NSF Sponsored Workshop

International Semantic Web Working Symposium (SWWS)

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Award Information

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Contents

Introduction

Workshop name:	International Semantic Web Working Symposium
Acronym:	SWWS
Location:	Stanford University, Palo Alto, California, USA
Time:	July 30-August 1, 2001

The International Semantic Web Working Symposium (SWWS) took place in Stanford, California, July 30 through August 1, 2001. The Semantic Web is a vision: the idea of having data on the Web defined and linked in a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications. In order to make this vision a reality for the Web, supporting standards, technologies and policies must be designed to enable machines to make more sense of the Web, with the result of making the Web more useful for humans. Facilities and technologies to put machine-understandable data on the Web are rapidly becoming a high priority for many communities. For the Web to scale, programs must be able to share and process data even when these programs have been designed totally independently. The Web can reach its full potential only if it becomes a place where data can be shared and processed by automated tools as well as by people.

The technical program of SWWS presented the state of the art in the development of the principles and technology that will allow for the Semantic Web to become a reality. There were two invited talks, one by Eric Miller (W3C Semantic Web activity lead) and the other one by Michel Biezunski and Steven Newcomb (co-editors of the ISO Topic Map norm), and one panel chaired by Vipul Kashyap of Telcordia on Emerging Semantics. The 35 full papers were selected from 58 submissions (29 from Europe, 21 from the USA, 3 from Australia and New Zealand, 2 from China, Japan/Thailand, and 3 from unidentified countries) by a Program Committee of 36 people. The rate of acceptance was approximately two out of three for each group. The papers were organised in three tracks: "Ontology and Ontology Maintenance", chaired by Deborah McGuinness and Mark Tuttle, "Interoperability, Integration, and Composition", chaired by Vipul Kashyap, and "Services and Applications", chaired by Jim Hendler and Sheila McIlraith. A tutorial track was chaired by Charles Petrie, which featured tutorials by Natalya Friedman-Noy (on Ontology Engineering), Christoph Bussler (on Semantic B2B Integration), Fabio Casati and Ming-Chien Shan (on Models and Languages for Describing and Discovering E-services). The track chairs have summarized in reports the lessons learned from the various presentations and from the discussions among the participants of the various tracks, thus demonstrating that the symposium was a rich working forum. In addition, 50 position papers that have also been included in the proceedings. The social program included a banquet at the Stanford Faculty Club and a joint reception with ICCS 2001. The joint reception featured an invited talk by Douglas Engelbart, Bootstrap Institute founder and Director.

While originally SWWS was planned for an attendance of 100, it actually gathered more than 245 participants from all over the world, encompassing a wide range of scientific backgrounds. The interest that was demonstrated from a highly technical participation from academia and industry demonstrates the emergence of a dynamic and vital community centered on the idea of a Semantic Web.

The event was sponsored by the Information and Data Management Program of the National Science Foundation. Additional support was given by the European IST OntoWeb network, DARPA (DAML program), INRIA, and by the following corporate sponsors: VerticalNet, Nokia, SpiritSoft, Enigmatec.net, empolis, Language and Computing, Network inference, Mondeca, LC4, Connotate technologies, and Ontoprise.

During the workshop, a steering committee was established for monitoring future editions and the second edition has been planned for Europe next year, under the name International Semantic Web Conference (Sardinia, June 10-12, 2002).

Credits

The co-chairs Stefan Decker, Jérôme Euzenat,, and Deborah McGuinness, have been co-editors of this report. The working track reports have been written by their chairs: Jim Hendler, Vipul Kashyap, Deborah McGuinness, Sheila McIlraith, Charles Petrie, and Mark Tuttle.

Symposium Program

Monday, July 30

8:00-9:00 SWWS Registration and Breakfast

9:00-9:30 Welcome (Organizers & Jim Hendler)

9:30-10:30 Invited Talk by Eric Miller (W3C Semantic Web Activity Leader)

10:30-11:00 Coffee Break

11:00-12:30 Parallel sessions

Working Track 1 Ontology and Ontology Maintenance
(Chairs: Mark Tuttle, Apelon, and Deborah McGuinness, KSL, Stanford University)

The Semantic Web As "Perfection Seeking": A View from Drug Terminology
Mark Tuttle, S. Brown, K. Campbell, J. Carter, K. Keck, M. Lincoln, S. Nelson, M. Stonebraker

Industrial Strength Ontology Management
Aseem Das, Wei Wu & Deborah McGuinness

OntoMap or How to Choose Upper-Model in One Day
Atanas Kirakov, Kiril Simov, Marin Dimitrov

Working Track 2 Interoperability, Integration, Composition
(Chair: Vipul Kashyap, Telcordia)

