Thoughts on Future Development for DAML

Carnegie Mellon University

Katia Sycara

Carnegie Mellon University

http://www.cs.cmu.edu/~softagents

School of Computer Science

Background

The DAML program has made significant progress in:

- Languages
  - Language for expressing Web Semantics (DAML+OIL/OWL)
  - Query Language for DAML/OWL
  - Ontology for Web Services (DAML-S/OWL-S)
- Tools
  - Authoring of ontologies
  - Semantic Annotation of documents
  - Semantic Web Services

The DAML Program is making progress in:

- Rules

DAML is a basic technology program whose results are hard to measure

Objective

- To solicit ideas from the research community of what the next steps of the DAML Technology could be so that the technology can be of value to the military and commercial technologies
- My presentation serves as an initial impetus for the above.

Why Now?

- On Horizon: Increasingly sophisticated tools for exploitation of the semantic web; increasing interest and needs in Web services
- Opportunity: Develop scalable and flexible semantic infrastructure to enable automated, long term, interoperable, dynamic workflows
- Challenge: We *do not* currently have sufficient expertise nor experience in building such systems
  - Needed is a long term effort with a stream of shorter term spin offs
- Outcome: Orders of magnitude effectiveness in military capability
  - Quantum leap in options and flexibility
  - Assured interoperability, security and predictability of system behavior

Decision Making Process

Data Inputs

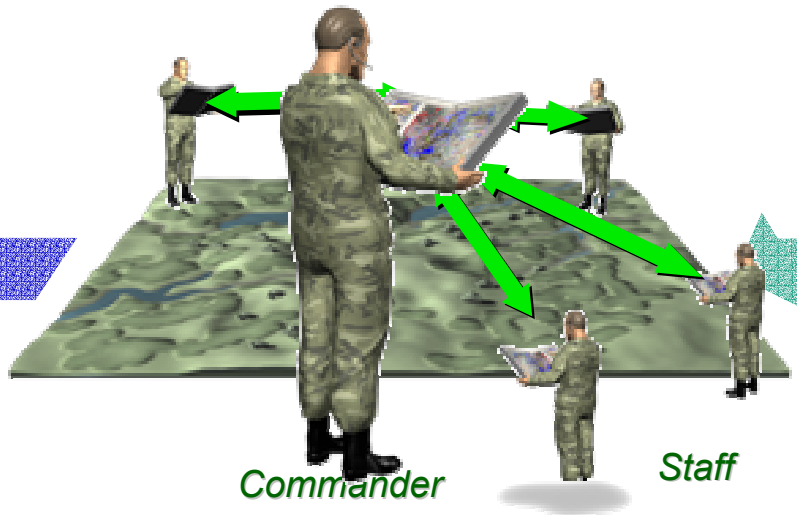
Entities
- Blue
- Red
- White

Environment
- Terrain
- Wx

Field Reports

Knowledge Inputs

Mission from HHQ
Field Reports
Collaborative Discussions



Outputs

Intent
- Assumptions
- Interpretations
- Goals

Plans
- Mission
- Times

Decisions
- Tasks

Acquire Data → Infer → Project → Explain

Collective understanding of intent, plans, tasks. Executors become planners

Understand Mission

Conceptualize COA

Develop Orders

Test / Operationalize COA

Wargame COA

Disseminate
Execute
Improvise

Alternative COA

Replan

Sample Challenge Problems

- **Battlefield**
  - Large scale, open and dynamic environment, increase shared situation awareness, quality and trust of information, increase system adaptivity and reconfigurability
- **Disaster response (Building explosion, earthquake, …)**
  - Assemble "coalition" team, "come as you are", adapt planned capabilities to current situation, search and rescue, …
- **Asymmetric threat response**
  - Track suspicious persons, monitor for threat situations, detect & respond to threats, …
- **Expeditionary Sensor Grid**
- **Intelligence analysis**
  - Classification and filtering, information extraction, query, information routing

Semantics impacts a wide range of critical applications

Requirements

- Dynamic workflows (long running systems)
- Dynamic establishment of trust and security of interactions; context-dependent policy compliance
- Fusing of multimodal information for increased situation awareness
- Assured interoperability among system components to increase shared awareness and system predictability
- Control of the dynamics of on line execution (system component interactions) for increased predictability
- Dynamic resource allocation in open environments
- System re-configurability and healing in response to unexpected events

