Knowledge Creation Tools for the Semantic Web

SRI International and USC/ISI

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Knowledge Creation Tools
Overall Program Summary

- What is the basic problem you are trying to solve?
  - Well-founded tools for characterizing the content and capabilities of SW resources

- What was the technical solution strategy?
  - Community-wide ontologies
  - User-centric tools for construction of and access to SW resources

- What were the basic elements of the research and program approach?
  - Ontologies of services, time, space, security
  - OWL-S Editor and NL front-end
  - Axiomatic semantics of DAML+OIL & OWL
Knowledge Creation Tools
Technical Problem and Approach

- Semantic Web Services via OWL-S
- Ontologies of Time and Space
- Ontology of Security
- Axiomatic Semantics for DAML+OIL and OWL
- Tools
  - Protégé front-end and OWL-S Editor
  - Natural Language QA System: QUARK / GeoLogic
Challenge: Make the Semantic Web a place that supports activities and transactions, in addition to knowledge

Objectives:

• Enable fuller automation of service use by software agents
  • Ideal: full-fledged use of services never before encountered:
    • Discovery, selection, composition, invocation, monitoring, decomposition
• Useful in the “real world”
  – Compatible with industry standards
  – Incremental exploitation
• Enable reasoning/planning about services
  • e.g., On-the-fly composition
• Integrated use with information resources
• Ease of use; powerful tools
• **OWL-S**: An OWL ontology supporting rich, unambiguous characterizations of services, with 3 interrelated sub-ontologies:
  – Profile: specifies service advertisements & requests
  – Process model: specifies control flow, data flow, interactions associated with an activity
  – Grounding: specifies details of communications (using WSDL)

• **OWL-S** supports reasoning about services / processes
  – Subsumption-based reasoning
  – Planning techniques
  – Has spawned much interesting work on service discovery, selection, composition, enactment, knowledge-based service engineering, etc.

• **SWSL**: superset of OWL-S concepts, drawing on more expressive KR formalisms (logic programming, FOL)
Time and Space

• Goal: Marking up temporal and spatial aspects of web resources and support reasoning about temporal and spatial content and capabilities of web sites

• Contributions:
  – OWL-Time: ontology of topological temporal properties, measures of duration, clock and calendar, temporal aggregates, event durations from event descriptions
    • Entry time ontology for quick and simple applications
    • Incorporation into OWL-S
    • On W3C Ontologies web site
    • Review article rated OWL-Time the best time ontology
  – Ontology of regions, bounding boxes, latitude/longitude, distance for QUARK/GeoLogica
  – Preliminary work on OWL-Space, including requirements, topological properties
Security

• Goal: Marking up security aspects (e.g., access control restrictions, data integrity, policies etc.) of web resources and support reasoning about mark-up for purpose of matching, enforcement, etc.

• Contributions:
  – Ontologies: security mechanisms, credentials, privacy
  – Security extensions for web services and agents
  – Policies: authorization and privacy policies for services
  – Reasoning: Matching algorithm for security mark-up
  – Implementation/Demos:
    • Design, annotation, and implementation of security services (en/decryption, signature services)
    • Web service application for matching privacy policies
    • Web service application for generating OWL credentials used in enforcing authorization policies
Axiomatic Semantics

- Specware/SNARK used to validate axioms for DAML+OIL.
- Three inconsistencies, numerous missing axioms, redundant axioms, simplifications discovered.
- Axioms for OWL formulated in Specware language.
- Consistency and intended consequences checked by SNARK.
Tools: Protégé Front-ends

- DAML+OIL plugin and OWL-S editor for Protégé
- OWL-S Editor
  - Easy, intuitive development environment for creation and editing of OWL-S services for users that are not experts in OWL-S
  - Graphical tool tailored towards the needs of SWS designers
  - Plugin to Stanford Medical Informatics’ Protégé/OWL editor
  - Open source software: [http://owlseditor.semwebcentral.org](http://owlseditor.semwebcentral.org)
  - Main Features:
    - Visual drag and drop composite process editor
    - Graphical overview of relationship between service instances
    - WSDL Import
    - IOPR Manager
    - Data flow editing (future)
Tools: QUARK/GeoLogica

