatio-temporal segmentation of image and video content;
- feature-based object recognition using ontologies;
- semantic web, information systems, databases will be more and more interconnected to solve similar problems;
- tools for automatic analysis of multimedia documents;
- automatic annotation and retrieval of image and video content.

5.2.5. Question 5.

“What are, in your opinion, the core issues and core problems that important researches try to overcome or your organization tries to overcome?”

Researchers’ answers are:

- lack of precision in retrieval;
- needs for personalisation;
- data management;
- middleware for semantic web applications (scalability, coordination, distribution);
- well founded approaches for semantic enhanced applications;
- support for evaluation, usability and reuse of ontologies, reuse of legacy data;
- providing logical basis for best practices in data access and sharing;
- automatic creation of semantic metadata embedded in textual or multimedia content;
- learning from information available on the WWW using semantic techniques;
- fuzzy reasoning in open-world knowledge using fuzzy description logics;
- editing and reasoning tools for fuzzy description logics;
- lightweight approaches to ontologies;
- P2P organization of data and knowledge;
- automatic spatio-temporal segmentation of video content.

Practitioners’ answers are:

- to embed knowledge of users into the applications;
- to give potential customers insight into semantic web;
- semantic ontologies are new technologies;
- to overcome rare practical use of semantic web/ontologies;

- to solve the problem that solution are not stable enough;
- to organize information, normalize information data;
- efficient information and knowledge management interoperability.

As in previous answers the practitioners' vision is too vague to be compared with researchers' answers. Therefore it seems impossible to discover gaps between research trends and organizational requests and needs. This assumption has been justified during the workshop session, when experts depicted other possible core problems to overcome such as:

- semantic mapping (among domain specific applications);
- automatic semantic annotation;
- easy to use semantic builders;
- dynamic knowledge generation using networks;
- role of brokers within networked knowledge;
- ontology negotiation;
- immigration to old systems;
- replicability of old systems;
- ontology evaluation and measurement of revenue on investments.

Finally other useful insights can be unveiled with the analysis of cases studied in other WPs (i.e. WP 1.1, WP 1.4.2).

5.2.6. Question 6.

"What are, in your opinion, the tools and solutions that will resolve these problems?" and "What are the tools and solutions (related to semantic and knowledge web) that your organization is developing?"

Researchers answered as follows:

- linguistic knowledge tools, natural language based information extraction tools;
- supporting uncertain knowledge representation;
- semantic (unveiling, matching) tools;
- semantic query languages and engines;
- ontology development tools and guidelines;
- ontology editors or annotators linked together with common solutions (word, frontpage etc.);
- ontology repository and evaluation tools;
- storage solutions for large knowledge bases (scalability, distribution, reliability);
- new tools for data integration and navigation;
- collaborative tools for creating and deploying dynamic and multiple ontologies;
- web services, service oriented architectures;
- relational databases to RDF mapping;
- fuzzy OWL.

Practitioners answered as follows:

- Web-celed: authorize getting data from website;
- Web-finder: autorize locating sites with specific content;
- CornX – connect your content;

- Webcrawler, wrapper;
- Tool of semantic mediation of legacy databases;
- Tool for network management;
- Project “knowledge management”;

Even if researchers have unveiled some concrete problems and provided directions on possible research activities, a comparison between the researchers’ and practitioners’ answers cannot be made. In particular more concrete examples, goals and case studies should be analysed, such as in an annex box, 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.
According to the business cases provided by the deliverable 1.2.1 other tools might be unveiled such as:

- query answering;
- annotation (manually, semi-automatic, or automatic);
- aggregation;
- matching;
- extraction (data, information, knowledge);
- navigation;
- services (i.e. for web services);
- semantic search;
- data integration;
- ontology editing;
- storage;
- retrieval;
- trusting and ranking systems;
- reconciler;
- planner.

5.2.7. Question 7.
“What are, in your opinion, the methodologies and technologies that will be used in the tools and solutions described above?”