Towards Semantic Interoperability in Agent-based Coalition Command Systems
David Allsopp, Patrick Beautement, John Carson, and Michael Kirton

Object Interoperability for Geospatial Applications
Isabel F. Cruz and Paul Calnan

Semantic Brokerage of Intellectual Property Rights
Roberto Garcia and Jaime Delgado

Working Track 3 (Web-) Services and Applications
(Chairs: Jim Hendler, DARPA and Sheila McIlraith, KSL, Stanford University)

DAML-S: A Semantic Markup Language For Web Services
Anupriya Ankolenkar, Mark Burstein, Jerry R. Hobbs, Ora Lassila, David L. Martin, Sheila A. McIlraith, Srini Narayanan, Massimo Paolucci, Terry Payne, Katia Sycara, Honglei Zeng

Serching for services on the semantic web using process ontologies
Mark Klein, Abraham Bernstein

Approach to Service Description for Matchmaking and Negotiation of Services
David Trastour, Claudio Bartolini

Tutorial Track
(Chair: Charles Petrie)

Ontology Engineering
Natalya F. Noy, SMI, Stanford University

12:30-02:00 Lunch

12:45-13:45 Demos

Demos by Verticalnet, Spirit-Soft, Mondeca, Empolis, SC4, Lastmileservices, UMBC, Stanford Medical Informatics, Griffith University, University of Bristol, University of Karlsruhe

14:00-15:30 Parallel sessions

Working Track 1 Ontology and Ontology Maintenance
(Chairs: Mark Tuttle, Apelon, and Deborah McGuinness, KSL, Stanford University)

The "Emergent" Semantic Web: An approach for derivation of semantic agreements on the Web
Clifford Behrens, Vipul Kashyap

Ontology versioning on the Semantic Web
Michel Klein & Dieter Fensel

Ontology Library Systems: The key for successful Ontology Reuse
Ying Ding & Dieter Fensel

Working Track 2 Interoperability, Integration, Composition
(Chair: Vipul Kashyap, Telcordia)

Adding Multimedia to the Semantic Web: Building an MPEG-7 ontology
Jane Hunter

Overcoming Ontology Mismatches in Transactions with Self-Describing Agents
Drew McDermott, Mark Burstein and Douglas Smith

Working Track 3 (Web-) Services and Applications
(Chairs: Jim Hendler, DARPA, and Sheila McIlraith, KSL, Stanford University)

The Briefing Associate: A Role for COTS applications in the Semantic Web
Marcelo Tallis, Neil Goldman, Robert Balzer

ITTALKS: A Case Study in the Semantic Web and DAML
R. Scott Cost, Tim Finin, Anupam Joshi, Yun Peng, Charles Nicholas, Harry Chen, Lalana Kagal, Filip Perich, Youyong Zou, Sovrin Tolia

Open Learning Repositories and Metadata Modeling
Hadhami Dhraief, Wolfgang Nejdl, Boris Wolf, Martin Wolpers

Tutorial Track
(Chair: Charles Petrie)

Semantic B2B Integration
Christoph Bussler (Oracle Corporation)

15:30-16:00 Coffee Break

16:00-18:00 Parallel sessions

Working Track 1 Ontology and Ontology Maintenance
(Chairs: Mark Tuttle, Apelon and Deborah McGuinness, KSL, Stanford University)

UML and the Semantic Web
Stephen Cranefield

Metamodeling Architecture of Web Ontology Languages
Jeff Pan, Ian Horrocks

DAML+OIL is not Enough
Sean Bechhofer, Carole Goble, Ian Horrocks

Semantic Web Modeling and Programming with XDD
Chutiporn Anutariya, Vilas Wuwongse, Kiyoshi Akama, Vichit Wattanapailin

Development of a Simple Ontology Definition Language (SOntoDL) and Its Application to a Medical Information Service on the World Wide Web
Rolf Grütter and Claus Eikemeier

Working Track 2 Interoperability, Integration, Composition
(Facilitator: Vipul Kashyap, Telcordia)

A Framework for Ontology Integration
Diego Calvanese, Giuseppe De Giacomo and Maurizio Lenzerini

A Scalable Framework for Interoperation of Information Sources
Prasenjit Mitra, Gio Wiederhold and Stefan Decker

On the Integration of Topic Maps ddata with RDF data
Martin S. Lacher and Stefan Decker

A formal infrastructure for Interoperability on the Semantic Web
Jérôme Euzenat

Working Track 3 (Web-) Services and Applications
(Chairs: Jim Hendler, DARPA, and Sheila McIlraith, KSL, Stanford University)

CREAM: Creating relational metadata with a component-based, ontology-driven annotation framework
Siegfried Handschuh, Steffen Staab, Alexander Maedche

