AI Planning for Grid/Web Services
Composition, Policy Analysis & Workflow

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IHMC, Pensacola, FL
I-X/KAoS Composer (& Enactor)

Collection of Available Semantic Web Processes/Services

OWL-S

Partial Plan

Partial Plan Amended with Policy Related Commentary

Policies Constraining Usage of Services

Consult Policies

Enforcement (e.g. via KAoS)

Enactment (e.g. via I-P^2)

Goal

I-Plan (Planning Service)

Select

Final Plan

KAoS Policy Service
Previous Relevant AIAI Work

- **O-Plan**
  - On-line web service exposing API via CGI scripts since 1994
  - HTTP interface since 1997
  - Simple - single user single-shot plan generator
  - Mixed-initiative – multiple options, multiple users with multiple roles, long transactions, collaborative planning, execution and plan repair on failure
  - Air Campaign Planning Workflow Aid - people and systems

- **I-X**
  - I-X supports the construction of mixed-initiative agents and systems which are intelligible to their users and to other systems and agents
  - Dynamic workflow generation and reactive execution support
  - I-Q query adaptor for OWL, OWL-S lookups via CMU Matchmaker, Semantic Web Queries via OWL and RDQL (AKTive Portal)
  - I-Plan planning/re-planning tool

- **CoAX and CoSAR-TS**
  - Coalition Command and Control/Search and Rescue Task Support
  - Use on CoABS Grid and with KAoS Domain and Policy Services
Previous Relevant IHMC Work

- **KAoS**
  - Developed domain and policy services compatible with several popular agent (e.g., CoABS Grid, Cougaar, Brahms, SFX) and distributed computing (e.g., CORBA, Grid Computing, Web Services) platforms
  - Use of OWL to represent application domain concepts and instances, and policy information
  - Analysis and policy disclosure algorithms built on top of Stanford’s Java Theorem Prover

- **CoAX and CoSAR-TS**
  - Use of KAoS to rapidly specify, deconflict, and enforce policies in coalition agents experiment (CoAX)
  - Use of KAoS to define, deconflict, and enforce policies governing access to CMU Semantic Matchmaker information in conjunction with AIAI’s I-X tool set (CoSAR-TS)
FY04 Progress

1. Initial exploration of the research agenda for using AI planners and workflow analysis capabilities as web service composition tools

2. O-Plan Web Service experiments
   - Dealing with Inputs & Outputs
   - Recovering Dataflow from Plan Goal Structure
   - OWL-S Import & Export

3. I-Plan
   - As a web service
   - As a Java planning tool (stand-alone and embedded)

4. KAoS Policy Analysis of workflows
   - Translate instances of OWL-S processes into KAoS Action Classes to allow policies to be written about OWL-S processes
   - KAoS Policy Semantics extended for more sophisticated insertion of policy obligations into OWL-S composite processes
   - KAoS role-value-map extensions allow generation of richer OWL-S dataflow semantics
FY04 Progress

5. Use KAoS Policy Analysis during I-Plan plan generation

6. Scenarios
   - Simple examples – e.g. document handling
   - myGrid biochemistry scenario to identify tool requirements
   - CoSAR scenario - Emerging web Interactive demo of all the integrated technology on CoSAR-TS scenario

Explorations
   - KAoS Workflow Policy Analyzer as a Web Service
   - Link to AKT work on OWL-S manual composition tool (SEdit)
O-Plan/I-Plan OWL-S Importer

http://ontology.ihmc.us/CoSAR-TS/CoSAR-TS-ServiceOntology.owl

[refinement ArabellCoastGuardCutter_Service (ArabellCoastGuardCutter_Service HospitalLocation_in ?pickupLocation_in ?countryOfHospital_in to ?injuryType_out ?person_out)
  (variables ?HospitalLocation_in ?pickupLocation_in ?countryOfHospital_in ?injuryType_out ?person_out)
  (constraints
    (world-state condition (type ?HospitalLocation_in) = Location)
    (world-state condition (type ?pickupLocation_in) = Location)
    (world-state condition (type ?countryOfHospital_in) = Country)
    (world-state effect (type ?injuryType_out) = Injury)
    (world-state effect (type ?person_out) = Person))
  (annotations
    (output-objects = (?injuryType_out Injury) (?person_out Person)))
  (input-objects = (?HospitalLocation_in Location) (?pickupLocation_in Location) (?countryOfHospital_in Country)))

[refinement CoarseMarineHelicopter_Service (CoarseMarineHelicopter_Service HospitalLocation_in ?pickupLocation_in ?countryOfHospital_in to ?injuryType_out ?person_out)
  (variables ?HospitalLocation_in ?pickupLocation_in ?countryOfHospital_in ?injuryType_out ?person_out)
  (constraints
    (world-state condition (type ?HospitalLocation_in) = Location)
    (world-state condition (type ?pickupLocation_in) = Location)
    (world-state condition (type ?countryOfHospital_in) = Country)
    (world-state effect (type ?injuryType_out) = Injury)
    (world-state effect (type ?person_out) = Person))
  (annotations
    (output-objects = (?injuryType_out Injury) (?person_out Person)))
  (input-objects = (?HospitalLocation_in Location) (?pickupLocation_in Location) (?countryOfHospital_in Country)))

