D 1.1.4 v3
System and knowledge technology components for prototypical applications and business cases

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Abstract.
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This document extends the previous deliverable D1.1.4v2 with details regarding the final outcome of the Industry-Research co-operations. We describe the results for our industry partners who have needs that can be met by research carried out in KnowledgeWeb. We identify open issues, remaining challenges and potential problems. Finally we consider how we can communicate our results to industry, continue to enable technology transfer also in the future and what are the necessary future research directions for industry mature semantic technologies.

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Executive Summary of Deliverable

In KnowledgeWeb, the main goal of the network is the technology transfer from academia to industry. As part of this, different initiatives have been taken within the network and co-coordinated together to maximize research impact on industry. This deliverable focuses on one of those initiatives, in which the cutting edge research being done by KnowledgeWeb researchers has been tied to real business cases whose identified industry requirements could be met by the research results being achieved.

The objective of the Industry-Research co-operation is to establish a working relationship between Semantic Web researchers and an industry partner, in which research results being produced in an area of Semantic Web research will be prototypically applied to the industry partner's selected business case. The co-operation not only seeks to achieve an individual success story in terms of some specific research and a given business case, but also to establish the value of Semantic Web technologies to industrial application in a more general sense. It achieves this by demonstrating the use of Semantic Web technology in a business setting, exploring their usefulness in solving business problems and ensuring future applicability by directing researchers towards meeting industrial requirements in their work.

In KnowledgeWeb, an Industry Board was formed at the beginning of the network to bring together potential early adopters of Semantic Web technologies from across a wide spread of industry sectors. Industry Board members have been involved in many initiatives of the KnowledgeWeb Industry Area, including the collection of business use cases and their evaluation (D1.1.2, D1.1.3). In order to more directly achieve close co-operation between researchers and industry, each research workpackage in the network was invited to select a use case whose requirements closely correlated to what would be achieved in their research work. (D1.1.4v1). First results have been reported in a previous deliverable (D1.1.4v2).

As the KnowledgeWeb network draws to a close, this deliverable reports on what has been achieved in the short period of the Industry-Research co-operations as well as what has been established to promote further transfer from academia to industry, both before the end of the network and thereafter. The co-operations have been a very challenging activity, given the early state of much cutting edge Semantic Web research and the differences in perspective between academia and business. However, we can report on our successes, not only in the production of some prototypical solutions and demos which can be shown to industry, but also in making Semantic Web researchers more aware of the importance of their work to solving business problems and the earlier recognition by academics of industry requirements and considering them in their research.

Hence, the KnowledgeWeb Industry-Research co-operations must be seen as a significant first attempt to align the ambitious cutting edge work on Semantic Web technologies done by leading researchers in Europe and the real world business problems encountered by European industry which may find a potential solution in those same Semantic Web technologies. Given a continued rise in awareness among Semantic Web researchers of the applicability of their work to industry and the continued rise in awareness among industry of the potential of the work of Semantic Web researchers, which has been begun in KnowledgeWeb, we ensure future technology transfer.

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1. Introduction

We are now in the last phase of our efforts within the KnowledgeWeb network to achieve technology transfer from academia to industry. Building on the foundations of earlier activities, particularly OntoWeb[1], we have recognized that it is necessary to bring *industry needs* and *research activities* together. We established an Industry-Research co-operation track and it is the results of this track that we provide in this deliverable, together with plans for proceeding both within the last months of the network and beyond.

Previously we have reported on the following:

- In D1.1.4v1 we selected some of the use cases provided to us by the Industry Board members and provided *executive summaries* for each identifying industrial requirements for Semantic Web research.
- Each Research WP was invited to identify a use case and to prepare a research time plan for meeting the use case requirements through their research and (when possible) make a first transfer of technology to the enterprise for prototypical evaluation. The use case selection, progress to date and future plans leading to technology transfer were presented in D1.1.4v2.

Now in D1.1.4v3, this deliverable, we report on what has been achieved for each of the six selected use cases and evaluate this achievement. For each co-operation, we identify the results which have been generated from the work and consider their applicability for communication to industry. Finally, some references are provided which contain more information, usually from the researcher perspective, on the work done within the Industry-Research co-operation.

In considering the outlook for the future following the achievements of these co-operations, we outline how technology transfer may still be supported during the remaining time of the network and beyond the duration of KnowledgeWeb. In particular, we focus on how Industry-Research co-operation can continue to be supported and its results disseminated to further raise awareness in both the research and industry communities. In this case, we have established in particular three initiatives for ensuring the future continuation of technology transfer:

- Communication channels to and events targeted at industry
- Further co-operations between Semantic Web researchers and industry partners
- A research agenda for semantic technologies in the enterprise

To conclude, we acknowledge the challenges of carrying out Industry-Research co-operation at this stage of maturity of semantic technologies. We consider the work described in this deliverable as an important early effort in ensuring later successful transfer of results.

[1] http://www.ontoweb.org

2. Final Report on Industry-Research Co-operations

For each Industry-Research co-operation chosen in Knowledge Web we provided a questionnaire (in the annex 1) to the responsible researchers and asked them to answer questions relating to what progress was made in the co-operation, their evaluation of the industrial success of their co-operation, and the re-usable results of that co-operation. The contents of this section are based on the researcher's response to the questionnaire.

The following co-operations are considered by this deliverable:

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2.1 WP 2.1: Scalability

Chosen Use Case:	Recruitment
KW Partners:	VUA, FU Berlin
IB Member:	WorldWideJobs GmbH

Progress

Within the Industry-Research co-operation, Knowledge Web researchers have developed an approach to online recruitment based on a Human Resources ontology **extending an existing prototype** which was the result of a national project (the German BMBF-funded Wissensnetze project). The extension combines the existing semantic matching capabilities of the prototype **with query approximation through a rule rewriting strategy**.

The prototype: (i) takes into account the real world requirements derived from the industrial use cases collected in the framework of Knowledge Web, (ii) utilizes the HR ontology developed in the German project Wissensnetze, and (iii) applies the rewriting rules as a simple technique for query relaxation. It also supports queries which include the amount of experience required from a job seeker. These queries represent typical query forms which can be expected in a real world Human Resources application which were not answerable or adequately answered by the original prototype with semantic matching.