OntoWebber: Model-Driven Ontology-Based Web Site Management
Yuhui Jin, Stefan Decker, Gio Wiederhold

Indexing a web site with a terminology oriented ontology
E. Desmontils, C. Jacquin

A semantic model for specifying data-intensive Web applications using WebML
Sara Comai, Piero Fraternali

Tutorial Track
(Chair: Charles Petrie)

Demos (Facilitator: Natalya F. Noy, SMI, Stanford University)

Verticalnet - Aseem Das
Spirit-Soft - Steve Ross-Talbot
Mondeca - Bernard Vatant
Empolis - Hans Holger Rath
LastMileServices - Raj Bapna
Stanford Medical Informatics - Mark Musen, Monica Crubezy, Natalya F. Noy
DSTC/Griffith University - Peter Eklund

19:00 Banquet at the Faculty Club

Tuesday, July 31

08:00-09:00 SWWS Registration and Breakfast

09:00-10:00 Invited Talk: Michel Biezunski, Steven Newcomb on TopicMaps

10:00-10:30 Coffee Break

10:30-12:00 Panel: Emerging Semantics (Vipul Kashyap)
Panelists: Ora Lassila (NOKIA Research), Jim Hendler (DARPA), Dieter Fensel (Free University of Amsterdam), Umeshwar Dayal (Hewlett-Packard), Clifford A Behrens (Telcordia)

12:00-13:30 Lunch

12:15-13:15 Demos

Demos by Verticalnet, Spirit-Soft, Mondeca, Empolis, SC4, Lastmileservices, UMBC, Stanford Medical Informatics, Griffith University, University of Bristol, University of Karlsruhe

13:30-15:30 Parallel sessions

Working Track 1 Ontology and Ontology Maintenance
(Chairs: Mark Tuttle, Apelon and Deborah McGuinness, KSL, Stanford University)

Utilizing Host-Formalisms to Formally Extend RDF-Semantics
Wolfram Conen, Reinhold Klapsing

RDF M&S revisited: From Reification to Nesting, from Containers to Lists, from Dialect to pure XML
Wolfram Conen, Reinhold Klapsing, Eckhart Ksppen

Track summary and discussion

Working Track 2 Interoperability, Integration, Composition
(Facilitator: Vipul Kashyap, Telcordia)

Describing Computation within RDF
Chris Goad

Design Rationale for RuleML: A Markup Language for Semantic Web Rules
Harold Boley, Said Tabet and Gerd Wagner

Enabling Semantic Web Programming by Integrating RDF and Common Lisp
Ora Lassila

Track Summary and Discussion

Working Track 3 (Web-) Services and Applications
(Chairs: Jim Hendler, DARPA and Sheila McIlraith, KSL, Stanford University)

Track Summary and Discussion

Tutorial Track
(Chair: Charles Petrie)

Models and Languages for Describing and Discovering E-services
Fabio Casati and Ming-Chien Shan (Hewlett-Packard)

15:30-16:00 Coffee Break

16:00-18:00 Facilitators Report, Announcement of BOF Sessions, Awards
Chairs: Isabel F. Cruz and Stefan Decker

19:30 Joint Reception with ICCS at the Faculty Club.
Invited Talk: Douglas Engelbart, Bootstrap Institute founder and Director.

Wednesday, August 1

8:00-9:00 Breakfast

09:00-10:30 Birds of the Feather Sessions

Joint Session with ICCS/DL

Ontology of Integration and Integration of Ontologies
Diego Calvanese, Giuseppe De Giacomo and Maurizio Lenzerini

Boolean Judgement Logic
Rudolf Wille

Concept Graphs and Predicate Logic
Frithjof Dau

Searching For Objects and Properties with Logical Concept Analysis
Sebastien Ferre and Olivier Ridoux

10:30-11:00 Coffee Break

11:00-12:00 BOF Wrap Up, Follow-up actions and Farewell

Symposium Organization

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Appendix: Web sites

The complete proceedings (659 pages), including position papers of many participants, are available online from the workshop site:

http://www.semanticweb.org/SWWS/

This site also features all the overhead material presented in the tutorial track.

This report can be found on the report web site:

http://www.cs.uic.edu/~ifc/SWWS/

This site also includes the contents of this report in HTML format.

Appendix: Report on the "Ontologies and Ontology Maintenance" track

Mark S. Tuttle, Vice-President, Apelon, Inc., mtuttle@apelon.com
Deborah L. McGuinness, Associate Director and Senior Research Scientist, Stanford University, dlm@ksl.stanford.edu

This document is:

- a narrative representation of the track summary slides and accompanying presentation and discussion for "Track #1 – Ontologies and Ontology Maintenance," and
- an appendix suggesting one way to implement Track recommendations.

