# OWL-S Tools and Applications

The OWL-S Coalition

presented by Massimo Paolucci

# Organization

- **OWL-S Authoring Tools**
  - KSL OWL-S Editor
  - CMU WSDL2OWL-S
  - Mind-Swap Ontolink
- **Web Service Discovery**
  - CMU OWL-S/UDDI Matchmaker
  - KSL Semantic Discovery Service
  - CMU OWL-S Broker
  - CMU OWL-S for P2P
- **Automatic WS Invocation**
  - CMU OWL-S Virtual Machine
- **Web Service Composition**
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  - CMU Computer Buyer
- **Applications**
  - Fujitso Task Computing
  - CMU *DAMLzon*: OWL-S for Amazon

POSTER

# OWL-S Editor

**Goal:** Editor tailored to the markup of Web Services in OWL-S
(not just an ontology editor -- focus on end user needs and intuitions)

**Input:** graphical and form entry **Output:** OWL-S & Ontolingua

**Anticipated Users:**

- Web service providers/developers
- OWL community

**Approach:**

- Graphical
- Ontology editors (OILed Protégé) and reasoner behind the scenes

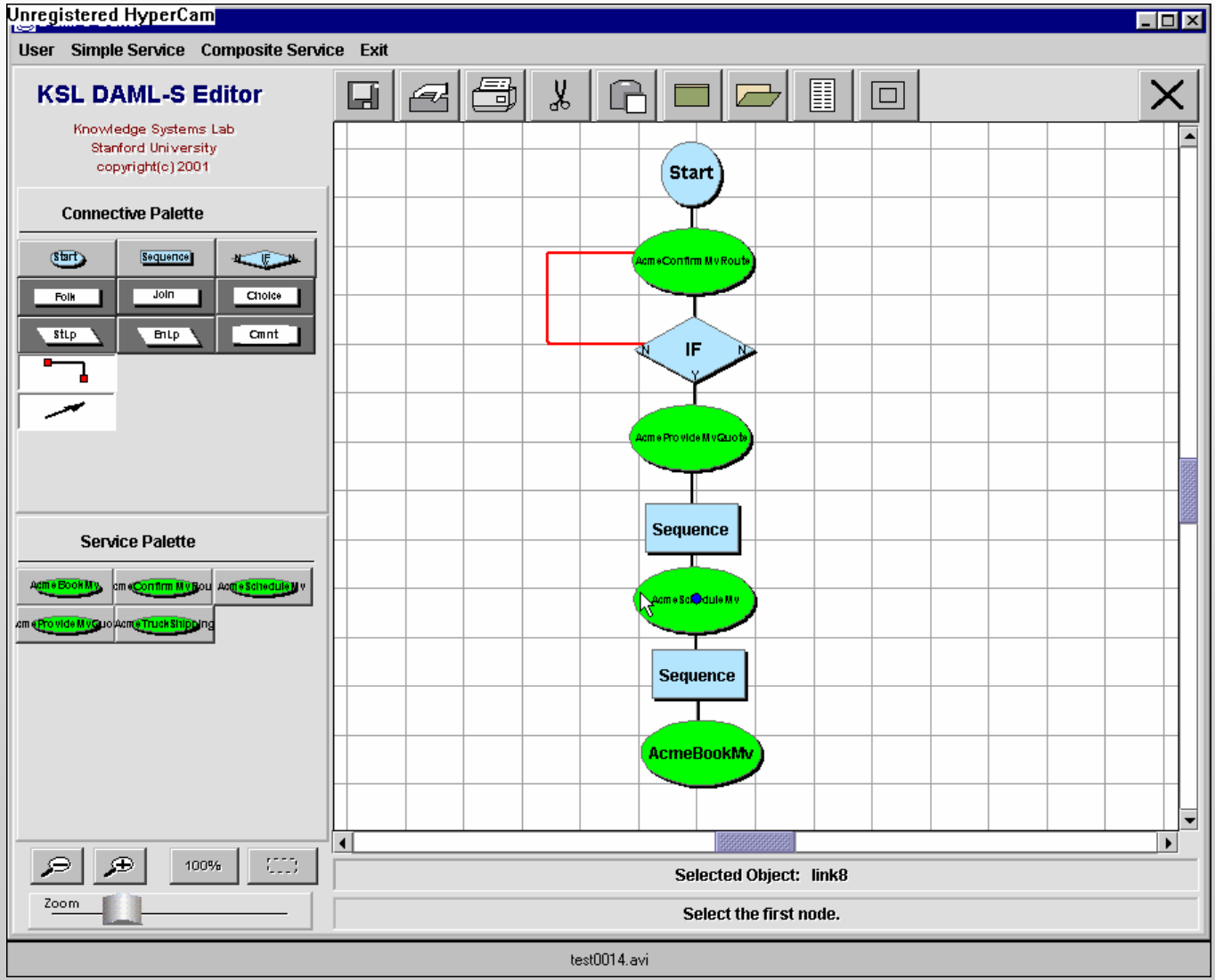
**Value added by reasoning:**

- Verification of properties of services
- Simulation of services
- Diagnostics

POSTER

# KSL OWL-S Editor

## Draw the control structure for composite services



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<rdfs:subClassOf rdf:resource="**http://www.daml.org/services/daml-s/2001/05/Process#Sequence**" />
- <rdfs:subClassOf>
- <daml:Restriction>