However, due to unforeseeable changes within the participating Knowledge Web partners and the Industry Board member, it was not possible to complete fully the co-operation in

order to apply the semantic matching approach to rank the final results and hence the "new" prototype has not been tested against the original one.

Evaluation

In the extended prototype, the following has been demonstrably achieved:

- Modelling of required experience:
  - We have developed a (small) experience ontology
- Delivery of job applications which maybe do not fit 100% to the defined requirements but are still acceptable for the employer
  - We developed a prototypical implementation with query relaxation

The open problems identified from this work which remain to be solved:

- user-based ranking of relaxing rules
- more robust and efficient query response from knowledge bases which can scale to real world enterprise size.

Results

The extended prototype shows the use of query relaxation defined by rules in providing further semantic matching functionality which is relevant to industrial application:

- Providing answers even to over specified queries
- Supporting relaxation of queries in meaningful ways
- Scaling query answering by providing less exact answers

Conceptually, **the work demonstrates that the ideas are sound and implementable**, however it can not yet be said that the work is industry ready. Rather, the result justifies further research into this approach, both to refine it for querying real world enterprise size knowledge bases and to extend it to other domains and ultimately to develop domain-independent best practises for formulating and using query rewriting rules.

There is available for further dissemination of this co-operation:

- Papers (references see below)
- Prototypical implementation (first public demonstration at Making Semantics Work for Business workshop at the 1st European Semantic Technologies Conference, Vienna, May 2007)

Unfortunately since parts of the HR ontology are not public the prototype is not available to download.

References

Application of the rewriting rules:

M. Mochol, H. Wache, L. Nixon: ***Improving the accuracy of job search with semantic techniques****, 10th International Conference on Business Information Systems (BIS2007), Poznan, Poland 25-27 April 2007.*

M. Mochol, H. Wache, L. Nixon: ***Improving the recruitment process through ontology-based querying****, 1st International Workshop on Applications and Business Aspects of the Semantic Web (SEBIZ 2006), collocated with the 5th International Semantic Web Conference (ISWC-2006), Athens, Georgia, USA, November, 2006.*

Peter Dolog, Heiner Stuckenschmidt, and Holger Wache. ***Robust query processing for personalized information access on the semantic web****. In 7th International Conference on Flexible Query Answering Systems (FQAS 2006), number 4027 in LNCS/LNAI, Milan, Italy, June 2006. Springer.*

2.2 WP 2.2: Heterogeneity

Chosen Use Case:	Recruitment
KW Partners:	INRIA, FU Berlin
IB Member:	WorldWideJobs GmbH

Progress

Since the initial test case using the recruitment scenario at the Ontology Alignment Evaluation Initiative workshop (at ISWC 2006) there have been problems in implementing the planned further work. The evaluation that had been planned required some heavy software engineering and there was a delay in obtaining the necessary industry support. When the industry support was obtained, insufficient time remained to complete the work.

There are many research groups working on ontology matching, however what was unique in the experiment planned by this co-operation was to be able to plunge research prototypes in an industrial production environment. We are not aware of any similar attempts to do this. What we learnt from this experience is that this does require a lot of work and commitment from both academic and industrial partners and this can certainly explain the lack of such real experience.

Evaluation

The recruitment scenario was chosen as one of the scenarios for evaluating ontology alignment tools at the Ontology Alignment Evaluation Initiative workshop (OAEI 2006). The uniqueness of this scenario, provided by KnowledgeWeb through the Industry-Research co-operation, was that it was based on a real world business case (recruitment) using industrial ontologies (in this case, based on HR-XML and a skills taxonomy). Alignment is an important aspect of the semantic solution, which requires a matching between a job offer and a job seeker. This was the first scenario in the OAEI workshop to be directly drawn from industry.

However, unforeseeable technical problems arose from the industry aspect of the scenario. Since the HR ontology taken from industry and used in the prototype was not

able to be publicly made available, it was not possible to send details of the schemas used to the workshop participants. Hence, the idea chosen was that the participants would send their matching algorithms and the tests would be performed by the university partner. The exchange of the matcher in the prototype – which had been developed for industry with the chosen partner – required more effort than originally foreseen, with the result that the resources necessary proved too much to complete the work.

Results

The lack of evaluation is tied to the fact that on the industry side, software is not designed with the idea that it will be possible to replace the matching components or that the alignments can be stored in a standard format. This is to be expected since the applications are made with the major aim of functioning and not of testing matchers. This does not mean that matching cannot solve the considered problems. We expect it will take some more years before this situation changes. Certainly a successful experiment would hurry this transition.

A description of the planned experiment is available in Deliverable 1.2.2.2.1 and could be used as a blueprint for a future experiment. We are also now more aware of the level of commitment required, both from our own side as well as the importance of a committed (over sufficient time) industrial partner. The Ontology Alignment Evaluation Initiative will be continued at the ISWC 2007.

The following projects may be able to take some of the lessons from this co-operation and achieve further progress:

- NeOn (www.neon-project.org) provides industry test cases really requiring matching and that we may be able to use for our experiments, in ecological resource inventory and pharmacy billing;
- OpenKnowledge (www.openk.org) has two different test cases in bioinformatics and emergency response.

References

Jérôme Euzenat, Pavel Shvaiko, ***Ontology matching****, Springer-Verlag, Heidelberg, 2007.*

Marc Ehrig, ***Ontology alignment****, Springer-Verlag, Heidelberg, 2007.*

Malgorzata Mochol, Anja Jentzsch, Jérôme Euzenat, ***Applying an Analytic Method for Matching Approach Selection****, Proc. ISWC Ontology Matching workshop, Athen (GA US), 2006*

2.3 WP 2.3: Dynamics

Chosen Use Case:	Application of Wiki Versioning to a Hospital Use Case
KW Partners:	DERI, NUI Galway
IB Member:	HP Galway