The Important Questions:

The scheduled track discussion produced agreement that questions #1-#7 below were important to answer, and that lack of answers to these questions was impeding progress on "Ontologies and Ontology Maintenance". Question #8 was added during the plenary track-summary presentation.

1. What can we do as individuals and as part of the semantic web community?

Attendees agreed that the considerable energy generated by the SWWS 2001 lacked constructive outlets. Put differently, the Semantic Web should not be about giving papers, unless the papers are about, for example, testable Semantic Web hypotheses, e.g., the utility of an "ontology of change". Everyone was frustrated by the "waiting around" for Semantic Web infrastructure to appear, and that creating "some" infrastructure was more important that resolving the remaining "expressivity vs. tractability" dilemmas (for example). Everyone also understood that there is always risk solving the easy parts of problems first, because that can make it harder to solve the harder parts later. Nevertheless, the consensus was "forge ahead!" (See Track Take-Home Message, below.)

2. How do we introduce and evolve standards productively?

Discussion focused on the need for PROCESS – especially in the context of standards, it being unlikely that much of anything regarding the Semantic Web would be gotten right "the first time."

3. Do we need to standardize on foundational models first?

To oversimplify, this is the dilemma posed by the hypothesis that it is sufficient, and potentially very helpful, if the field could agree on minimalist semantics (expressivity) and a syntax in which to represent units of meaning, leaving for distributed, incremental, and local development the problem of creating actual ontologies – that would be expressed, represented and communicated using the foundational model.

4. Do we all believe that experimentation should continue?

This is an hypothesis formulated by the Track, and it focuses on the fact that a) there are some remaining expressivity vs. tractability details to resolve, and b) that we have no proof that proposed Semantic Web standards and tools are useful or even work at all.

5. Is the current Semantic Web standards development process adequate?

This addresses the dilemma posed by a general acknowledgement that the Semantic Web poses new challenges; that is, the current standards process may be the best that we know how to create, and it still may

be inadequate – because, for instance, it deals with distributed semantics. At worst, it needs field-testing and feedback from actual use.

6. Do we need Semantic Web glossaries? ("pumpkins?")

Even if there was not consensus on the definitions, all agreed that Semantic Web glossaries would be a big help; they would be something to disagree with, and catalyze alternative definitions for important concepts.

7. Do we need some ontology ontologies?

Everyone recognized the "ontology ontology" problem and that it's lack of resolution was an impediment to progress, and that "we are all part of the problem." That is, it's hard to find out what ontologies exist, and whether they are worth using, etc. This is part, but not all, of the deep ontology re-use challenge.

8. What are the communities of stakeholders, and their characteristics?

The plenary audience challenged us to think beyond ourselves in the context of #1-#7 and identify the larger populations of stakeholders. This is a good idea, a challenge to be taken on for, among many other things, the next SWWS.

Tools Wanted and Described:

Everyone wants Semantic Web tools in general and ontology development, maintenance, and re-use tools in particular. The following list of "tools wanted for (ontology) …" was formulated during the Track Summary session.

- Maintenance
- Versioning
- Collaboration
- Reasoning
- Merging
- Creation
- Validation
- Classification
- Serving
- Management of change
- Tool library management

The attendees offered the following list of existing tools and their sources:

- VerticalNet (Ontology builder, Ontology server)
- OntoText (OntoMap)
- Telcordia (Schemer)
- Many folks (Oil Ed)
- XONAR (RDF Schema Explorer)
- Apelon (TDE (Terminology Development Environment), DTS (Distributed Terminology System))

Track #1 Imperative:

The track attendees agreed that the Semantic Web community needed to "start doing it," and, in particular, participate in end-to-end solutions and projects. No one had any specific objectives here, but everyone agreed that this was both a good goal and plan. We agreed to sum this up as the Track #1 take-home message:

Make our own dog food.
And eat it!

(And "XML is not enough.")

Co-Chairs' Appendix:

At the urging of track co-chair Deborah L. McGuinness, track co-chair Mark S. Tuttle has begun discussions with several Federal Agencies, e.g., VHA (Veterans Health Administration), NCI (National Cancer Institute), NLM (National Library of Medicine), and FDA (Food and Drug Administration) regarding potential Semantic Web demonstration projects. Because these four agencies are involved in collective and individual "formal terminology" projects, there is an opportunity to reuse these terminologies as ontologies on the Semantic Web. As suggested in the Track #1 paper by Tuttle, et al., a VHA+NLM+FDA+HL7 (Health Level 7) collaboration aimed at producing a potential national reference terminology for drugs (medications) may be the best place to begin to look at Semantic Web issues in a practical and scalable context. Deborah L. McGuinness has suggested use of DAML+OIL for this potential experiment.