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- <rdfs:subClassOf>
- <daml:Restriction>
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- <daml:Restriction>
<daml:onProperty rdf:resource="**http://www.daml.org/2001/03/daml+oil#rest**" />
<daml:toClass rdf:resource="**#PROCESS-LIST-141**" />
</daml:Restriction>

# Finally, generate the OWL-S for the services

- <rdfs:Class rdf:ID="**PROCESS-LIST-141**">
<rdfs:subClassOf rdf:resource="**http://www.daml.org/services/daml-s/2001/05/Process#ProcessList**" />
- <rdfs:subClassOf>
....-

DEMO upon request

# WSDL2OWL-S/OntoLink


**www.daml.ri.cmu.edu/wsdldamls**

# Mapping WSDL to OWL-S

- Exploits relation between WSDL and OWL-S to generate (partial) OWL-S specification
  - Automatic generation of Grounding
  - Partial generation of Process Model and Profile
  - Up to 80% of work required to generate a OWL-S description is done automatically
  - Allows programmers to concentrate on the information that is really different between the two Web services descriptions
- Combined with Java2WSDL to provide **Java2OWL-S**

# Contribution

- Tool to facilitate generation of OWL-S
- Methodology to generate OWL-S
- In constant use by the community since Spring 2003

# Moving On…

## Tools for Web Service Discovery

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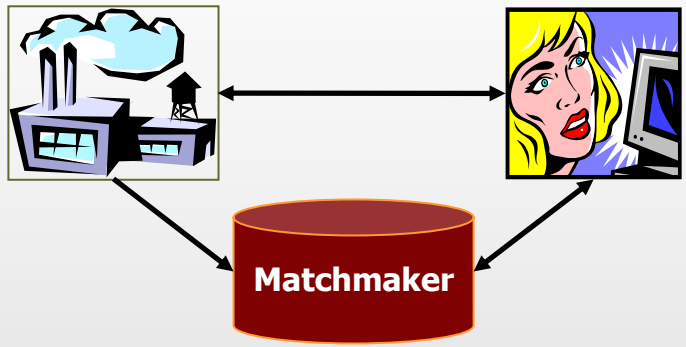
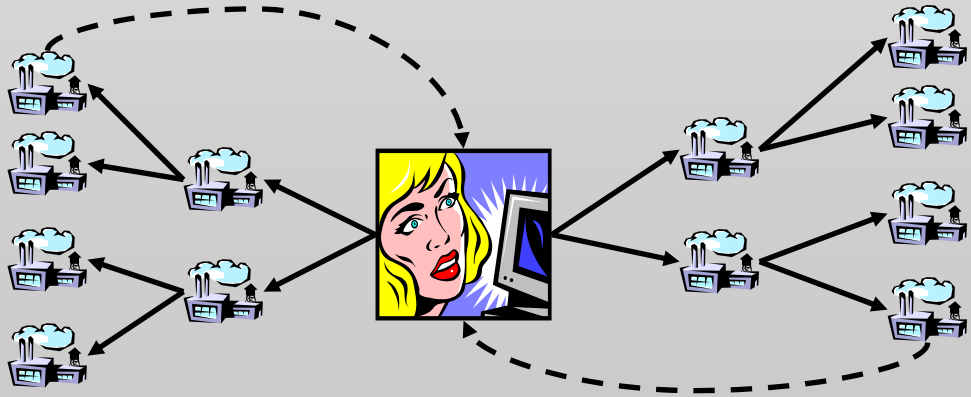
# Three Models of Discovery