Researchers’ answers are:

- OWL;
- metadata for ontologies, ontology best practices methodology; subsymbolic to symbolic mapping techniques;
- benchmark for ontology evaluation;
- SPARQL, RDQL, mediators for ontological heterogeneity;
- machine learning;
- human language technology, natural language processing;
- interface design; easy to use – all the heavy stuff are hidden from the users;
- computer supported collaborative work;
- logics;
- information extraction;
- neural networks and learning theory;

- UML, XML, WSDL UDDI, CWM (Warehouse Model);
- SW engineering (a la Agent Oriented Software Engeneering).

Practitioners' answers are:

- File systems, database, document management;
- Ontologies, text mining, reasoning;
- RDF, RDFS, web services;
- Taxonomies, topic maps, ontologies, agents.

5.2.8. Question 8.

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

Researchers consider that knowledge and semantic web will influence many disciplines such aseconomics, human sciences, cognitive science and vice versa, and these will influence knowledge and semantic web solutions, tools, methods, and theories.

Other simple considerations depict knowledge and semantic web as the promoter of:

- transparency in job market, purchasing processes, etc;
- personalization of on line services (marketing);
- easy eCommerce;
- to make business open, more flexible, and less human involved;
- information sharing and acquisition performed by software agents rather than humans;
- more efficient human decision processes and interactions;
- empowerment of targeting disclosed information;
- empowerment of community oriented learning with mixed virtual and face-to-face interactions;
- changes in the communication patterns;
- empowerment of knowledge integration, reaction time, that transform life and organizations as more open and complex.

Contrary to the expectations, practitioners depicted only one vague scenario, based on information integration and interoperability systems.

5.2.9. Question 9.

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

Also in this question researchers seemed to have a clearer vision of the foreseen scenario and impacts that knowledge web and semantic web will have in the market. In particular they have depicted the following scenario:

- middle management will become unnecessary;

- the relevance of third parties providing data integration and mining will gradually substitute the direct B2B information sharing;
- specialisation will remain necessary (e.g. a job provider for computer scientists) where particular expertise can be additionally provided;
- all obvious information will be available easily to those who are entitled to get it;
- less time will be lost waiting for some info (think about the time google helps you to spare having an answer);
- knowledge becomes more distributed, owned and controlled by many individuals and groups [Euzenat, Pin and Ronchaud, 2002];
- most of the content archives, from museums and libraries to TV channels and digital cinemas, will hold multimedia content;
- information management of the multimedia content production chain (from pre-production to post-production);
- competitiveness, marketing, market segmentation, brand identity will become more sophisticated.

Practitioners answered as follows:

- organizations will concentrate on their core business (specialization);
- new types of collaboration, based on B2B platform, will be developed;
- transaction costs will be reduced.

Some of the answers above listed, seem to contradict themselves. For instance how can organizations be more focused on their core business, specialize their knowledge, and cooperate with other organizations in a virtual value chain, without third party that:

- guarantees shared standards and directions, in communication processes;
- provides evaluation and comparison among a huge number of organizations spread all over the globe;
- enables the creation of consortium through which people can aggregate.

5.3. Some useful insights from the analysis

Although the first round of Delphi questionnaire 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.

6. Final remarks and future challenges

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 to 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 businesses 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.

Finally, the results presented here are preliminary and a more detailed deliverable with the shared view of the consortium will be given in month 24 (December 2005). 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. Therefore, as described in paragraph 4.2 the plan to proceed in the future is the following:

– July/August 2005: the identification of a small group of experts who will address the Delphi and roadmapping processes in the next periods. Due to the difficulties in meet

face to face, many conference calls will be organized in order to obtain a first common vision on how do we will proceed in managing this activity and the Delphi questionnaire.

- September 2005: a second round of the Delphi questionnaire will be submitted to a committed group of experts (senior research practitioners involved in the KW NoE), and will be disseminated through the KW portal.

- October/November 2005: the Delphi questionnaires should be elaborated and if it is necessary a third round of the Delphi questionnaire should be submitted.

- November/December 2005: preliminary results of Delphi questionnaires should be provided in the first version of the 2nd version of D 1.4.1. In particular the description of a common and shared scenario, some needs and eventually some technology locks will be depicted.

References

[Clar, 2003] G., Clar Forecasting options for the future - to gain foresight to select and shape them. *Journal of Forecasting. Special Issue on Technology Foresight* . 22:2-3 , pg 83 – 91, 2003.

[Cunningham, 1993] J.B., Cunningham. Action research and organizational development. London: Praeger, 1993.