- Application: question answering from English text.
- Domain: Geography for intelligence and geosciences.
- Ontology/Theory of regions, bounding boxes, latitude/longitude, distance, time.
- Procedural attachment to Teknowledge ASCS, Alexandria Digital Library Gazetteer, etc.
- Answers to queries extracted from proofs.
Knowledge Creation Tools
Technical Progress

• What technical problems or obstacles were there and when/how did you overcome them?
  – Consensus and community-wide adoption are difficult to achieve
  – DAML/OWL language versions and layers were moving targets
  – Late development of adequate expressivity

• Are there any metrics that are relevant to your program? How did you measure technical progress and success? What were your intermediate goals?
  – Challenge applications / guiding case studies
  – Consensus of DAML community (ontologies)
  – Broader acceptance in standards community
    • OWL-S outreach, W3C submission
  – Technology transition
    • E.g., Fujitsu & FCS adoption of OWL-S
  – Number of users (tools, ontologies)
    • Dozens ➔ hundreds

• Did you meet your original or revised programmatic goals?
  – Yes
Knowledge Creation Tools
Milestones and Accomplishments

• Over the course of the time you have been funded by the DAML program, what have you accomplished year-by-year?
  – What were the concrete products of your work?
    • Ontologies: services, time and space, security
    • Specifications
      – OWL-S submission, axiomatic semantics, security service descriptions (ontological, wsdl)
    • Software: DAML+OIL plugin, OWL-S editor, QUARK/GeoLogica, security matching algorithm, security services, privacy policy matcher, DAML/OAA bridge, travelocity demo
    • Reports, papers, etc.: 27 papers, over 50 presentations in journals, books, conferences, workshops and invited talks, on AI, NL, KR, and SW
Knowledge Creation Tools
Milestones and Accomplishments

- What was shown in your various demos?
  - Travelocity demo, QUARK/GeoLogica with access to OWL Web pages, Validation of DAML+OIL and OWL axioms, Editor for OWL-S and DAML+OIL, security services in OWL-S, matching privacy policies
  - Ease of access and knowledge creation
- What can you point to of your work in specifications?
  - OWL-S releases & W3C submission
  - SWSL report (forthcoming)
  - Axioms for geographical space
  - DAML+OIL and OWL axioms
  - OWL-Time specification
Knowledge Creation Tools
Transition/Handoff

- Where are the results of your work available?
  - Did you influence specs (where?)
    - OWL-S releases & W3C submission; W3C SWS workshop is expected
    - SWSL report (forthcoming)
    - OWL-Time on OWL-Time and W3C Ontologies Web sites
    - DAML + OWL axioms (revision), OWL axioms, on SRI and Kestrel DAML web sites.
    - Building of OWL-S Editor influenced OWL-S ontology (uncovering inconsistencies, under-specifications)
    - Work on OWL-S & SWSL influenced development of rules & FOL markup
  - Did you build software (where is it, what is its status)
    - OWL-S Editor, open-source, http://owlseditor.semwebcentral.org
    - DAML+OIL Editor, open-source, www.ai.sri.com/daml/DAML+OIL-plugin
    - Security Services: www.csl.sri.com/~denker/owl-sec (markup)
    - Procedural attachments to ASCS Semantic Web service, Alexandria Digital Library Gazetteer, etc.
    - Matching algorithms for security and privacy (not publicly distributed)
Knowledge Creation Tools
Transition/Handoff

- Book about OWL-S (written elsewhere)

- Did you write papers (where, how many)
  - 27 papers, over 50 presentations, in journals, books, conferences, workshops, invited talks, in AI, NL, KR and SW

- Did you contribute to a commercial company?
  - Fujitsu

- Did you contribute to a DoD pilot or product?
  - Participated in The DAML Experiment