- Matchmaking




- Broker

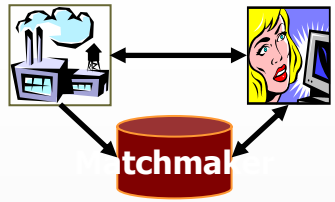
- P2P



# Matching Engine

- Core of all discovery mechanisms is a **Matching Engine** that
  - takes Requester description of *ideal* Web Service to interact with
  - advertisements of providers
  - Matching Engine finds Web Service(s) that more closely fit the description
  - Result is a flexible matching which shows the relation between advertisement and request
- Extensions: matching on additional properties:
  - **Security**:
    - Match security requirements of Requester and Provider

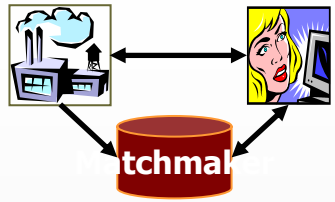
DEMO



# OWL-S 4 UDDI

- UDDI is the de-facto standard registry for Web services
  - UDDI Provides keyword search of Web Services
  - **NO CAPABILITY SEARCH**
    - It is impossible to find a WS that does …
- **OWL-S 4 UDDI** integrates OWL-S Matching engine within UDDI
  - **PROVIDES CAPABILITY SEARCH**
  - Leverages on OWL-S semantic representation

DEMO



# Architecture

*Publish* UDDI Port

*Inquiry* UDDI Port

*Capability* Port

Business Registry

Green Pages
Business Description

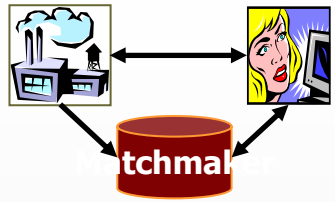
Yellow Pages
Service Properties

White Pages
Ports and Bindins

OWL inside

Matching Engine

DEMO



# Contribution

- OWL-S encoded in UDDI allows an expansions of the registry functionalities adding capability-based discovery
- OWL-S4UDDI provides ***clear evidence of the contribution of Semantic web to Web services technology***
- In collaboration with Toshiba (Japan), the DAML-S matchmaker is currently available on the NTT UDDI registry (Main UDDI provider in Japan).

# Semantic Discovery Service

- We argue that:
  - Web Services must embrace representation and reasoning ideas from Semantic Web community
  - Must also recognize evolutionary influence of industry standards and machinery on Semantic Web services
- From this viewpoint, we build on BPEL4WS, a leading choreography framework
- Integrate Semantic Web technology to enable automated service discovery, customization, and semantic translation
- Our efforts take the form of a *Semantic Discovery Service* (SDS)

# Contribution

- By integrating the SDS with BPWS4J, the industrial system gained the following abilities:
  - Automatic, runtime binding of service partners
  - Selection between multiple service partners based on user-defined constraints
  - Integration of service partners with syntactically distinct but semantically translatable service descriptions
- Does not automate composition of Web services, which requires:
  - Well-defined operational semantics describing functional behavior of service partners
  - Automated reasoning machinery to manipulate them

DEMO

# OWL-S Broker

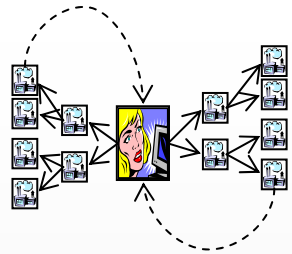
- Broker performs both discovery and mediation for a client
- Challenging OWL-S:
  - OWL-S Process Model describes an interaction between 2 parties: a provider and a requester
  - Broker introduces third parties


# Extension to OWL-S

- Dynamic loading of the Process Model
  1. The Broker publishes an initial Process Model
  2. During the interaction the Broker communicates a new Process Model
  3. The Broker and the Requester adopt to the new Process Model for the rest of their interaction