Appendix: Report on the "Interoperation, Integration, and Composition" track

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21 September, 2001

Abstract

This is a report on the proceedings of the track on Interoperation, Integration, and Composition as a part of the International Semantic Web Working Symposium, held in Stanford from July 30 – August 1, 2001. The track description and organization is first discussed. Then we present a brief discussion on the issues discussed and the missing gaps identified for enabling the Semantic Web. Next we shall discuss the research agenda and identify the priorities for academia and industry.

Track Description and Organization

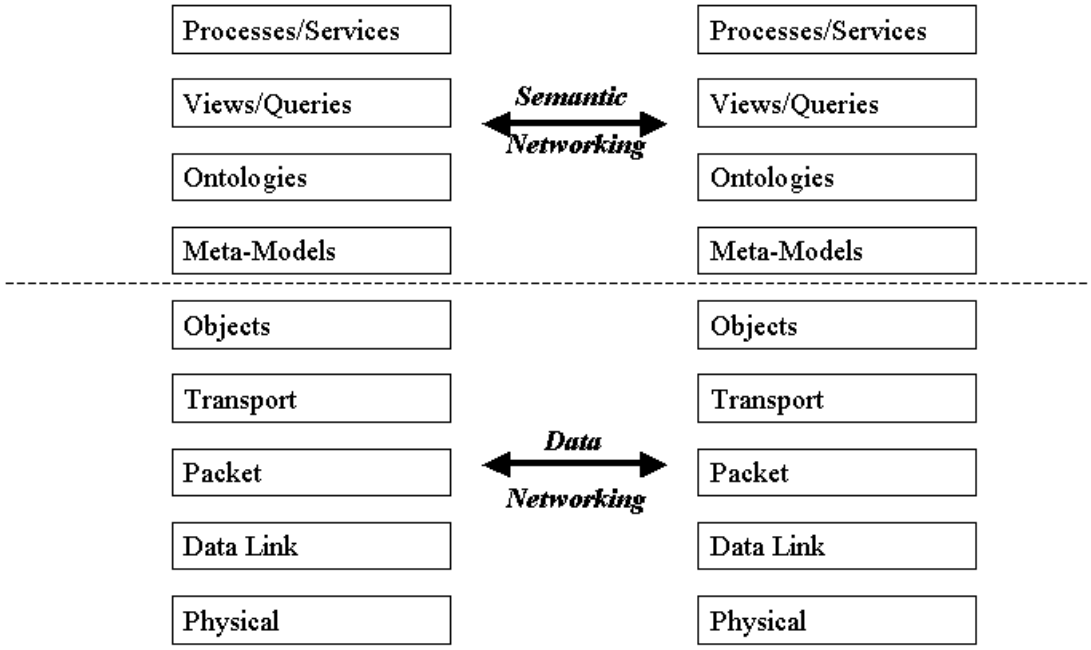
Interoperation and Integration can be defined by broadening the current definitions used in the federated database literature. Interoperation may be defined as a loose coupling across information sources, semantic metadata descriptions and ontologies. Typically an external agent or system is responsible for decomposition of an information request and mapping the decomposed pieces onto the given targets. Integration on the other hand refers to a tight coupling and suggests that the given information sources, semantic metadata descriptions are somehow coalesced together and can be queried as a single unit. Composition on the other hand refers to the act of combining pieces of information at a level granularity smaller than that involved in integration and interoperation. Examples of pieces are: constraints, policies, vocabularies and language transformations. An interesting case of composition is when you may want to compose proofs of correctness to prove higher level security and transaction policies.

Based on the above definition the track was (approximately) divided into four broad sessions involving 12 presentations.

> ***Session 1:*** This section focused on applications demonstrating the value of semantic integration, interoperability and composition. This session had 3 presentations
> ***Session 2:*** This session primarily focused on ontology integration issues in multimedia and agent based systems. This session had 2 presentations
> ***Session 3:*** This session focused on frameworks for ontology integration and semantic interoperability. This session had 4 presentations.
> ***Session 4:*** This session focused on "semantic web programming", i.e. issues related to gluing together web sites based on the semantics of information. This included markup and representation languages and adaptation of standard programming languages for this task. This session had 3 presentations.

Issues

The central observation of all the speakers presenting in the track can be summed up as: ***It is crucial for the interoperability layer to migrate from the syntactic to the semantic!***
Semantic Interoperability (in the general sense including integration and composition) could be implemented at different levels, and there were proposals to organize them in a layered manner. This is illustrated in the figure below and seeks to differentiate between data networking and "semantic" networking.



