DAML Tools for Intelligent Information
Annotation, Sharing and Retrieval

UMBC
MIT Sloan School
Johns Hopkins University Applied Physics Lab

Tim Finin
Benjamin Grosof
James Mayfield

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Overall Program Summary

OWL helps enable agents in open, heterogeneous, dynamic environments share knowledge and cooperate on tasks while managing privacy, commitments, trust, and security. To do this, we must ensure that:

- OWL integrates with common agent frameworks and standards
- OWL integrates with other KR paradigms for real world reasoning -- rule based systems, Bayesian reasoning, etc.
- OWL permits IR systems to index and retrieve documents with text, multimedia and knowledge
Intelligent Information Annotation, Sharing and Retrieval

Technical Problem and Approach

• Current agent systems are not OWL enabled
  – Develop ontologies, software & tools to use OWL in FIPA systems
  – Develop a declarative, OWL based policy language to constrain and advise agent behavior
  – Demonstrate and evaluate use of OWL & Agents in realistic applications

• Integrate OWL with rule-based & uncertainty reasoning
  – Work with groups to develop specifications for RuleML, SWRL, etc
  – Build prototype translation systems and demonstrations
  – Annotate OWL content with Bayesian info and generate BNs
  – Demonstrate utility for ontology mapping

• Information retrieval systems must work with RDF content
  – Augment existing IR systems like Google with Swangle terms
  – Develop Swoogle as a native RDF search engine
Intelligent Information Annotation, Sharing and Retrieval

Technical Progress

• Agents and OWL
  – Developed standards, ontologies and software to use OWL in FIPA systems and demonstrated them in trading agents and pervasive computing applications
  – Developed Rei policy language and demonstrated for security & privacy in web services, collaboration tools and pervasive computing
  – WWW2005 Policy Management for Web Workshop

• OWL and reasoning
  – Helped lead efforts to integrate rule reasoning into the semantic web (RuleML, SWRL, SWRL FOL) resulting in solid specs
  – Developed tools to translate the above to standard rule engine form
  – Developed an ontology to annotate OWL content with Bayesian info and translate the ensemble into a Bayesian Network

• OWL and Information Retrieval
  – Developed Swoogle, a crawler-based IR system for RDF documents
  – Developed Swangling, a technique to allow standard IR engines (e.g., Google) to index RDF triples in retrievable form
Intelligent Information Annotation, Sharing and Retrieval
Milestones and Accomplishments

**Agent & Systems**
- ITTALKS
- Vigil
- Distributed IDS
- soup
- Cobra

**KR**
- SweetJess
- DLP
- Rei
- Bayes OWL

**IR**
- OWLIR
- Swoogle
- Swangler

**specs**
- W3C WebOnt Working group
- SWSI & SWSA

**Papers/MS/PhD**
- 4/0/0
- 20/1/0
- 25/4/1
- 28/5/5
- 5+/7?/2?

**Legend**
- Software or service: $S$
- Ontology: $O$
- Ph.D. Dissertation: $D$
- Spec impact: $I$
UMBC, JHU/APL, and MIT/Sloan are working together on a set of issues to be integrated into agent-based applications involving search and using rule-based reasoning: UMBC: Integrating communicating agents, DAML and the Web; JHU APL: DAML and information retrieval; and MIT Sloan School: DAML, rules based technology and distributed belief.

Features

- Generation from DB to DAML and HTML mediated by MySQL, Java servlets, and JSP.
- Generation of DAML descriptions and user profiles from HTML forms.
- Creation & use of DAML-encoded user models describing interests and ontology extensions.
- Ontologies for events, people, places, schedules, topics, etc.
- Automatic HTML form (pre) filling from DAML.
- Syncing of talks with Palm calendars via Coola.
- Automatic classification of talks into topic ontology.
- A XSB-based DAML/RDF reasoning engine.
- Agent-based services:
  - ITTALKS agent with KQML API using DAML as content language
  - Intelligent matching of people and talks based on interests, locations and schedules.
  - Agents using both Jackal and FIPA’s Java Message Service
  - Notification via email and mobile devices via SMS and WML.
  - Discovery of relevant background papers from NEC CiteSeer
  - Automatic generation and maintenance of user models
  - Talk recommendations via collaborative filtering
  - Integration with STP (Smart Things and Places) ubiquitous computing project

http://ittalks.org/

Ittalks.org a database driven web site of IT related talks at UMBC and other institutions. The database contains information on

- Seminar events
- People (speakers, hosts, users, …)
- Places (rooms, institutions, …)