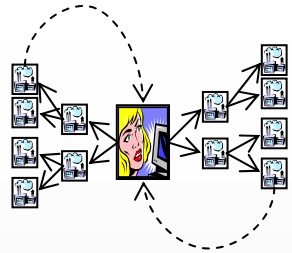
- First step toward multiparty interactions
  - Same mechanism can be used for
    - Modeling Auctions
    - Modeling transactions requiring third parties

- Supports automatic composition of Web Services



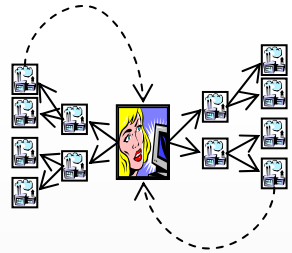
# P2P Discovery

- No Centralized registry
  - NO UDDI/Matchmaker
  - NO BROKER
- Discovery based on message passing between peers
- Useful for ad-hoc networks and ubiquitous computing
- Support switch from file-sharing to service-sharing



# Basic idea

- Advertisement
  - Web services advertise using P2P network
  - Requesters may store advertisements
- Request
  - Requesters broadcast requests for services using P2P network
  - Providers match their capabilities with the request and respond when the match is positive
- Transport
  - Based on Gnutella network



# Contribution

- Show how OWL-S can be used in P2P networks
  - We describe a Web services discovery protocol that makes use of Gnutella for connectivity and OWL-S for capability descriptions
- Supports use of OWL-S in ad-hoc network and ubiquitous computing
- Support switch from file-sharing to data/service sharing

# Moving On…

## Automatic WS Interaction

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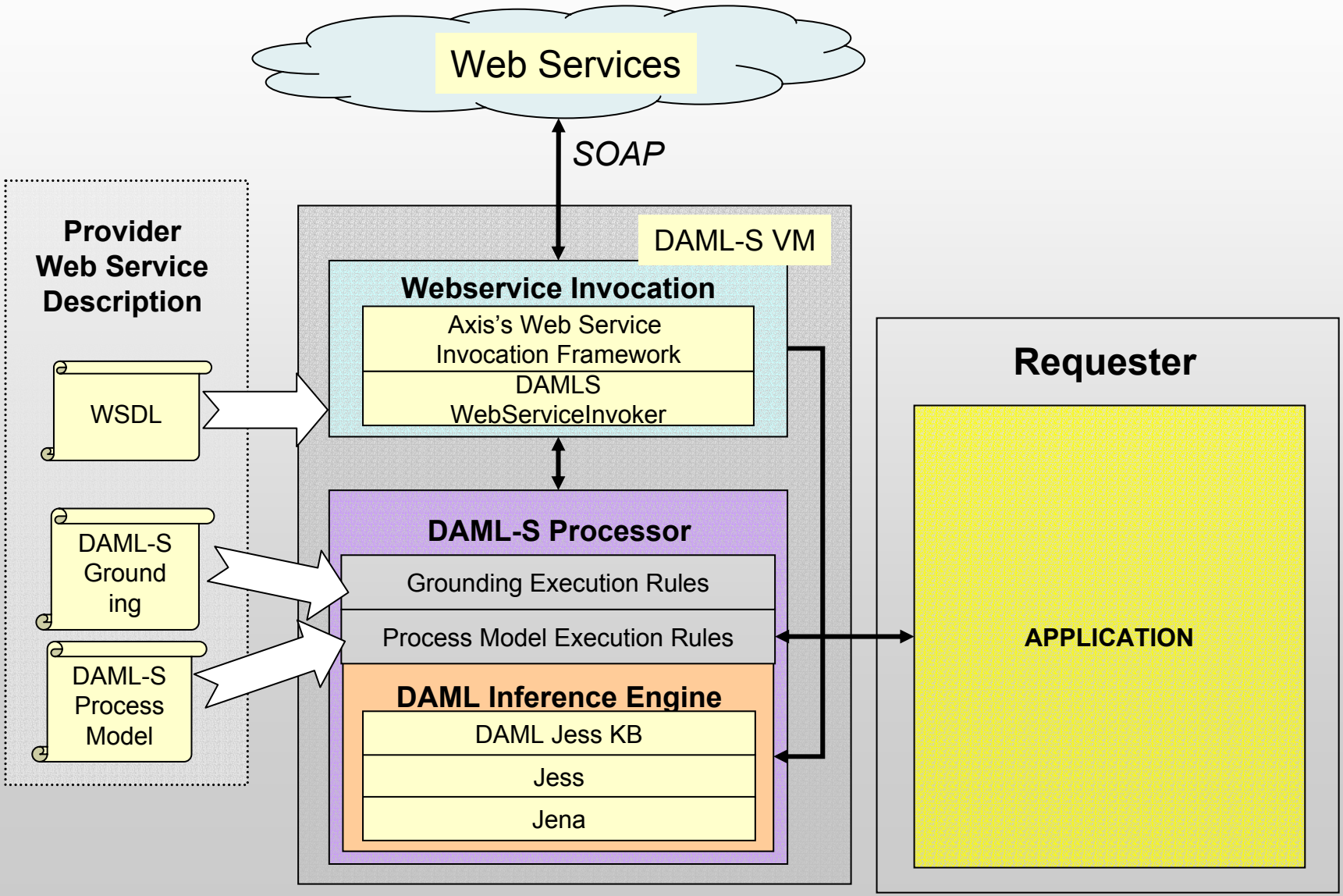
# OWL-S Virtual Machine