Building on the success of the data networking and middleware communities, the above picture tries to relate organize and relate the semantic web efforts along multiple layers, some of whom are described below:

> ***Object Interoperability:*** This is the layer at which the current middleware products are aimed in the industry. However these objects are primarily defined as containers for software and for streamlining the software development process. The CORBA, EJB object models are examples of standards at this layer.
> ***Meta-Model Interoperability:*** This is the layer at which the cross-over from the "data" space to the "knowledge" space takes place. The objects here are viewed as containers of knowledge to be fleshed out by upper layers. The OKBC and RDF(S) core models are examples of standards at this layer.
> ***Ontology Interoperability:*** This is the layer where ontologies, schemas and classifications are built upon common underlying standardized meta-models. The ability to use different ontologies to specify and query information constitutes interoperability at this layer.
> ***Meta-Data (View/Query) Interoperability:*** Semantic metadata descriptions can be constructed from one or more underlying ontologies. Issues at this layer would be to decompose information requests into those supported by the individual semantic metadata descriptions corresponding to the information sources.

The ability to organize semantic web research along these layers helps us organize the work require to build out the underlying infrastructure of the semantic web. The issues that arise are: development of standards and industry wide APIs at each of the layers. Building up semantic-web specific functions such as semantic routings, "semantic" content delivery networks. Specification of further application layers may also be required.

One of the most important topics on which semantic interoperability depends is the problem of ontology interoperation, which was discussed by a large number of speakers. Some topics that were discussed were: integration between RDF, Frame based and Object Oriented data (meta-model reconciliation), merging and exchange of data between different RDF models, and the ability to specify mappings across terms in different ontologies. Some of the issues that were discussed in the context of the latter topic were the

reconciliation of various types of heterogeneities and techniques for specifying articulation rules and correspondence across ontologies.

Languages for representation of ontology transformations/mappings and for "semantic" web programming were also discussed. Approaches to represent computations in RDF were presented and their similarity to the notion of web services was noted. Representations of active/re-active rules and action using RDF, and integration of RDF/DAML+OIL with a programming language were two diverse approaches discussed. An interesting paper on proving properties of transformations based on composition of the transformations (and their corresponding proofs) was also presented.

Some interesting presentations dealt with the issue of semantic web in the presence of multimedia data. The MPEG-7 standard was discussed and the need to specify the semantics of the MPEG-7 metadata was recognized. The ability to compose semantics of document components in the presence of spatio-temporal constraints was identified as a crucial requirement for multimedia semantics. The need to link and interoperate with ontologies from other domains was also recognized. Digital Rights Management was especially an important topic from the perspective of multimedia data and there were discussions related to rigorous specification and enforcement of digital rights associated with a multimedia document. There was a suggestion from a participant that ongoing and previous work in digital libraries should be leveraged for the semantic web.

Missing Gaps

Whereas there were a lot of issues relating to the Semantic Web covered by the speakers in the track some critical problems that need to be addressed had not been covered. Some of the problems that comprise the missing gap are:

Ontology Impedance: Ontology impedance may be defined as the semantic mismatch between two or more ontologies that are being merged. There was widespread acceptance of the fact that, when merging ontologies, we will have to deal with ontology impedance. Work needs to be done to estimate the consequent loss of information that results from this impedance.

Scalability/Performance: Issues related to scalability of web servers serving semantic web content is a critical issue on which the future semantic web depends. Work is needed to come up with techniques that exploit "semantics" to design better caching techniques, e.g., semantic content distribution networks. There is also a need for metrics and measurements to evaluate how well algorithms for the semantic web will perform and scale.

Dynamic Ontologies: A fundamental but flawed assumption being made by all the speakers was that ontologies are static in nature. The techniques presented were based on the assumption. Real world ontologies are likely to be dynamic and evolve over time and algorithms and techniques for the semantic web need to be adapted to account for this possibility.

Semantic Metadata Extraction: Two crucial factors that will determine the success of the semantic web are: the ease and cost of developing and maintaining ontologies, mappings and articulation rules; and the ease of constructing semantic annotations. Tools that drive the extraction process based on text processing and NLP techniques (most of the data on the web is textual) are important.

Research Agenda

The research agenda for the Semantic Web can be divided along the following lines. Industry research typically needs to focus on shorter term, applied research with emphasis on proof of concept prototypes that can be productized if there is commercial potential. Academia perform longer term fundamental research, since they don't face commercial or business pressures. We now try to outline the research agenda for industry and the academia in the context of the semantic web.

Some research priorities for the industry are as follows:

Scalability/Performance: This is likely to be one of the topmost priorities of the industry. As new semantic web technologies emerge, research needs to be done to ensuring the scalability of these technologies.

Multimedia Data: The industry is likely to be interested in semantic annotations to various types of multimedia data, such as images, video. Current interest is centered around specific information domains such as GIS, Medical Images and News Videos.