This database is used to dynamically generate web pages and DAML descriptions for the talks and related information and serves as a focal point for agent-based services relating to these talks. To add your organization to ittalks.org and receive a domain (e.g., mit.ittalks.org) contact info@ittalks.org. See http://daml.org/ for more information on DAML and the semantic web.
Rei Policy Spec Language

• Rei is a product of Lalana Kagal’s dissertation (2004)
• An OWL based declarative policy language
• Models deontic concepts of permissions, prohibitions, obligations and dispensations
• Meta policies resolve conflicts
• Speech acts can dynamically modify policies
• Used to model different kinds of policies
  Security; privacy; team formation/collaboration/maintenance; conversation constraints
• Use at UMBC, in joint DAML projects and by Global Infotek and Fujitsu
TAGA: Travel Agent Game in Agentcities

Motivation
- Market dynamics
- Auction theory (TAC)

Features
- Open Market Framework
- Auction Services
- OWL message content
- OWL Ontologies
- Global Agent Community

Technologies
- FIPA (JADE, April Agent Platform)
- Semantic Web (RDF, OWL, DAML+OIL)
- Web (SOAP, WSDL, DAML-S)
- Internet (Java Web Start)

Ontologies
- http://taga.umbc.edu/ontologies/
  - travel.owl – travel concepts
  - fipaowl.owl – FIPA content lang.
  - auction.owl – auction services
  - tagaql.owl – query language

Owl for:
- contract enforcement
- publishing communicative acts
- negotiation
- protocol description
- representation and reasoning
- modeling trust
- publishing communicative acts
- negotiation
- protocol description
- representation and reasoning

OWL Everywhere

http://taga.umbc.edu/
**CoBrA Features**

1. Uses **OWL** for context modeling and reasoning
2. Uses abductive reasoning to **detect and resolve inconsistent context knowledge**
3. Extend the REI policy language for **privacy protection**
4. Adopt the **FIPA standards** for communication & knowledge sharing

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**EasyMeeting** an intelligent meeting room prototype that provides services for speakers, audience & organizers based on their situational needs.

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**Context Broker Architecture**

http://cobra.umbc.edu

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**EasyMeeting** an intelligent meeting room prototype that provides services for speakers, audience & organizers based on their situational needs.
• The UMBC ebiquity portal exposes its content in RDF using a set of OWL ontologies for papers, people, projects, photos, etc.
• Lab members can add arbitrary RDF assertions about any of the portal’s objects.
• It’s designed as a modular, configurable package using O/S software that others can use to create their own portals.
• An reasoning component is planned to apply ontology sanctioned inferences & heuristics.

http://ebiquity.umbc.edu/
Adding Rules to OWL

• Theory, algorithms and concepts
  – Combining LP rules + ontologies
    (1) Predicate refers to ontology URI. (2) Description Logic Programs KR and fusion. (3) Courteous inheritance for OO default inheritance. (4) In-Progress: hypermonotonic reasoning to unify nonmonotonic LP with FOL.
  – Translation between rule (+ontology) systems/KRs
    • SweetJess: Situated Courteous LP ↔ production rules
    – In-Progress: Combine {Courteous LP, RuleML} with F-Logic Programs (Hilog, frame syntax) for SWSL-Rules

• Tools: SweetRules, V1, V2
  – SweetJess, SweetOnto (DLP), SweetPH (Process Handbook), SweetXSB, SweetCR (CommonRules), core architecture

• Specifications
  – RuleML (co-led), SWRL (co-led), FOL SWRL, FOL RuleML. SWSL Rules and FOL (co-led)
Adding Rules to OWL

- Services and security application scenarios
  - Contracts: SweetDeal prototype
  - Trust policies
  - SWSL requirements analysis including match of nonmonotonic LP to majority of SWS tasks
- Metrics
  - KR expressiveness and coverage of translation/merging/ inferencing
  - Importance and number of distinct rule/ontology systems that interoperate
  - Scalability of inferencing for SCLP
- See: Rules plenary session for details
- See: Demonstrations of SweetRules and SweetDeal
# Unified Ontology Support using Bayesian Networks

## Motivation
- Reasoning within an ontology is uncertain due to noisy/incomplete data
- DL based reasoning is over-generalized and inadequate
- Relations between concepts in different ontologies are inherently uncertain

## Approach
- Translating OWL ontologies to Bayesian networks (BNs)
- Concept mapping as conditional probabilities
- Joining translated BNs (by probabilistic mappings) dynamically
- Ontology reasoning (in and across ontologies) as Bayesian inference

## Translation Process
- Extend OWL for probability annotation
- Define structural translation rules from RDF graphs to directed acyclic graphs of Bayesian networks
- Construct conditional probability tables for individual variables in the BN DAG.