- OWL-S VM a generic processor for the OWL-S Process Model
  - It can interact with any OWL-S Web service
  - Based on the Process Model formal semantics(Ankolekar et al 2002)
  - Exploits Web services technology such as Axis and WSIF

# Architecture



# Contribution

- OWL-S VM can be used to automatically invoke OWL-S Web services
  - It conforms with the OWL-S semantics
  - It is based on OWL inference engine
- The use of OWL-S does not result in a performance penalty
  - In interactions with Amazon.com only 8% of time was devoted to the OWL-S VM

# Moving On…

## Web Service Composition

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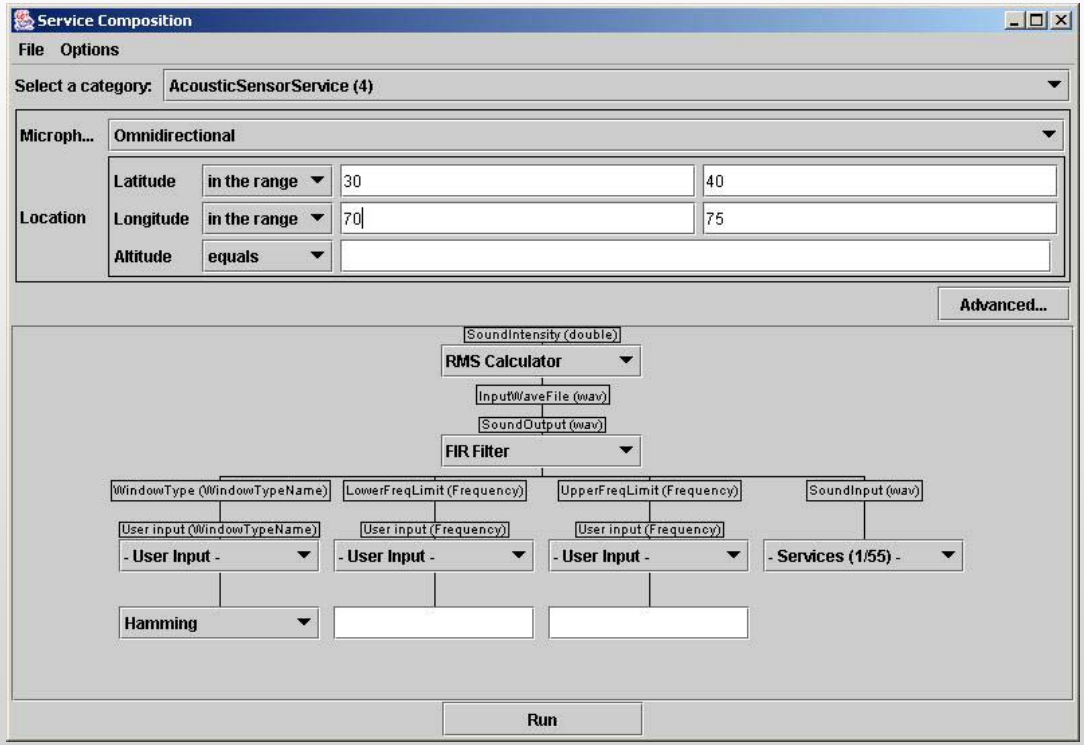
# MindSwap's Web Service Composer

- Demonstrates how tasks can be composed from different OWL-S services.
- Leads the user (via a web interface) through a top-down dynamic view of the composition
- Generates a composition that is directly executable through WSDL groundings.