Progress

Since the last report on the Industry-Research co-operation, the Knowledge Web researchers have been very active in seeking industrial use cases for their work and in ensuring its industrial relevance. As a result the use cases were redefined and the dynamic lifecycle platform is being currently prepared for applications in industry (particularly e-health). We have analysed several needs and respective requirements put on the use of Semantic Web technologies in the e-health use cases elaborated by the RIDE EU project. **Example use cases are**: **longitudinal electronic health records**, **epidemiology repositories** or **public health surveillance**. In all the analysed cases, there is an explicit need for *ontology integration* techniques facilitating the medicinal data integration. Moreover, need for means to *efficiently process* possibly *large amounts* of unstructured data (i.e. natural language text) in dynamic environments is emphasised. We aim to tackle these challenges namely by incorporation of ontology learning and development of dynamic ontology integration methods within the ontology lifecycle platform implementation. When presenting the progress of our research at several venues during the last months, we gathered some feedback from the interested industrial audience and identified the following possibilities of concrete industrial cooperation: application of the lifecycle platform in maintenance of pharmaceutical ontologies (Scientific Commons), in facilitation of clinical trials processing (cooperation with industrial partners of University of Manchester). Moreover, a representative of the Chevron petroleum company recently expressed interest in the platform and its possible application to maintenance of ontologies employed in searching for gas and oil.

Hence major progress has been made in the definition and implementation of this kind of dynamic lifecycle/evolution platform for ontologies, with industrial usage in mind.

Evaluation

A number of (e-health) industry requirements have been identified which are relevant for this work:

- integration of new knowledge into an existing ontology
- scalability
- accessibility (for non-expert users)

As development of the technology is still continuing, it is still too early for actual industrial application of the technologies, which is needed to evaluate how the identified requirements are being met. However, as requirements from the industry are being

identified now and are guiding the technology development, **we expect the resulting product to be industry ready** within the current limitations of the research (e.g. vis-à-vis scalability).

An aspect of evaluation for which researchers need to develop methodologies is the semi-automatic assessment of the quality of learned ontologies.

Results

A basic prototype of the lifecycle/evolution platform is to be released (under an open source license) after the summer 2007 (planned date September 30, 2007) at http://ontoware.org/. In parallel to the release, **evaluation in selected industrial use cases with the notified industry partners** (e.g. Scientific Commons or Chevron) will have already started by the date. The results and the evaluation itself will be endorsed by the OOA consortium (e.g. publishing reports on industrial feedback questionnaires, advertising the work to broader audience), should the duration of this process exceed the ending date of the Knowledge Web network.

An existing result which can be redesigned for industry and used in dissemination is the SemVersion library (publicly available at http://ontoware.org/projects/semversion/; a directly deployable Java library and documentation of the ontology versioning system are provided there)

Other projects which may be able to continue this work:
- NeOn
- DOGMA-related ontology projects at VUB

References

Vit Novacek, Loredana Laera, Siegfried Handschuh. ***Semi-automatic Integration of Learned Ontologies into a Collaborative Framework.*** *In Proceedings of IWOD/ESWC 2007.*

Vit Novacek, Loredana Laera, Siegfried Handschuh. ***Dynamic Integration of Medical Ontologies in Large Scale.*** *In Proceedings of WWW2007/HCLSDI. ACM Press 2007.*

Vit Novacek, Siegfried Handschuh, Loredana Laera, Diana Maynard, Max Voelkel. ***Dynamic Ontology Lifecycle Scenario in Translational Medicine.*** *In Proceedings of the 5th European Conference of Computational Biology (ECCB 2006) - Book of Abstracts, Oxford University Press 2007.*

2.4 WP2.4: Semantic Web Services

Chosen Use Case:	Dynamic Business to Business Integration
KW Partners:	DERI Galway, DERI Innsbruck
Industrial Partner:	Bell Labs Ireland

Progress

In this Industry-Research co-operation, **a number of scenarios within the B2B integration scenario were identified**, involving data mediation, discovery, and composition of services. All these use cases has been evaluated according to a community-agreed methodology defined by the SWS challenge methodology with satisfying success levels defined by the methodology. This is an important step when proving the added value of the semantic web service technology applied to B2B integration domain. In addition, we have partially finalized the standardization process within the OASIS Semantic Execution Environment Technical Committee (OASIS SEE TC) and W3C Semantic Annotations for WSDL and XML Schema (W3C SAWSDL WG). However, the standardization process in both groups is still ongoing.

We have not achieved the integration of our technology with industry systems such as policy systems, etc. The reason for this was that we did not get appropriate support from our industrial partner due to licence issues. However, to our best knowledge and in cooperation with the industrial partner we were able to model the policy rules in WSML rule language and perform the reasoning in our environment.

There are other participants to the SWS Challenge who address the same problems. They achieved similar results, however **other participants did not address the complete set of scenarios as we did nor did all succeed at the level as we did**. The reason why they did not succeed as we did was that some of them used a hybrid solution for their semantic approach – a combination with approaches e.g. with BPEL - instead of rule-based choreography for conversations between services.

All details are available at http://www.sws-challenge.org

Evaluation

The main industry requirement identified with the industry partner was the ability to react to changes in the back-end systems. By means of semantic technologies and semantic descriptions of services, **we have demonstrated that changes in back-end systems require changes in semantic descriptions only**. We assume that the effort for changes of semantic descriptions is significantly lower than effort in changes of environment built on traditional approaches. However this evaluation still needs to be done. Another requirement we successfully addressed was **standardization of grounding mechanisms** built on SAWSDL which is now in its last stage in W3C and standardization with OASIS SEE TC which is still ongoing.

We have only partially fulfilled the requirement of Integration of SWS technology with existing technologies. The reason for that was that we have not got the access to the industry technology due to licensing issues.

We plan to solve this within our follow-up projects when we define this requirement as part of our project plan (during the project preparation phase).

Results

The Industry-Research co-operation has **demonstrably solved a business case from the B2B domain**. We have shown how the technology deals with requirements from B2B domain and how this technology reacts to changes in back-end systems which might occur over systems lifetime. However, the more elaborated comparison and discussion on existing solutions and our semantic technology need to be done. We plan to address this issue in upcoming SWS Challenge sessions.