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**Diagram:***

- **ontono1**
  - Probabilistic ontological information
  - P-onto1
    - OWL-BN translation
    - Probabilistic annotation
    - concept mapping
  - BN1
  - Probabilistic ontological information

- **ontono2**
  - Probabilistic ontological information
  - P-onto2
    - OWL-BN translation
    - Probabilistic annotation
  - BN2
  - concept mapping

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Student: Z. Ding. Faculty: Dr. Y. Peng, Dr. T. Finin, Dr. A. Joshi. Ack: DARPA Contract F30602-00-2-0591. 09/03.
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Derived Conditional Probability Tables

Student: Z. Ding. Faculty: Dr. Y. Peng, Dr. T. Finin, Dr. A. Joshi. Ack: DARPA Contract F30602-00-2-0591. 09/03.
The web, like Gaul, is divided into three parts: the regular web (e.g. HTML), Semantic Web Ontologies (SWOs), and Semantic Web Instance files (SWIs).

A SWD’s rank is a function of its type (SWO/SWI) and the rank and types of the documents to which it’s related.

SWD IR Engine
Swoogle puts documents into a character n-gram based IR engine to compute document similarity and do retrieval from queries.
OWL Search using SwangleTool

OWL Document + Swangled triples

SwangleSearch

Query Triple

OWL Document + Swangled triples

Inference

Swangler

Indexing and Search

Swangler

JENA

Web Search Engine

Filters

Semantic Markup

Inference Engine

Local KB

Semantic Markup

Semantic Markup Extractor

Encoder

Ranked Pages

Semantic Web Query

Encoded Markup

Text Query

Filters

Text

Swangler

Vision

Darpa

UmBC

Daml

Biquity
Transition/Handoff

- **Specifications**
  - Participated in W3C WebOnt, SWSA, SWSI
  - Co-founded RuleML, Co-led SWRL
- **Software products**
  - Swangler, F-OWL, SweetRules (+ SweetJess), Rei, Swoogle
- **Major demonstration systems**
  - ITTALKS, TAGA, EasyMeeting, Groove Team Agent, ebiquity site, *SweetDeal*
- **Services**
  - Swoogle
- **Papers, tutorials, workshops**
  - 82 refereed papers, 17 MS theses, 8 PhD dissertations, 6 conference tutorials, several workshops
- **Users**
  - Swoogle has 100s of users, Rei used by ~4 other groups, SweetJess and F-OWL each used by several groups
## Remaining Issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Remediation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SweetRules polishing</td>
<td>Complete design and implementation and documentation of existing components (e.g., SweetJess) and SWRL support</td>
</tr>
<tr>
<td>Rei policy language needs rules</td>
<td>Incorporate SWRL/RuleML languages. Can we compile Rei policies to OWL+SWRL?</td>
</tr>
<tr>
<td>Swoogle needs instance data</td>
<td>Extend Swoogle’s database to include all instance data. How well will it scale?</td>
</tr>
<tr>
<td>Swangler lacks query I/F</td>
<td>Build a query interface for swangled Semantic Web documents. Develop a good usecase (intranet?)</td>
</tr>
<tr>
<td>IR over mixed RDF and text</td>
<td>Develop tools to enable Swangler and Swoogle to work with documents that embed RDF in XHTML.</td>
</tr>
<tr>
<td>Bayes OWL completion</td>
<td>Extend OWL2BN translation algorithm to properties. Can probabilities be estimated from Swoogle data? Do mapping usecase.</td>
</tr>
<tr>
<td>SweetRules adoption</td>
<td>SweetRules authoring tools and studio/IDE environment; continued maintenance beyond 2005</td>
</tr>
</tbody>
</table>
We’ve demonstrated that

- **OWL** helps agents in open, dynamic environments to share knowledge and manage privacy, commitments, trust, and security.
  - Demonstration: ITTALKS system, TAGA multiagent system, SOUPA ontology for pervasive computing

- **OWL** can be integrated with other KR paradigms for *real world* reasoning
  - Demonstration: SweetJess, SweetRules, Bayes OWL, Rei

- **OWL** is compatible with the information retrieval paradigm
  - Demonstration: Swoogle as an RDF search engine, Swangling permits IR systems to index and retrieve documents with text, multimedia, and knowledge.

- **OWL** facilitates the sharing of knowledge thru web portals
  - Demonstration: ebiquity web pages