**http://www.mindswap.org/~evren/composer/**

# Contribution

- WS composition environment
  - Uses SHOP2, a well established planner
  - Contains an OWL-S execution environment
- Used for many applications of WS composition ranging from
  - Information gathering
  - Language translation
  - etc…

# KSL Automated WS Composition Tool

**Problem:** Automated Web Service Composition

*E.g., Make my travel arrangements for the DAML PI Meeting*

**Approach:**

I. Plan a sequences of services that realize user's objective. (NP complete or worse)

II. Customize reusable generic procedures
- Define and archive reusable **generic procedures**
- Customize with **user's constraints**.

(NP complete or worse in a reduced search space)

**Advantages: efficiency, ease of use, customization**

# Status & Challenges

## Implementation:

✓ DAML+OIL/DAML-S FOL -> Ontolingua, Golog & sit'n calculus in Prolog

✓ Java, Prolog, Ontolingua-DAML+OIL translator, OKBC,
DAML-S to PDDL translator, bubble gum, scotch tape

## Challenges:

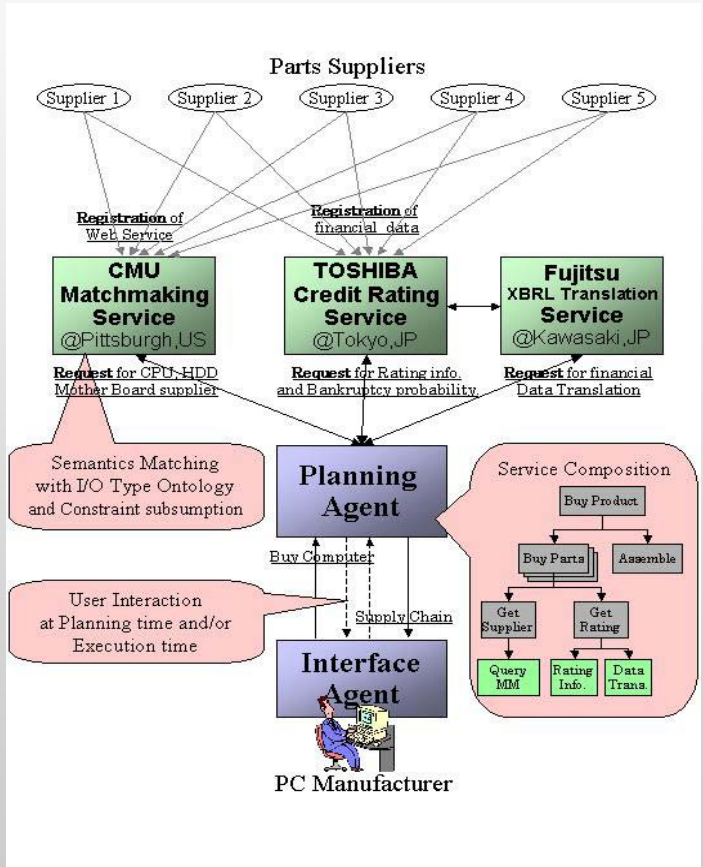
- Conversion to OWL-S and JTP
- OWL-S-ize our work; Reduce number of repn's required.
- Technical challenges:
  - Execution Monitoring & Recovery, Info vs. world-chging services
  - Automate Service Selection
  - Low-level synchronization, message passing and grounding issues

# CMU Composition Architecture

- Exploits Retsina Architecture for WS composition
  - OWL-S/UDDI Matchmaker for discovery
  - Retsina planner to control the agent
    - Use interleaving of planning and execution to allow communication while planning
  - OWL Reasoner
  - OWL-S Virtual Machine to communicate with other Web Services

# Contribution

- Used in a number of applications: travel domain, supply chain management
- Supports composition and execution of Web Services
- Connection with autonomous agent technology




in collaboration with TOSHIBA

# Moving On…

## Applications

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# Task Computing

- User wants to do "Tasks" while on the run
  - email – printing – sharing documents – complex tasks