The research is not yet ready for industry. It must be shown how the technology is layered on the existing infrastructure and how it interacts with existing systems. For this purpose some parts of our technology need to be standardized (such as grounding mechanisms built on SAWSDL or the architecture). In particular, the grounding mechanism built on SAWSDL provides a "common interface" between semantic descriptions and non-semantic descriptions (in our case WSDL). The standardization is still ongoing while at the same time, the alignment of service semantics with this grounding mechanism must be further finalised. While we have demonstrated how this is possible to be done and what the added value of this approach is, **the complexity of business standards still needs to be addressed**.

In addition, our prototype is available[2] and we have provided that to our industry partners. We have produced a number of research papers on that topic (published in ICSOC2006, CEC/EEE2007, ESWC2007) and we plan to write more publications in that area. We have also organized a number of tutorials (e.g. in ESWC2007) which include this topic and we have demonstrated our work in the SWS Challenge workshop. We plan to follow up on these results and used them as a basis for our future research in the context of European and national funded projects so that the remaining issues could be solved and the technology will be even stronger for the industry adoption.

The following scenarios have been realised as part of the Semantic Web Services Challenge:

[2] http://sws-challenge.org/2006/submission/deri-submission-discovery-phase3/
http://sws-challenge.org/2006/submission/deri-submisson-mediation%20v.1/
http://sws-challenge.org/2006/submission/deri-submisson-mediation%20v.2/

1. Maciej Zaremba, Tomas Vitvar, Matthew Moran, Thomas Haselwanter: **Mediation Scenario** http://sws-challenge.org/wiki/index.php/Workshop_Budva. Addressing the mediation scenario for B2B integration when proprietary back-end systems of one company needed to be integrated with a partner using RosettaNet standard. Whole scenario has been successfully addressed.

2. Maciej Zaremba, Tomas Vitvar, Matthew Moran: **Discovery Scenario**. http://sws-challenge.org/wiki/index.php/Workshop_Athens. Addressing discovery scenario when a supplier needed to be discovered and selected from suitable ones. Whole scenario has been successfully addressed.

3. Maciej Zaremba, Tomas Vitvar, Matthew Moran: **Composition Scenario**. http://sws-challenge.org/wiki/index.php/Workshop_Innsbruck. Addressing composition scenario when more services can satisfy the user need. Whole scenario has been successfully addressed.

Work will continue to the end of Knowledge Web. The co-operation plans to address additional scenarios of the SWS challenge, namely scenarios when services can be filtered based on non-functional properties (QoS, financial, etc.). In addition, we will give the tutorial on SWS in the context of business process management in the upcoming ICWS conference, and we co-organize the workshop on service composition and SWS challenge to be held at the Web Intelligence conference[3].

The SUPER project (http://ip-super.org) may be able to continue some of this work.

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[3] http://events.deri.at/sercomp2007/

2.5 WP 2.5: Language Extensions

Chosen Use Case: Health Care Kidney Case
KW Partners: U of Manchester, U of Bolzano
IB Member: France Telecom

Progress

The main output of this Industry-Research co-operation is a concrete proposal for **a more expressive ontology language, OWL 1.1**, which has been made and critical mass for standardization has been achieved. All major reasoners and several editors have implemented support for OWL 1.1. OWL 1.1 has **many industrial supporters**, including HP, Oracle, Boeing, Siemens, Science Commons and NASA.

Progress on rule language standardization has been slower, as a diverse range of interests have failed to achieve immediate consensus on goals. The Rules Interchange Format Working Group continues to make steady progress, however. For OWL 1.1, consensus among these groups has been achieved.

Continuing adoption of semantic web languages in industry is evidenced by the active W3C Semantic Web Health Care and Life Sciences Interest Group.

More about these proposals can be found at:
OWL 1.1 http://webont.org/owl/1.1/
SPARQL http://www.w3.org/TR/rd-sparql-query/
Rules http://www.w3.org/2005/rules/
HC&LS http://www.w3.org/2001/sw/hcls/

Evaluation

Achievement of consensus with major industrial partners is a strong demonstration of the applicability of the proposals to industrial requirements. Work on bridges to other communities, such as the recently-developed mapping[4] between Open Biological Ontologies format and OWL 1.1, could provide great value in the future.

Semantic web query languages are making slow progress towards expressive languages such as OWL. The progress is being slowed down by low-level issues for simpler languages.

It is expected that semantic query languages based on SPARQL might achieve industrial uptake in 2 years. Rules appear to be a much more long term possibility.

Results

[4] http://www.cs.man.ac.uk/~horrocks/obo/

The co-operation can demonstrate industrial applicability – there are many applications very dependant on OWL 1.1 features such as QNR, and there are now:

(1) Standard languages to encode those
(2) Many tools which support them

OWL 1.1 is industry ready, however more industry experience is needed before large medical systems are widely deployed using the technology. We have enabled that progress to begin.

There are commercial (RacerPro), open source/free (Protégé, FaCT, Pellet) and research prototype tools (IformiT). OWL tutorials and demos are given regularly at OWL-ED and other venues, including LPAR 2004, ICAI 2004, IJCAI 2003, and every International Semantic Web Conference.

In the remainder of KnowledgeWeb, D2.5.7 will address bringing OWL to a wider community via various language bindings. D2.5.8 will address interoperability between OWL and other semantic models.

Other projects which make use of the results of this co-operation:
- REWERSE (http://rewerse.net/)
- Tones (http://www.tonesproject.org/)

References

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2.6 Multimedia Analysis and Annotation

Chosen Use Case:	Automated Semantic Multimedia Annotation
KW Partner:	CERTH
IB Member:	Motorola

Progress

In D1.1.4v2 we presented emerging technology transfer requirements within the context of multimedia semantic analysis, interpretation and annotation. The need for introducing uncertainty support into the knowledge representation formalism and the corresponding reasoning services were among the most prominent ones. The **fuzzy extensions defined within WP2.5, have formed the basis** on which the uncertainty of the produced analysis results has been handled within the aceMedia content analysis chain. Additionally, SW technologies have been successfully employed for the representation of both media-related and domain-specific knowledge, including contextual knowledge, for which however, RDF reification had to be employed.

