Coalition Search and Rescue - Task Support
Intelligent Task Achieving Agents on the Semantic Web

Final Report

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Project Summary

- To provide capabilities linking:
  - models of organizational structures, policies, and doctrines
  - with intelligent task support software

- The project integrates:
  - AIAI’s I-X planning and collaboration technology
  - IHMC’s KAoS policy and domain services
  - Semantic Web Services of various kinds

- Search and rescue operations - rapid dynamic composition of available policy-constrained services - good use case for Semantic Web

- Other participants in the application include: BBN Technologies, SPAWAR, AFRL, and CMU
Project Goals

- Development of base technologies:
  - I-X/I-Plan
  - K AoS Policy and Domain Services,
- Deployment of the technology in a realistic CoAX agents demonstrator scenario,
- Integration of these two technologies with a perspective of a uniform tool release in the future.
Project Yearly Outline

● **Year 1:** Distributed multi-agent systems were developed and integrated with the semantic web in a realistic coalition search and rescue scenario:
  – AAAI-2004 Intelligent Systems Demonstrator for CoSAR-TS

● **Year 2:** An initial web services composition and policy analysis tool for semantic web services (I-K-C) was implemented:
  – IEEE Intelligent Systems journal article and an ISWC 2004 conference paper
Details of developed technology
I-X Technology

- Reasoning about and exchanging with other agents and services any combination of Issues, Activities, Constraints and Annotations
  - represented in the <I-N-C-A> ontology.
- Collaborative task support and exchange of structured messages related to plans, activity and the results of such activity.
- Information can be exchanged with other tools via OWL, RDF or other languages.
- The system includes an AI planner
I-X Process Panel and Tools for a Coalition Search and Rescue Task

I-Space

Messenger

Map Tool

Artificial Intelligence Applications Institute, University of Edinburgh, UK
Institute for Human and Machine Cognition, Pensacola, Florida
I-X Process Panels

- Intelligent ‘to-do’ list for its user
- In conjunction with other users’ panels, it can become a workflow,
  - reporting and messaging ‘catch all’
  - allowing the coordination of activity
- Presentation of the current items of each of the four sets of entities comprising the <I-N-C-A> model
- Can take requests to:
  - Handle an issue
  - Perform an activity
  - Add a constraint
  - Note an annotation
Policies and Semantic Web Services

- Semantic Web Services to be used by people but also by software agents
- Policy ensure that human-imposed constraints on agents interactions are respected
- Policy-based controls can also be used to govern interaction with traditional (non-agent) clients
- Proposals for SOAP-based message security and XML-based languages for access control (e.g., XACML2) have begun to appear recently
- However only declarative ontology-based policy semantics can fulfill the SWS requirements
Use of Ontology in KAoS

- Descriptions of actors, actions, situations at different levels of abstraction, policies
- Possibility to dynamically calculate relations among policies and current situation, as well between policies themselves based on ontological relations of used concepts
  - Dynamic extension of the policy framework by specifying platform ontology and linking it with generic KAoS framework ontology
  - Extension of the framework itself by adding new ontologically-described components
  - See: http://ontology.ihmc.us/
**KAoS Policies**

- Main types of supported policies:
  - Authorization – **Negative and Positive**
  - Obligation – **Negative and Positive**
    » Associated with a Trigger Specifying Conditions Activating this Obligation

- **Policy controls** actions
  - Includes a description of the *action template/class*
  - Constitutes a test for the applicability of the policy

- **Policy posses a priority, which enables it to take precedence above contradicting ones**
  - Will be replaced by a more general precedence mechanism
    » Encoded in OWL
<?xml version="1.0" ?>
<!DOCTYPE P1 [ 
<!ENTITY policy  "http://ontology.ihmc.us/Policy.owl#" >
<!ENTITY action  "http://ontology.ihmc.us/Action.owl#" >
<!ENTITY domains  "http://ontology.ihmc.us/ExamplePolicy/Domains.owl#" >
]>}
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  xmlns:owl="http://www.w3.org/2001/03/owl+oil#"
  xmlns:policy="http://ontology.ihmc.us/Policy.owl#"
>
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  <owl:imports rdf:resource="http://ontology.ihmc.us/Action.owl" />
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</owl:Ontology>

<owl:Class rdf:ID="OutsiteArabelloCommunicationAction">
  <owl:intersectionOf rdf:parseType="owl:collection">
    <owl:Class rdf:about="&action;NonEncryptedCommunicationAction" />
    <owl:Restriction>
      <owl:onProperty rdf:resource="&action;#performedBy" />
      <owl:toClass rdf:resource="&domains;MembersOfDomainArabello-HQ" />
    </owl:Restriction>
    <owl:Restriction>
      <owl:onProperty rdf:resource="&action;#hasDestination" />
      <owl:toClass rdf:resource="&domains;notMembersOfDomainArabello-HQ" />
    </owl:Restriction>
  </owl:intersectionOf>
</owl:Class>

<policy:NegAuthorizationPolicy rdf:ID="ArabelloCommunicationPolicy1">
  <policy:controls rdf:resource="# OutsiteArabelloCommunicationAction " />
  <policy:hasSiteOfEnforcement rdf:resource="&policy;ActorSite" />
  <policy:hasPriority>10</policy:hasPriority>
  <policy:hasUpdateTimeStamp>446744445544</policy:hasUpdateTimeStamp>
</policy:NegAuthorizationPolicy>
Description Logic Reasoning

- Subsumption-based reasoning used for determination of disjointness:
  - Finding policy conflicts by determining if two classes of controlled actions classes are disjoint
  - Harmonization of policies

- Instance classification:
  - Policy exploration, disclosure, and distribution

- Usage of Stanford inferencing engine – JTP
KPAT Hides Complexity

Dynamically obtains list of selections from the ontology repository based on the current context.