Gap: the user should use configurations and "leg work" to use the tools

- Services offered in the environment

UPnP: Universal Plug and Play

# Task Computing

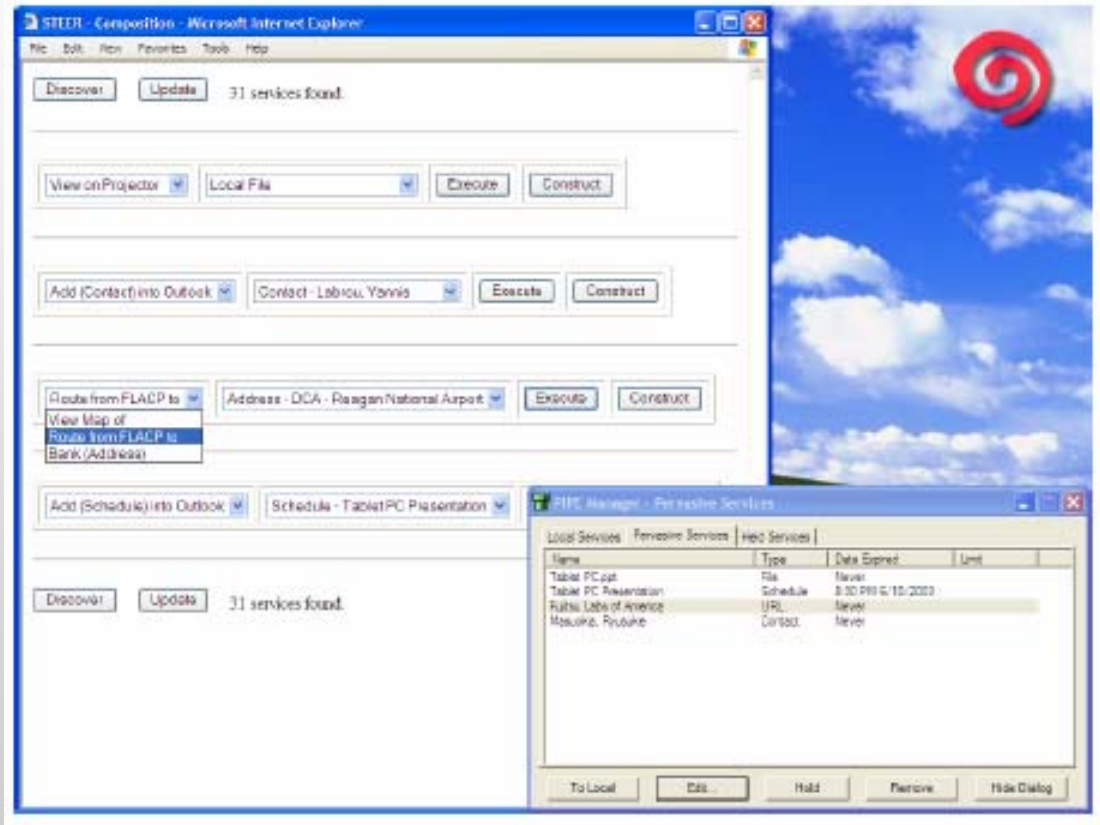
- "Task Computing" is computation to fill the gap between a user' tasks and the available means.

- Help users with access Services (Web based and not) and
  - Discovery using UPnP
  - Composition
  - Manipulated at execution time, not at the design time

- Use:
  - Semantics (OWL-S)

# Task Computing

- Task Computing Environment
  - Implemented using RDF, OWL, DAML-S and pervasive computing discovery (UPnP).
  - Supports composition of services within a pervasive environment
  - Generates DAML-S process models which are then enacted