Although the fuzzy extensions semantics have been utilised, the actual representation and implemented reasoning had to adhere to ad hoc solutions: fuzzy OWL is still a proposal, not adequate tool support (editors, repositories, etc.) exists, and the implemented fuzzy DL reasoners are still in a quite early stage to be integrated in a real application context. Furthermore, as current ontology repositories do not provide support for fuzziness, all inferences had to be made explicit and stored to the employed by the application repository, while uncertainty in queries has been simulated through the use of a respective data type property. The efforts however, towards the consecutive update of the developed fuzzy DL reasoners and towards their integration with existing SW tools (e.g., the coupling of FiRE with Sesame initiative within the K-Space project), indicate that **more complete solutions can be expected to be made feasible in the near future**. This belief is further reinforced by the number of recent projects addressing semantic multimedia content analysis and management, in which SW technologies and fuzzy language extensions are utilized as core components for prototypical methodologies and implementations.

The aceMedia use case addresses semantic analysis, annotation and retrieval of multimedia content. It uses RDFS ontologies for the representation of domain specific and media related information, RDF reification for contextual knowledge representation, DL-based reasoning for the integration of content annotations and the extraction of implicit knowledge, and a customized approach for representing and reasoning under uncertainty.

Evaluation

The aceMedia use case encompasses a variety of industry requirements with respect to multimedia content annotation, analysis and management. The implemented algorithms and demos have demonstrated **the applicability of SW technologies towards a uniform representation formalism** that facilitates modules' interaction and information exchange, the potential of fuzzy extensions to partially meeting the ambiguity in multimedia, and a formal representation of contextual knowledge.

Fuzzy extensions were initially considered adequate to handle effectively the ambiguity in multimedia content analysis, understanding and retrieval. However, the incompleteness

of the available prior knowledge, as well as the extracted one, highlights possible potential for approaches to approximate reasoning and non standard inferences.

Results

The aceMedia project constitutes a pragmatic demonstration of SW technologies application in multimedia content analysis and annotation. Although not providing a complete solution (still open issues to be addressed, some within the goals of more recent projects), **the implemented demo versions show the value and further potential**. At the same time, the experiences gained, form valuable lessons for future directions.

In order to be industry ready, it requires for a complete, robust solution, whose formalization would ensure the generality of application and its extensibility. As an important part of the research relates to the expressiveness of current SW languages and corresponding tools support, porting the aceMedia approach directly to industry strongly interrelates with the respective SW advances. Practically the aforementioned translate into requirements for: formalization of uncertain knowledge and respective tools support, formalization of rules and ontology integration, scalable query answering and reasoning.

Available results include:

- the aceMedia demo, covering both personal and commercial content, and
- relevant publications. (see references)

The aceMedia use case highlighted a number of future direction, issues and new challenges with respect to semantic multimedia content analysis and manipulation within a SW framework. Apart from the requirements with respect to formal uncertainty representations and more effective reasoning and management tools support, two dimensions of significant importance include:

- cross-media analysis, where additional requirements are posed due to the multimodality of knowledge considered, and their semantic modelling and integration, and
- non-standard approaches to reasoning, as purely deductive reasoning alone proves not sufficient

Other projects[5] which can use the results of this co-operation: particularly K-Space, X-Media, BOEMIE and MESH constitute research consortiums working on the same topic. As, in the case of aceMedia, the main research directions focus on the exploitation of

[5] http://www.acemedia.org/aceMedia, http://www.boemie.org/, http://www.kspace-noe.net/, http://www.x-media-project.org/X-Media%20Project/X-Media%20Project%20Home.html, http://www.mesh-ip.eu/?Page=Project, http://www.salero.eu/

formal explicit knowledge and (possibly extended) inference services for the extraction of semantic descriptions from multimedia content. Additional aspects include among other scalability, logic programming and DL-based reasoning integration for non standard inferences support, and ontology evolution.

References

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K. Petridis, S. Bloehdorn, C. Saathoff, N. Simou, S. Dasiopoulou, V. Tzouvaras, S. Handschuh, Y. Avrithis, I. Kompatsiaris and S. Staab: ***Knowledge Representation and Semantic Annotation of Multimedia Content****, IEEE Proceedings on Vision Image and Signal Processing, Special issue on Knowledge-Based Digital Media Processing, Vol. 153, No. 3, pp. 255-262, June 2006.*

S.Dasiopoulou, C. Saathoof, Ph. Mylonas, Y. Avrithis, Y. Kompatsiaris, and S. Staab, ***Introducing Context and Reasoning in Visual Content Analysis: An Ontology-based Framework****, in Semantic Multimedia and Ontologies: Theories and Applications, Paola Hobson, Ioannis Kompatsiaris (Editors), Springer-Verlag, 2007, to appear.*

3. Outlook

Each of the six Industry-Research co-operations has pushed a particular semantic technology to a particular industry, where we have identified an industrial requirement which could benefit from the given technology. The results of these co-operations have been that in every case both industry and researchers have had the opportunity to learn about both the industrial relevance of leading Semantic Web research and the difficulties of bringing successfully this research into an industrial setting. These co-operations also have a **potential wider result** – there are related efforts within the network on providing information about these co-operations to industry as a whole, pushing technology transfer to individual industry partners and ensuring that ongoing and future Semantic Web research takes industrial requirements into account. This reflects a key realization underpinning this activity: these individual co-operations represent **principles that can be applied generally to achieving technology transfer**, including beyond the duration of the network.

To form a clear outlook from the results of these co-operations we consider the impact of the activities on all three areas of KnowledgeWeb: Industry, Education and Research. In the following chapter, we conclude with a look further into the distance: how the final results of the network, in part enabled by the Industry-Research co-operations, can be a basis for the future transfer of semantic technologies from academia to industry.