[refinement U.S.ArmyHelicopter_Service (U.S.ArmyHelicopter_Service HospitalLocation_in ?pickupLocation_in ?countryOfHospital_in to ?injuryType_out ?person_out)
  (variables ?HospitalLocation_in ?pickupLocation_in ?countryOfHospital_in ?injuryType_out ?person_out)
  (constraints
    (world-state condition (type ?HospitalLocation_in) = Location)
    (world-state condition (type ?pickupLocation_in) = Location)
    (world-state condition (type ?countryOfHospital_in) = Country)
    (world-state effect (type ?injuryType_out) = Injury)
    (world-state effect (type ?person_out) = Person))
  (annotations
    (output-objects = (?injuryType_out Injury) (?person_out Person)))
  (input-objects = (?HospitalLocation_in Location) (?pickupLocation_in Location) (?countryOfHospital_in Country))))
KAoS Policy about an OWL-S Process

Using vocabulary from CoSAR -TS OWL-S Process ontology policies
COSAR-TS Web Interactive Demo

### Coalition Search and Rescue Coordinator

#### Issues

<table>
<thead>
<tr>
<th>Description</th>
<th>Annotations</th>
<th>Priority</th>
<th>Action</th>
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<tbody>
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#### Activities

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#### State

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Value</th>
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<tbody>
<tr>
<td>longitude Southampton</td>
<td>1.404</td>
</tr>
<tr>
<td>maxSpeed USS_Michigan</td>
<td>70km/h</td>
</tr>
<tr>
<td>weapon USS_California</td>
<td>&quot;loaded&quot;</td>
</tr>
<tr>
<td>Weapon YMD</td>
<td>Biological</td>
</tr>
<tr>
<td>maxSpeed USS_California</td>
<td>52km/h</td>
</tr>
<tr>
<td>maxSpeed GaoMarineHelicopter</td>
<td>120km/h</td>
</tr>
<tr>
<td>type red-sea</td>
<td>Location</td>
</tr>
<tr>
<td>type Health</td>
<td>Airplane</td>
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#### Annotations

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<th>Value</th>
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**I-K-C – CoSAR-TS Search & Rescue**

**Coalition Search and Rescue Coordinator**

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<th>Description</th>
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<tbody>
<tr>
<td>Example</td>
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<tr>
<td>Setup initial state</td>
<td>Normal</td>
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<tr>
<td>Sea rescue pilot at sea</td>
<td>Normal</td>
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<td></td>
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<tr>
<td>Pickup and transport pilot at sea</td>
<td>Normal</td>
<td>No Action</td>
<td></td>
</tr>
<tr>
<td>US Marine helicopter service gahwad heli long red sea</td>
<td>Normal</td>
<td>No Action</td>
<td></td>
</tr>
<tr>
<td>Treat injury pilot at sea</td>
<td>Normal</td>
<td>No Action</td>
<td></td>
</tr>
<tr>
<td>Arabella hospital service pilot at sea</td>
<td>Normal</td>
<td>No Action</td>
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### State

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<tr>
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<td>-1.434</td>
</tr>
<tr>
<td>Max speed USS Michigan</td>
<td></td>
<td>70Km/h</td>
</tr>
<tr>
<td>Weapon USS California</td>
<td></td>
<td>&quot;10 loaded torpedo&quot;</td>
</tr>
<tr>
<td>Weapons WMD</td>
<td></td>
<td>Biological</td>
</tr>
<tr>
<td>Max speed USS California</td>
<td></td>
<td>52Km/h</td>
</tr>
<tr>
<td>Max speed US Marine Helicopter</td>
<td></td>
<td>120Km/h</td>
</tr>
<tr>
<td>Type red sea</td>
<td></td>
<td>Location</td>
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<tr>
<td>Type Heathrow</td>
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<td>Airport</td>
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### Annotations

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**Message**

No plan was found

**File**

- Planning statistics:
  - Steps taken = 13
  - Alternatives posted = 0

---

**Final world state:**

1. (latitude AAI) = 55.944
2. (longitude AAI) = -3.166
3. (type Arabella) = country
4. (latitude Arabella Coastguard Cutter) = 23.45
5. (longitude Arabella Coastguard Cutter) = 38.65
6. (max speed Arabella Coastguard Cutter) = 35Km/h
7. (type Arabella Coastguard Cutter) = cutter
8. (altitude Bandar Airport) = 10
9. (longitude Bandar Airport) = 19.25
10. (latitude Bandar Airport) = 37.0
11. (type Bandar Airport) = airport
12. (latitude Birmingham) = 52.45
13. (longitude Birmingham) = -1.75
14. (route Caucasian Celebrity Public London) = USS 3