[Cuhls, 2003] K., Cuhls From forecasting to foresight processes - new participative foresight activities in Germany. *Journal of Forecasting. Special Issue on Technology Foresight* . 22:2-3 , pg 93 – 111, 2003.

[Denzin and Lincoln, 1994] N.K. Denzin and Y.S Lincoln. Handbook of qualitative research. London: Sage, 1994.

[Euzenat, Pin and Ronchaud, 2002] J. Euzenat, J.-E.Pin and R. Ronchaud. Research Challenger and Perspectives of the Semantic Web. *Strategic Research Workshop*. France, 2002

[Glene and Peshkin, 1992] C. Glesne and A. Peshkin. Becoming qualitative researchers: An introduction. New York: Longman, 1992.

[Groenveld, 1997] P. Groenveld. Roadmapping integrates business and technology. *Research Technology Management*, 1997.

[Howe and Lewis, 1993] R. Howe and R. Lewis. A student guide to research in social science. Cambridge: Cambridge University Press, 1993

[Kappel, 2001] T. A. Kappel. *Perspectives on roadmaps: how organizations talk about the future.* The Journal of Product Innovation Management 18: 39-50, 2001.

[Kreuger, 1988] R.A. Kreuger. Focus groups: A practical guide for applied research. London: Sage, 1988.

[Li and Kameoka, 2003] M. Li and A. Kameoka. *Creating Added Value from Roadmapping Process: A Knowledge-Creating Perspective*. Engineering Management Conference, 2003.

[Merton, Fiske and Kendall, 1990] R.K. Merton, M. Fiske and P.L. Kendall. The focused interview: A manual of problems and procedures. (2nd ed.). London: Collier MacMillan, 1990.

[Morgan,1988] D.L. Morgan. Focus groups as qualitative research. London: Sage, 1988.

[Patton, 1990] M.Q. Patton. Qualitative evaluation and research methods. (2nd ed.). London: Sage, 1990.

[Phaal, 2002] R Phaal. Foresight Vehicle Technology Roadmap. Technology and Research Directions for Future Road Vehicles. UK Department of Trade and Industry 2002.

[Phaal, Farrukh and Probert, 2000] Phaal, C.J.P. Farrukh and D.R. Probert. Tools for technology management – structure, organization and integration. *Proceedings of the IEEE Int. Conference on Management of Innovation Technology (ICMIT), 12-15th November, Singapore, 2000.*

[Phaal, Farrukh and Probert, 2004] Phaal, C.J.P. Farrukh and D.R. Probert. Collaborative technology roadmapping: network development and research prioritisation. *Int. J. Technology Intelligence and Planning, Vol. 1, No. 1, 2004.*

[Ribak and Schaffers, 2003] A. Ribak and H. Schaffers. Context-Aware Collaborative Environments for Next-Generation Business Networks. *Research Agenda and Roadmap,* 2003.

[Rinne, 2004] M. Rinne. *Technology roadmaps: Infrastructure for innovation*. Technological Forecasting & Social Change. 71: 67–80, 2004.

[Shah, Finin and Mayfield, 2002] U. Shah, T. Finin and J. Mayfield. *Information Retrieval on the Semantic Web*. CIKM, 2002.

[Sheth and Meersman, 2002] A. Sheth and R. Meersman. *Amicalola Report: Database and Information Systems Research Challenges and Opportunities in Semantic Web and Enterprises*. SIGMOD Record, 2002.

[Stewart and Shamdasani, 1990] D.W. Stewart and P.N. Shamdasani. Focus groups: Theory and practice. London: Sage, 1990.

[Vojaka and Chambers, 2004] B. A. Vojaka and F. A. Chambers. *Roadmapping disruptive technical threats and opportunities in complex, technology-based, subsystems: The SAILS methodology*. Technological Forecasting & Social Change. 71: 121–139, 2004.

[wordnet.princeton.edu, 2005] Concept of "road map" from WordNet online lexical database. Princeton University Cognitive Science Lab, 2005.http://wordnet.princeton.edu/

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;
- ***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 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

For further information please contact
Roberta Cuel
Faculty of Economics
University of Trento
roberta.cuel@economia.unitn.it
http://fandango.cs.unitn.it/cuel