3.1 Communication to Industry

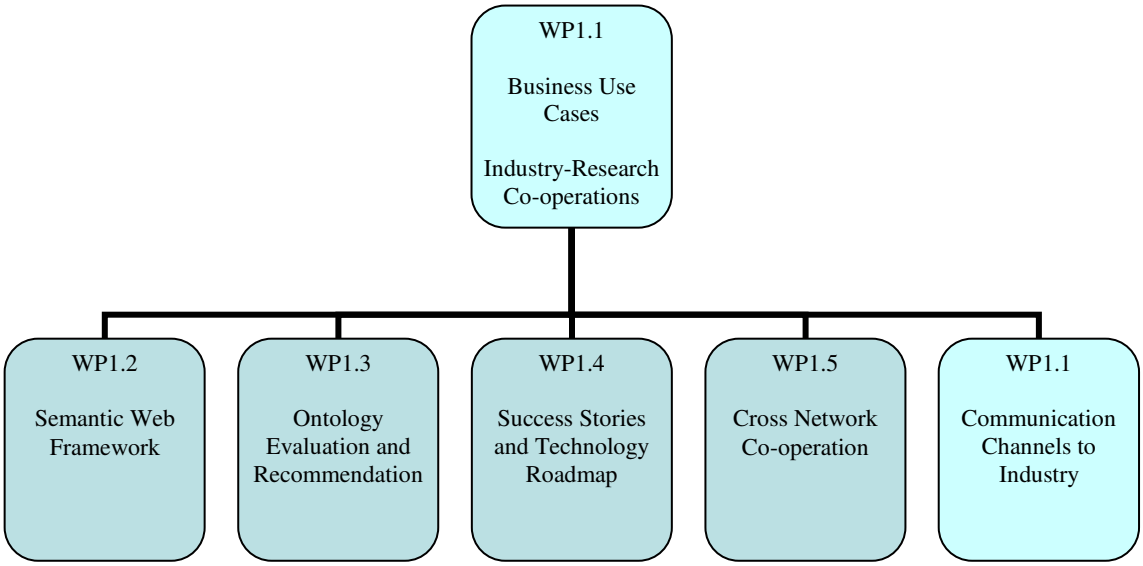
The Industry Area of KnowledgeWeb brings together many activities whose combined focus is to achieve the network goal of transfer of semantic technologies from academia to industry. The use cases and the Industry-Research co-operations are a significant aspect of this effort, as they act as **representative examples of the application of semantic technologies to real world business problems**. As a result, they form an input to a number of other activities running until the end of the network.

WP1.2 develops a Semantic Web Framework which classifies the semantic technologies according to their functionalities and defines the functionalities that should be provided by different components and the dependencies between the components. Selected business use cases are used to validate the framework by attempting to describe the semantic solution in terms of the components of the Semantic Web Framework. Subsequently, it is expected that semantic solutions proposed for business problems can be formally described and validated by the framework, which defines the expected functionalities of proposed components as well as the dependencies which exist between them.

WP1.3 establishes an Ontology Outreach Advisory[6] (OOA) to develop strategies for ontology recommendation and standardization, and promote the ontology technology to industry. In line with the use case analysis, the first domain chapters focus on key adopter industry sectors: Healthcare & Life Sciences and Human Resources & Employment. The OOA is being established as a non-profit organization and will continue to exist after the conclusion of the network.

WP1.4 and WP1.5 focus on dissemination of results to industry. In WP1.4 a number of reports on success stories are foreseen as well as the organization of a technology showcase and the production of a Technology Roadmap. WP1.5 focuses on cross-network co-operations. It is clear that results from the Industry-Research co-operations should be disseminated using these channels. We will report on communication to Industry as an activity of WP1.1, not only restricted to the Industry-Research co-operations, in a final deliverable D1.1.5v3.

This is illustrated in the below diagram.



Here, we focus on two events organized in 2007 within the activity of this workpackage (WP1.1) whose focus is the technology transfer between Industry and Research:

- At the 1st European Semantic Technology Conference (ESTC), May 30-June 1 2007 in Vienna, Austria, we organized an industry workshop **Making Semantics Work for Business** (MSWFB).
- At the International Semantic Web Conference/Asian Semantic Web Conference 2007 (ISWC/ASWC 2007), November 2007 in Busan, Korea, we will organize an industry workshop **First Industrial Results of Semantic Technologies** (FIRST).

[6] http://www.ontology-advisory.org/

Making Semantics Work For Business (MSWFB) focused on presenting Semantic Web research to interested industry participants at the 1st European Semantic Technology Conference. Attendance was around 15-20 persons. During the workshop, input was also gained for the Knowledge Web Technology Roadmap and Education to Industry activities from the industrial participants. Of the accepted talks, 3 represented our Industry-Research co-operations (WP2.1, WP2.3 and WP2.4). Given the discussions which took place, industry interest in the potential of semantic technologies is present, however **mature enough technology which can convince industry is still lacking**. The major achievement of our workshop was to involve Knowledge Web researchers, where their involvement (and generally, their interest in demonstrating industrial value of their work) was arguably a result of their participation in the Industry-Research co-operations in Knowledge Web. Given their continued efforts to produce industrially mature results and our established participation in the ESTC conference, together with the expectation of good participation at ESTC 2008 and a dedicated workshop day, we hope to not only follow up MSWFB next year with **demonstrations of further results** of our co-operations but also to achieve **an even stronger level of industrial participation**.

The First Industrial Results of Semantic Technologies (FIRST) workshop will take place during the ISWC 2007 conference. It is intended to complement the In Use track which already involves and attracts many industrial participants. Its focus will be on presentations from the industry regarding experiences as early adopters of semantic technologies. We hope to win many Industry Board members to present at this workshop and to participant as attendees. The main attendee group however is intended to be the semantic technology researchers. In contrast to previous industry events where researchers present to industry (and often fail to speak the same language), this workshop takes a different approach: **it invites the industry to tell researchers what they achieve with the current technology and what they still need**. Hence researchers should gain an insight into the industrial application of their work and learn of the open industry needs which they could work towards meeting. The aim of **Industry-Research co-operation will be strengthened** by this bringing together of industry with a message to research and research with an ear to industry. Finally, by taking the pulse of industrial application of semantic technologies, the workshop should provide input to the research agenda for industry which we develop (see section 3.3).

3.2 Continued technology transfer through Education

We have results from the Industry-Result co-operations which can be developed into educational resources, both learning materials which can be uploaded and made available on the educational Web repository REASE as well as tutorials based on those learning materials. The first content has been generated by the ESTC workshop Making Semantics Work For Business, where not only the presentations by Knowledge Web researchers representing some of the co-operations (WP2.1, WP2.3, WP2.4) but also the other presentations as well have been uploaded as Industry material onto REASE. The three aforementioned workpackages presented results of their Industry-Research co-operations to an industrial audience. This shall be continued both by individual efforts of the separate co-operations as well as joint effort supported by WP1.1 (e.g. the FIRST

workshop at ISWC 2007). The aim is to ensure **a body of learning materials for industry** focused on real business use cases, with demonstrable results in some cases (all three presentations at MSWFB were able to demonstrate some software) as well as tutorials based around those co-operations.