**Check Plan**
Some Features of the Approach

1. **Planning using OWL-S Service Model IOPE Core**
2. **Can easily extend to accommodate richer temporal, resource and performer constraints**
3. **Policy analysis feedback during planning**
4. **Should separate plan-time model from run-time enactment environment**
5. **Single shot plan service with re-plan facility or richer “mixed-initiative” multiple-options mode**
6. **Exploring links to a graphical web service editor**
7. **Exploring seeking web service description information at planning or enactment time**
8. **Can run as separate services or as embedded tools**

Artificial Intelligence Applications Institute, University of Edinburgh, UK
Institute for Human and Machine Cognition, Pensacola, Florida
Continuing Issues

1. OWL-S input beyond primitives
2. OWL-S output espec. wrt Preconditions/Effects
3. Two way I-X <-> KAoS rich interchange
4. Widen scope of KAoS policy analysis
5. Discrete vs. continuous analysis of workflows
6. Mixed-initiative planning support, GUI
7. Multiple option exploration, GUI
8. Current service environment vs enactment model
9. When to stop planning – how far to commit
10. LOTS of planning power when we need it
OWL-S Semantics Issues

- **OWL-S doesn't yet define a way to express preconditions and effects**
  - The intention is to fix this in SWSL

- **It is awkward to express the data-flow in a composite process that invokes the same service more than once**
  - The intention is to fix this in OWL-S 1.1

- **There are partial orders of service invocations and temporal constraints that the OWL-S control structures cannot express**
  - The intention is to fix this in SWSL
OWL-S Workflow Issues

- **Current Process Model ontology is more suited to the purpose of defining internal structure of a single service**

- **Need to attach Profile restrictions to a step of the workflow; used to find a Matchmaker-registered service that meets requirements during enactment**

- **Composite processes are made up of non-unique instances of processes. We have not been able to find a way to add additional information to a particular step, for instance:**
  - Profile restrictions
  - Policy analysis results
OWL-S Deployment Issues

- There doesn't seem to be an authoritative document that precisely defines the OWL-S semantics. Many questions aren't answered by the Technical Overview or by the OWL definitions of the OWL-S ontologies.
- RDF is awkward to use and difficult to read, and OWL-S doesn't yet have an agreed alternative "surface syntax".
- There is currently no OWL-S editor.
- Doing simple things with OWL-S requires lots of software (e.g. Jena2 and all that it requires or the OWL-S API which requires Jena2 and more).
Continuing Work

- Complete integration of I-Plan Planner with KAoS policy analysis services
  - Also allow the use of WSDL workflow analyses
- Java Web Start version of KPAT to obviate the need for prior installation on user’s machine
- Generic KAoS enforcer for OWL-S
- Mixed-initiative planning, integration with AKT project graphical composition tool
- Web-based demonstration integrating I-Plan, I-P², CMU Matchmaker, KAoS and servlets simulating services
AIAI Summary Report

**2003 Goal**
- Link I-X coordination and task support with KAoS agent, domain and policy services
- Demonstrate in a Search & Rescue scenario in TTCP Binni C2 Domain
- To be shown as AAAI-2004 Intelligent Systems Demonstrator http://www.aiai.ed.ac.uk/project/cosar-ts/demo/isd/

**2004 Goal**
- Create a web service composition tool based on AI planning technology that can account for execution policy issues, requirements and constraints

**Release Plans**
- Currently I-X version 3.3 and CoSAR demonstration are available via web for research use
- Open source I-X version 4.0 for research and US government use planned for September 2004. Tool based on this put on SemWebCentral soon after.

**Plans to end of Project**
- Do our best to package the results (effort mostly used to date)
- Do our best to continue to participate in SWSL and W3C SWS-IG
IHMC Summary Report

- **2003 Goal**
  - Provide KAoS domain and policy services to I-X
  - Different from and complementary to CMU Matchmaker Policies and OWL-S security extensions
  - Develop policies and enforcers for Search & Rescue scenario in TTCP Binni C2 Domain

- **2004 Goal**
  - Provide policy analysis capability for OWL-S composite processes (next: WMSO)

- **Release Plans**
  - Web hosting of KAoS and CoSAR demonstrations for research use
  - Distribution of KAoS on SemWebCentral for research and US government use planned for October 2004

- **Plans to end of Project**
  - Enrich policy analyses of OWL-S specified workflow
  - Finish the live Web demonstration of integrated technology and CoSAR scenario by August 2004
  - Collaborate with CMU on Matchmaker improvements and usage
  - Develop generic policy enforcer for OWL-S services
Further Information

- http://www.aiai.ed.ac.uk/project/cosar-ts/
- http://ontology.ihmc.us/
- http://i-x.info