Ontology Integration/Interoperation: The applications of ontology integration/interoperation techniques that the Industry is likely to be interested in is catalog integration and business process modeling and integration. There is a need for definition and interoperation across multiple process based ontologies.

Digital Rights Management: Applications related to digital rights management especially those related to formal semantic specifications of digital rights might be important for industries as they try to protect their intellectual property over the web.

Some research priorities for academia and long-term projects undertaken by some industrial R&D Labs are as follows:

Ontology Integration/Interoperation: Given that ontology mismatch is a certainty on the Semantic Web, research is needed to categorize the different types of mismatch and metrics to measure the amount of mismatch. Metrics for mismatch can be adapted to estimate loss of information.

Languages for Ontologies: Representational languages with specific properties might be required to represent ontologies and transformations across ontologies represented using different languages. Correctness proofs about these transformations are an important area of research.

Semantics of Multimedia Data: Multimedia data, typically consists of components that might be of different digital media. The challenge here is to "compose" the component semantics to determine the semantics associated with the multimedia document. Spatio-temporal constraints play an important role for capturing semantics of multimedia data and need to be explored.

Tractable areas of high complexity problems: It is well known the inference and proof procedures for complex logics, likely to play an important role for capturing semantics, are computationally expensive and intractable. Research is needed into tractable techniques such as Markov processes for inferences and processing.

Expression of "shared meaning" in the social sense: Ontologies and shared knowledge develop as a result of social and consensual processes. Current semantic models assume consensus and focus on formal representations of semantics. Research is needed to come up with semantic models that capture both the formal and the consensual nature of meaning.

Semantic Digital Rights Management: Concepts like trust, credibility, permissions and obligations are likely to become important in the future semantic web. Research on proof procedures and modal logics to establish these concepts.

Cognitively enabled Ontology Authoring: Current ontology development tools are evolving to incorporate usability principles for ontology authoring. There is a need to research into human cognitive abilities and define tools that take advantage of those abilities.

Industry and academia both seek funding from Government agencies such as DARPA, NSF, etc. Industry in particular seeks funding for long-term projects that do not have immediate commercial viability. It is a moot point whether the semantic web will be the next "internet" to be funded by DARPA. Government funding may turn out to be an exciting way to promote industry academia collaboration, as seen in the CoAx project by Allsopp, et. al.

Conclusion

In conclusion, the Interoperation, Integration and Composition track had an interesting collection of papers, but crucial problems important for the enabling of the semantic web were either missing or not dealt with. Some open difficult problems were alluded to but not explicitly dealt with. In general, the track had a very strong academic flavor and attempts should be made to involve the industry in a more significant manner.

Appendix: Report on the "Web Services and Web Applications" track

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Jim Hendler, University of Maryland & DARPA DAML program, hendler@cs.umd.edu

The Web Services and Web Applications Track of SWWS was facilitated by Sheila McIlraith (Stanford University) and Jim Hendler (DARPA). It was comprised of ten paper presentations and an invited talk. Participants included academics, researchers, students, and IT professionals from startup companies, large companies and the government. The track was organized so as to allow time for not just presentations, but also for interaction between attendees and presenters and for open discussion among the participants. The track, as the name implies, included two main themes: the application of semantic web technologies on the web and the emerging area of web services.

Web Applications

The papers relating to applications of the semantic web showed that real applications are starting to emerge, that demonstrate the use of this new technology and the exciting things that can be done. The applications presented include:

- The Briefing Associate: A software tool that allows the automatic creation of semantic web markup while using Microsoft Powerpoint to create briefings.
- IT Talks: A system deployed at the University of Maryland Baltimore County, which is used for the advertisement of talks in the information technology area. The system used semantic mark up to suggest which talks a user might wish to see, and to note scheduling problems. Markup of the abstracts was augmented by use of automated extraction tools.
- Open Learning Repository: A set of tools and techniques that use semantic web technology for building and managing e-learning repositories.
- Web Site management: A methodology by which ontologies help in the specification and personalization of web sites and the management thereof.
- An ontology-based tool for web site terminology indexing.
- Cream: a tool for the creation of metadata terminologies and for using them in annotating documents.

Participants were pleased to see this evidence that the research ideas in the semantic web are starting to transition to real applications. Discussion focused on the commercialization aspects of some of these applications, on the commonalties and differences between the approaches, and on the efficacy of semantic markup for use in deployable applications.

Several issues emerged as critical needs to be addressed in moving applications from research to practice. Two in particular were felt to be critical for the future success of these systems:

- How do we deal with the diversity of languages and tools that are starting to emerge for semantic content. Currently XML, XML schema, RDF(S), DAML+OIL, WebML, and various other tools are available for metadata storage, querying, etc. It is clear that there is a need for unifying frameworks, toolkits, etc.
- The need for well-defined semantics in the metadata languages. Many of the applications we saw in this session were using ontology languages like DAML, or extensions of RDF(S). Consensus was that completing the RDFS standard, and moving to a web ontology standard that extended RDFS and XML Schema was important for these applications.