Furthermore, the Industry Board of Knowledge Web contains many other industry partners for whom the results of the Industry-Research co-operations may be relevant. Hence, we have clustered the Industry Board members under the six co-operations described in this deliverable (Appendix 2). Each member has been contacted directly with an offer to receive current and future results from the relevant co-operation. They have also been offered the opportunity to have direct contact to a Knowledge Web researcher active in the given field. Based on responses, we hope to establish **further direct contacts between industry and research** which can lead to concrete technology transfer.

3.3 A research agenda for semantic technologies in industry

The Industry Research co-operation has also been an important learning experience for the Knowledge Web researchers, bringing them greater awareness of the industrial requirements which their research has the potential to address, and at the same time the research challenges which must be overcome if semantic technology can one day adequately address those requirements.

An evaluation of the results of the Industry-Research co-operations in Knowledge Web can bring us a better understanding of the key research challenges in the Semantic Web field which must be overcome to clear the path for technology transfer from academia to industry at a significant scale. This understanding needs to be shared with the research community as a whole, in order to direct future Semantic Web research towards meeting industry needs and succeeding in industrial application. Hence we intend to create by the end of the network a “research agenda for semantic technologies in industry”, in co-operation with the Knowledge Web Research Area.

This deliverable is the first step towards generating this research agenda. Clearly the results of the co-operations, with further analysis where necessary, form the principle input to this research agenda, possibly refined together with the Industry Board. We plan to complete the research agenda by the end of the network, with the FIRST workshop in November an opportunity to present first ideas to assembled industry leaders and receive useful feedback and input. This agenda will be presented within WP1.4, and will also be used to produce “briefing notes” for Semantic Web researchers which summarize key results of the KnowledgeWeb work in different research areas and can be distributed to researchers at future events.

4. Conclusions

The purpose of this deliverable has been to provide a final report of progress in the Industry Research co-operations. The overall target of this co-operation was:

(1) successful transfer of Semantic Web technologies (prototypically) into enterprise environments (where research is mature enough)

(2) orientation of the Semantic Web research to meeting industrial requirements/producing industry ready tools (where research is not yet mature)

(3) dissemination of results to the industry partner and the wider industrial community

(4) production of educational materials based on concrete business cases for use in Semantic Web education for industry

We close this deliverable with an evaluation of achievement in each of these points.

4.1 Technology transfer to industry

In KnowledgeWeb, we state that our major goal is the technology transfer of Semantic Web research into industry. What results can we report from each of the co-operations carried out within KnowledgeWeb? The table below provides a short summary of the main result of each co-operation:

Scalability (Query Approximation)	An extended prototype has conceptually proven the concept of query approximation by using rewriting rules.
Heterogeneity (Ontology Alignment)	An experiment has been formulated and an insight gained into the level of commitment needed to carry it out.
Dynamics (Ontology Lifecycle)	A prototype system is in development, and is being guided by concrete industrial requirements and will be evaluated by chosen industry partners.
Semantic Web Services	Mediation, composition and discovery of Semantic Web Services have been demonstrated within the B2B scenario. Standardization continues as an important prerequisite for industry uptake.
Language Extensions	OWL 1.1 has been proposed, incorporating extensions necessary in chosen industrial use cases, and has tool and user support.
Multimedia Analysis & Annotation	A demo system validates the use of semantic technologies in a multimedia

	scenario using results in fuzzy reasoning and contextual knowledge representation.

The major problem identified across the co-operations was the lack of maturity of the research being done to transfer directly into industrial settings. It should be noted that the co-operations were focusing on cutting edge research work done by leading European Semantic Web research centres, so industrial maturity of the research could not have been expected. The industry partners have been made aware through the co-operations of the relevance of the proposed semantic solutions to their business problem, and in half of the cases industry will continue to be involved in evaluating the results (and in all cases, further Industry Board members have been contacted with regard to the co-operations and invited to receive further information, with the aim of involving them closer in future development).

On the research side, we can consider one principle achievement: we have directed the current research – in areas which are of great industrial relevance in some years from now when they do reach maturity – towards industrial requirements at an early stage, which is quite significant. Research at later stages is more difficult to shift in a new direction, once many people have already invested much effort in it. Hence it is also an achievement that research in query approximation, ontology alignment, ontology versioning/lifecycle, Semantic Web services, ontology extensions and rules as well as multimedia analysis is already, at this earlier stage of development, already being strongly directed towards industrial requirements. We believe this will prove vital for the industrial applicability of the research results which will be produced in the coming years.

4.2 Research achievements and agenda

Following on from the previous section, we feel an important achievement of these co-operations has been raising awareness of the industrial requirements on semantic technologies among leading European Semantic Web researchers, which will be formalized in a research agenda before the end of the network.
Results can already be seen in terms of papers, presentations and demonstrations which have resulted from the Industry Research co-operations.

In particular, we can mention the following research achievements:

- Validation of the work on query approximation through an extended prototype
- Validation of the industrial applicability of Semantic Web Service discovery, mediation and composition through the B2B scenario
- Validation of the language extensions work (fuzzy reasoning) in a multimedia analysis and annotation scenario, with a prototypical demonstrator.

We also hope to see future fruits of our co-operations through:
- A successful experiment on ontology alignment in an industrial scenario
- An ontology lifecycle system applied to and evaluated in industrial settings
- A standardization of language extensions and their application in industry through the availability of mature tools and methodologies

4.3 Dissemination of results

In this year, we can point to two specific dissemination events:

- The Making Semantics Work For Business workshop (MSWFB) at ESTC 2007
- The First Industrial Results of Semantic Technologies workshop (FIRST) at ASWC/ISWC 2007

This is additional to individual dissemination of results from co-operations which are undertaken by the separate research groups, as well as the WP1.1 initiative to raise awareness of the work among the Industry Board through the communication channels (newsletter, website) and direct communication (email), which will be further reported on in D1.1.5v3.