- How did you change the world? Who is using what you developed?
  - OWL-S used by Fujitsu Task Computing initiative, FCS program & related work, many research efforts around the world
  - Versions of QUARK/GeoLogica have been exported to NASA (Goddard) and George Mason University for use in an NGA contract.
### Knowledge Creation Tools
#### Remaining Issues

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<thead>
<tr>
<th>Issue</th>
<th>Remediation</th>
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<tbody>
<tr>
<td>OWL-S features</td>
<td>Continuing work on OWL-S</td>
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<tr>
<td>- Ground to WSDL 2.0</td>
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<td>- Exceptions/Faults</td>
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<tr>
<td>OWL-S editor</td>
<td>Continuing work on OWL-S Editor</td>
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<td>- IOPR Manager</td>
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<td>- Data Flow</td>
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<td>- Multiple KBs</td>
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<td>Applying SWRL for policies, tight integration with OWL-S, and effects on service composition</td>
<td>Final release of OWL-S will have integrated concepts for security/policy Composition of SWS and policies will be resolved in theoretical framework</td>
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<td>OWL version of temporal aggregates</td>
<td>In progress</td>
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<td>Set theory for OWL axioms too weak</td>
<td>Under revision now</td>
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<td>OWL axioms with first-order theorem prover can validate ontologies but only in logical syntax.</td>
<td>Front end to be installed</td>
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<td>Issue</td>
<td>Remediation</td>
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<td>Standardization</td>
<td>• Initiation of working group at W3C (or other) with OWL-S, SWSL as inputs.</td>
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<td>(Note: W3C now planning SWS workshop 1\textsuperscript{st} half of 2005.)</td>
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<td></td>
<td>• OWL-Time</td>
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<td>• Standardization of semantic security annotations</td>
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<td>OWL-Space</td>
<td>• Other funding?</td>
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<td>Real-world tool deployment</td>
<td>• Fully transition OWL-S editor into commercial and/or military programs</td>
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Knowledge Creation Tools
Summary

• What is the take-away message from your program?
  – Summarize your program’s problem, solution, approach, and outputs
  • Problem: Knowledge acquisition and use for the Semantic Web
  • Developed broad, comprehensive ontologies of services, time, security
    with wide community consensus
  • The world wants OWL-S and SWSL:
    – Researchers are doing many interesting things with SW services
    – A few commercial and military users are doing substantial applications
    – The path to SWS isn’t clear or incremental enough for commercial users
    – Good opportunities for this in W3C and OASIS.
  • OWL Editor makes knowledge entry and use easy
  • First-order theorem proving has progressed from an object of research to
    an effective and practical tool in QUARK/GeoLogica

• Creation of the knowledge that will make the
  Semantic Web semantic, through community-wide
  ontologies of basic domains and easy-to-use
  knowledge creation and access tools
Backup Slides
Knowledge Creation Tools
Publications

• Waldinger, R., Jarvis, P., and Dungan, J. *Program Synthesis for Multi-Agent Question Answering*. in International Symposium on Verification (Theory and Practice); Festschrift celebrating Zohar Manna’s 64th Birthday, Springer Verlag, Lecture Notes in Computer Science, July 2003. [PDF, Details]


• Waldinger, R., Reddy, M., Culy, C., Hobbs, J., and Dungan, J. *Deductive Coordination of Multiple Geospatial Knowledge Sources*, in American Geophysical Union, Fall Meeting, San Francisco, CA, December 4-10 2002. [PDF, Details]


Knowledge Creation Tools
Publications 4

• Presentations (partial list)
  – Semantic Web for Military Users (SWS Tutorial)
  – Intelligent Service Integration (AAAI 2002)
  – openNet meeting, July 2004
  – SWS panels at WWW2001, WWW2004
  – Semantic Web App’s for National Security (forthcoming)
  – Semantic Technology conference (forthcoming)
  – EUROLAN tutorial on NL and the Semantic Web, Aug 2003

• Workshops organized
  – SWS2004 at ISWC
  – SWS workshop at WWW2005 (forthcoming)

• Other
  – W3C workshop on Constraints & Capabilities for WS