Web Services

Three papers and an invited talk focused on web services, with a particular emphasis on the interaction of Semantic Web and Web Services. Paper topics included a discussion of the proposed DAML-S ontology-based services language, and on how to advertise and search for web services. In addition, James Snell from the Emerging Technologies group at IBM presented an invited talk on the emerging "acronym hell" of web services. He discussed many of the emerging specs, particularly UDDI, SOAP and WSDL. This was followed by a lively discussion of web services and the directions this work is taking in industrial practice.

Based on the presentations and discussions, it became clear that web services is emerging as an important application for the Semantic Web, and a hot-bed of activity in industry -- web services are hot. Currently, however, there is little or no "semantic" web in the web services world, but participants felt this was sure to follow.
Industry is currently focusing on the development of technology and infrastructure languages and tools to support web services. This includes a welter of approaches including service advertisement languages and registries (WSDL, UDDI), service protocols (SOAP), workflow description languages (WSFL, XLANG) and software frameworks (.Net, WebSphere, and eSpeak). A number of large software/hardware vendors are focused heavily on web services (e.g. Microsoft, IBM, Sun and HP).

It was also clear that there was a lot of academic work in this area, with a number of projects being inherently interdisciplinary with participants from AI, networking, databases, business schools and other groups. Support for this research is coming from both the US government (DARPA) and the EU IST program.

A number of issues arose from the discussions in this session. These include some shared concerns with the applications track with respect to languages, tools and infrastructure as described above, and some particular issues including:

- How can academic researchers interact with the emerging industrial standardization efforts and how can efforts like DAML-S help make sure that new technologies can inform current efforts. Industry is working bottom-up, academia top-down, how do we make sure that these will meet in the middle?
- The business case for how the semantic web dovetails with web services is still not completely clear. If web services turn out to be primarily deployed at the protocol level, the need for semantic web technology is minimal. If, on the other hand, web services are to advertise, interact, and be supported by agent-based computing, then the need for approaches like DAML-S are manifest.
- The chicken/egg problem - without semantic markup, there's not a lot of motivation for the industrial base to pay attention to the semantic web. Without industry investment/support, the W3C and others have trouble developing standards and getting sources marked up. Current government funding helps to jump start this level, but the semantic web community needs to figure out how to both publicize these efforts and increase the dissemination of this technology.

Conclusion

Participants in this session were able to see that the semantic web is more than simply some sort of academic foolishness or rewarmed AI vision. The applications showed real technology and tools are being built in the Semantic web community, and that there is a lot of interest in these technologies on the part of industry and government. The web services track showed one area where there is tremendous industrial interest and where semantic web technology could be an important part of the work.

Appendix: Report on the tutorial track

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Stanford Networking Research Center
Friday, Sep 7th 2001
http://snrc.stanford.edu/~petrie/agents/tutorial.html

Demonstrations

We had 7 demonstrations in 2 hours!
The good news is that there seems to be lots of commercial development though some of the demonstrations seemed shallow.

Ontology Engineering

Natalya Noy (Stanford Medical Informatics)

This was an excellent overview of basic issues. It emphasized the need for application-specific ontologies. Somewhat surprisingly, it not emphasize formal semantics, which is what distinguishes ontologies from glossaries.

Semantic B2B Integration

Christoph Bussler (Oracle Corporation)

This was an extremely comprehensive overview of evolving standards and issues.
Chris mentioned that there were over 200 emerging standards and this was no joke.
He distinguished between semantic and technical integration and also did not emphasize formal semantics.

Models and Languages for Describing and Discovering E-Services

Fabio Casati, Ming-Chien Shan (Hewlett-Packard Labs, Palo Alto)

This was a good overview and discussion of a few important emerging standards.
The tutorial focussed on interoperable process standards. Ontologies wrt formal semantics not an issue.
The issue was raised by the audience: can standards initiatives overcome tendency of commercial intrests to have proprietary formats?
The answer was: follow stock price of non-compliers.

Last words: "Pragmatic Unification"

This is my personal view, as expressed during the conference. We should do applications and promote applications.
In fact, I believe that ontologies require applications to be meaningful, and that ontological integration is meaningful only with the interaction of applications.
I advise working with commercial E-Commerce folk to use academic expertise. Otherwise, formal ontology work will go the way of academic software agent technologies.
We should try standards, but modify them based on experience and success.
Let ontological integration depend upon required interoperation of applications.