Uses Jena - Java OWL manipulation library to build policies.
Beyond Description Logic for Policy Representation

- Originally KAoS used only OWL-DL (initially DAML)
- Limited in situations when needed to define policies where one element of an action’s context depended on the value of another part of the context:
  - Example – Loop Communication Action
  - Relation between Trigger Action and Obliged Action
- These requirements can be fulfilled by role-value-map semantics
  - Maps allow policy to express equality or containment of values that has been reached through two chains of instance properties
- KAoS was equipped with mechanisms adding role-value-map semantics to defined policy actions when necessary
Generic Semantic Web Service Policy Enforcer

- Intercept SOAP messages
- Understanding arbitrary Semantic Web Service invocations:
  - Follows annotations from WSDL interface to OWL-S interface
- Apply appropriate authorization policies to request – filtering these forbidden
- It is equipped with a mechanism to perform obligation policies,
  - which is in a form of other Web Service invocations
CoSAR-TS Scenario

- Based on the Arabello military scenario from the CoAX (Coalition Agents eXperiment) project
- The story begins with an event that reports a downed airman in the Red Sea
- Rescue resources (transportation, medical, notification) represented as dynamic Semantic Web Services
  - Description based on ontology developed for the DARPA SONAT experiment
- The selection of a SAR resource is made using the CMU Semantic Matchmaker to find a suitable service
- These lookups comply with KAoS policies
CoSAR-TS demo details
Constraining/Advising
Service Workflow Composition
I-Plan – KAoS integration

- OWL-S
- KAoS - OWL-S Mapping
- KAoS Ontology
- Collection of Available Semantic Web Processes/Services
- Policies Constraining Usage of Services
- Partial Plan Amended with Policy Related Commentary
- Policy Annotation Ontology
- Goal
- I-Plan (Planning Service)
- Final Plan
- KAoS Policy Service
I-X new capabilities

- Extend the I-Plan planning elements to allow for the creation of composed workflows ahead of execution
- Import of services described in OWL-S to be used within the planner
  - Dealing with Inputs & Outputs
  - Recovering Data flow from Plan Goal Structure
- I-Plan as a web service
Plan Web Service Workflow Composition
Workflow Compositions

- Incremental plan built by I-Plan defined using combination of processes expressed using OWL-S
- KAoS analyzes the proposed plan and annotates it with policy decisions:
  - Currently considers individual workflow actions
  - In the near future, will take into account action context within the workflow; e.g. actions preceding the given action
Mapping the OWL-S Process to KAoS Concept Action

- OWL-S concept of Process maps semantically to the KAoS concept of Action
- OWL-S represents Processes as instances, KAoS represents Actions as classes
- Need to create an OWL class based on the OWL-S process definition instance
- OWL-S API is used to:
  - load OWL-S process workflows,
  - find all processes within a workflow
  - get detailed definitions about each of them,
- Using Jena, KAoS builds the OWL class that corresponds to a subclass of the KAoS Action class being either authorize or obliged by policies
KAoS Workflow Analysis

- Action class extracted from the workflow is analyzed for policy compliance:
  - Action authorization and possible additional obligations
- Using subsumption reasoning K AoS finds relations between the current action class and action classes associated with policies:
  - Deterministic conclusions – when checked action fully subsumes policy action
  - Nondeterministic conclusions – when checked action is neither fully subsumed nor fully disjoint with policy action
  - K AoS builds a representation of the new action class by computing the difference between the current action class and the relevant policy action class
I-Plan Java Tool
On-line resources

- CoSAR-TS AAAI-2004 Intelligent Systems Demonstrator
  http://www.aiai.ed.ac.uk/project/cosar-ts/isd/

- KAoS KPAT Java Web Start demonstration
  http://norma.coginst.uwf.edu:8080/coalition/KPAT-TCP.jnlp
  http://ontology.ihmc.us

- I-K-C tool demonstrations
  http://www.aiai.ed.ac.uk/project/i-k-c
  http://projects.semwebcentral.org/projects/i-k-c

- Web service composition examples
  http://todday.inf.ed.ac.uk/linux/web-demos/web-service-demos/web-service-examples.html

- Demonstration on-line web services composer running via a SOAP interface
Conclusions

- New sophisticated functionalities in AIAI’s intelligent planning technology and IHMC’s KAoS services
  - fully OWL compliant
- The cooperation between AIAI and IHMC was significantly strengthened
  - collaborate on future projects
  - release tool integrating both technologies
- The project deepened understanding of the Semantic Web technology
  - realistic military scenarios
- Tested for technologies developed by other DAML program participants
- Communication of the value of lessons learned on the project to the OWL and OWL-S committees and forums