4.4 Education of industry

In co-operation with the Knowledge Web Education area, materials suitable for industry education which are produced from the co-operations and their dissemination of results are shared with the REASE repository. First result of this is the presentations at the MSWFB workshop. At the same time, the involvement of researchers at industry events, such as the three presentations at MSWFB, trains researchers in the art of communication of Semantic Web research to industry. This can help build future tutorials and materials in the research areas directed at and suitable for industry.

4.5 Summary

A major effort has been expended in WP1.1 and the Knowledge Web Research Area in supporting a number of Industry-Research co-operations. This deliverable has presented the results of those co-operations. From the point of view of industry, the participating industry partners have gained a greater awareness of the possible semantic solutions for their business problems and been involved with researchers in attempting to realize such a solution. Given the current immaturity of the cutting edge research being done in KnowledgeWeb, we can not fairly expect significant transfer of results but can point to some notable achievements:
- cutting edge work on query approximation validated by a prototype
- cutting edge work on Semantic Web Services validated in a B2B scenario
- cutting edge work on fuzzy reasoning and other language extensions validated by a demonstrator platform for multimedia analysis and annotation

Also in the remaining co-operations important lessons have been learnt and efforts initiated by this work which will continue, even beyond the lifetime of the network. The results of the co-operations have been and will continue to be communicated more widely to the industry, both through further direct communications (based on existing

contacts in the KnowledgeWeb Industry Board) and educational events and material dissemination (using also the Industry Portal and REASE repository).

We feel that another achievement through this experience has been raising awareness in the Semantic Web research community of the importance of considering industrial requirements in the research as well as of the challenges encountered in attempting technology transfer from research to industry. Industry interest in Semantic Web technology is clear and demonstrable in the Industry Board that Knowledge Web has established as well as industry participation in events such as the European Semantic Technology Conference (ESTC). However, the research in Knowledge Web is cutting edge and less mature than would be required for industry uptake. Our Industry-Research co-operation has had a major effect in directing these cutting edge research activities, which we identified as meeting specific and significant industry requirements, towards industry needs. Hence while it is still too early to be able to expect concrete technology transfer, we believe we have established the importance of meeting industry requirements within the Semantic Web research community in KnowledgeWeb.

Hence, the true value of the co-operation work should crystallize in the short and medium term as Semantic Web research continues towards results which are more industry mature and industry interest in semantic technologies and early adopter uptake increases in parallel to this.

Appendix 1: The Questionnaire

The following questionnaire was provided to the representatives of each Industry-Research co-operation.

Use Case

Name of contributor:
Research WP:
Industry contact:

Progress

In D1.1.4v2 you outlined the technology transfer planned for the next phase of the network (M30-42). What has been achieved in this period?

What has not been achieved? For each, please state the reasons for it not being achieved.

Did you complete the stated milestones on time? If not, please indicate what prevented you from doing so.

Do you know other research groups or industries working on this topic?
Did they achieve any result?
If no, why?

If yes, please indicate some references (websites, projects, etc.)

Evaluation

You have also identified a number of industry requirements which your research is applicable to. Please state for which requirements the research done has demonstrably met that requirement. How is this demonstrated?

Are there other requirements which you did not originally consider but believe to be demonstrably met by the research done?

Are there requirements that you originally identified which are not met by the research? Can you briefly state why you believe this is the case?

Please provide a short list of open problems indicating when (in your opinion) they will be solved.

Results

Would you say your work has demonstrably solved a business case? Please describe how you would demonstrate to an industry practitioner that it was solved. If not, please describe the main obstacles which prevented you from solving the business case.

Would you say the research done is industry ready? Please describe what needs to be done before it could be provided to the industry (e.g. suitable documentation, integration with other systems). If not, please state if you expect it to become industry ready (in what time scale?) and what obstacles still prevent its industry readiness.

Please indicate some topics that will not be solved in short and medium term explaining the main reasons.

Finally, we would be interested to know what results are already available from the co-operation that could be re-used in future dissemination (tools, papers, tutorials, demos etc.) Are there results which could be re-designed for industry? (e.g. code, academic papers)

Please write a list of the most relevant semantic based demos in your area, for each of them provide a general description, the main features, and the open problems.

Do you expect some further output in the next 6 months?

References

Please provide references and a short summary of the first 3 best papers related to this topic.

Please provide names and references of the most important research projects related to this topic.

Appendix 2: Industry Board Clusters and Invitation Letter

The KnowledgeWeb Industry Board was clustered between the six Industry-Research co-operations as shown in the below table. The industry partners were chosen based on the relevance of the business problem to their activities and were contacted directly with an offer to receive more information about the results from the given co-operation. The bold names are those who have responded to date. In total, 12 companies have agreed to further contacts.

Responders agreed to "subscribe" to further notifications of progress in the use case as well as given the option of direct contact to the relevant researchers. Hence we aim to build further Industry-Research contacts before the end of the network which can continue beyond KnowledgeWeb's duration.

Human Resources & KM *Approximate Reasoning*	Human Resources & KM *Ontology Alignment*	Multimedia Analysis and Annotation. *Fuzzy and Contextual Reasoning*	Business Process and Data Integration *Semantic Web Services*	Healthcare and Life Sciences *Language Extensions*	Medical Systems *Ontologies Versioning and Lifecyle*
Green Cacti **neofonie**	Distributed Thinking Illy caffè Tele Sistemi Ferroviari (TSF) Semtation **Robotiker**	IFP **BT Labs** **Synergetics** Illy caffè **iSOCO** OntoText TIF **TXT e-solutions** Merrall Ross **neofonie** France Telecom	SNCF Telefonica Daimler **BT Labs** Niwa (Hanival) Office Line Engineering **iSOCO** TIF **TXT e-solutions** Risaris Ltd France Telecom **Computas Techno AS**	**Biovista** **BT Labs** **Cognium Systems** Institut de Biomedecine	**Biovista** **Synergetics** Semtation Robotiker **Cognium Systems** **L&C Language and Computing** Empirical BioWisdom **HealthGrid**