These requirements are a blend of Agent issues and Semantic issues

Time to take the A in DAML seriously

Semantically Based Autonomic Computing in the Large

Machine understandable

- task descriptions
  - Action preconditions and effects, dependencies, task dependencies
- messages
- message exchange patterns
  - Expected ordering of messages, expected valid answers
- contracts
  - Contract terms
  - Roles, obligations, conditions, constraints, commitments, consequences that are part of the contractual agreements
- Bridging data base and unstructured data

Semantically Based Autonomic Computing in the Large

Putting together dynamic workflows requires runtime:

- **User support for workflow definition**
- **Locating Agents and Services**
  - **Dynamic creation and matching of advertisements and requests**
- **Invoking Agents and Services**
  - **Constructing valid messages based on the published signature/interface of a service**
- **Understanding**
  - **Interpreting the results of invoking a service**
- **Brokering**
  - **Mediating multi party interactions**

Semantically Based Autonomic Computing in the Large

Putting together dynamic workflows requires runtime:

- **Automatically Composing Results of Agent Reasoning**
  - **Combining the results of different services in a meaningful workflow**
  - **Constructing plans to achieve meta-goals based on available Services/Agents**
- **Dynamic composition of trust workflows**
  - **Interoperability of proof carrying code**
- **Constructing semantically adaptive connectors for execution monitoring**
  - **For valid expected data of particular pedigree**
  - **From authorized partners**

Technology Gaps

- Large scale ontology creation and management (different levels of modeling, versioning)
- Large scale ontological annotations
- Version control of ontologies
- Identification of tradeoffs between performance and understandability of system components

Research Gaps

- Policy representation and reasoning
  - Who is allowed to discover a service
  - Who is allowed to invoke it
  - Visibility: who is allowed to see who is involved in the interaction and what part they play
  - Message and interaction adaptivity to changing policy requirement
  - Expression and enforcement of policy and doctrine
- Verification and Proof
  - Trust in information sources
- Ontology mapping
- Support for effective non-monotonic reasoning

Research Gaps

- Dynamic acquisition of context
- Dealing with partial failure
- Approaches to support hybrid reasoning (e.g. logic based and probabilistic)
- Interoperability (different levels and specifications)
- Support for seamless integration of reasoning about time
- Communication semantics and inference mechanisms to support multi party interactions (e.g., conversations, agreements, commitments)

Research Nuggets

- Hybrid, scalable workflow models: how to put together e.g. Petri Nets and PSL to generate some prediction of correct behavior?
- Dynamic discovery (and reuse) of workflows with appropriate QoS guarantees to support dynamic workflow assembly; we have service discovery as a start
- Can appropriate workflows and composition schemas be learned? (workflow mining)
- Hybrid, scalable reasoning systems for robust reasoning: logical inference and probabilistic models
- Creating execution networks of systems that are “secure by design” by integrating semantic security descriptions and reasoning in service descriptions (performance hit?)
- Just-in time security: role- , time- task- and team- based security to decrease vulnerability

Research Nuggets

- Distributed "join" over semantic web and db data to increase information completeness
- Anytime reasoning for inference to increase execution predictability and component synchronization
- Dynamic, context-dependent creation of semantic brokers
- Dynamic architectures (e.g. through communication and use of process models)
- Autonomous distributed reasoning on information quality
  - P2P reputation mechanisms
  - Audit trail of processing on the information
- Optimal workflow composition; coalition formation modeling
- Robust design of multiparty interaction performance models of systems by combining negotiation reasoning with semantic descriptions

Metrics

- Measure performance of same tasks with or without semantic support
- Ascertain quality (correctness, completeness) of workflow results
- Ascertain predictability of results
- Algorithmic performance

Expected Significance

- Orders of magnitude increase in flexibility of making decisions in uncertain environments
- Reducing decision time by X-fold
- Y-fold decrease in setting up systems that can interoperate

Relevant DoD programs

- DARPA
  - REAL
  - ANTS
  - Self generating systems
- Interoperability MURI (under ONR)