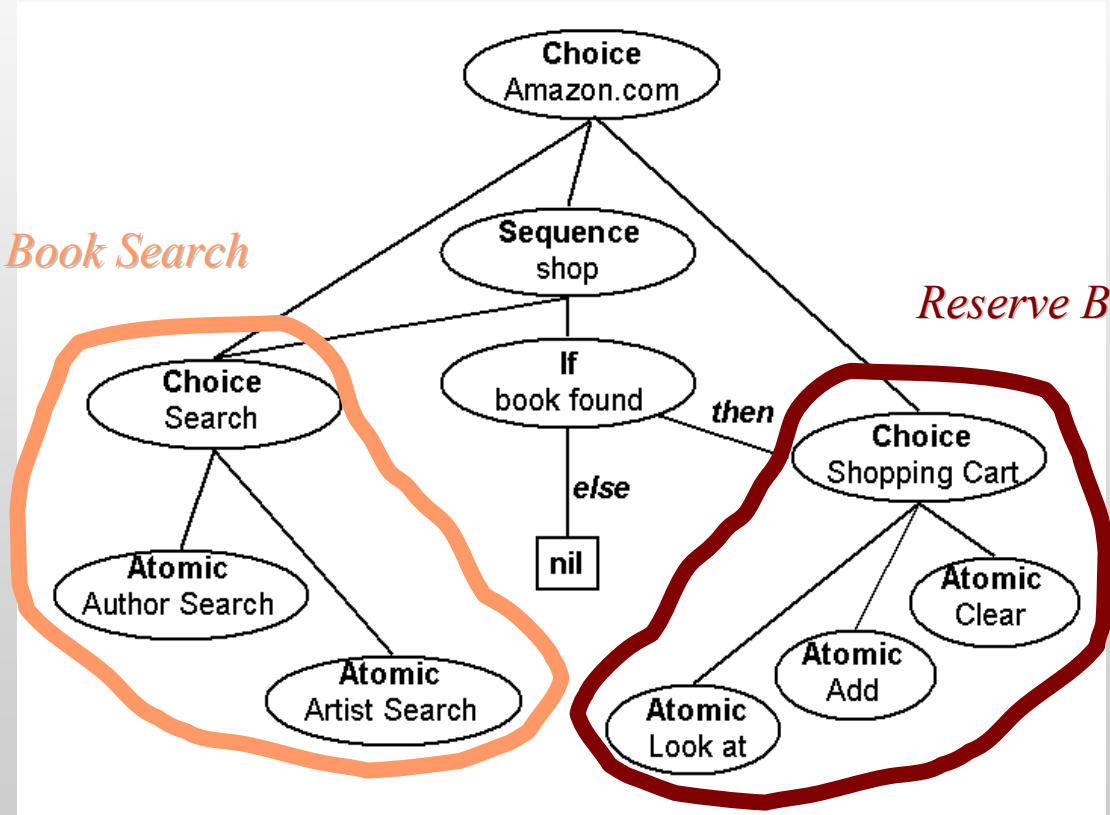



http://www.flacp.fujitsulabs.com/~rmasuoka/papers/Task-Computing-ISWC2003.html

DEMO upon request

# DAMLzon: DAML-S for Amazon.com

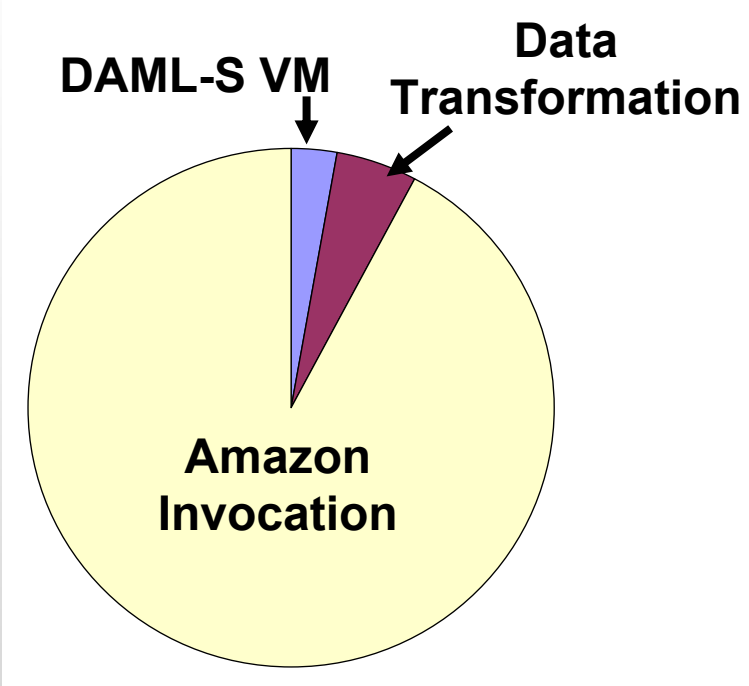
- Amazon provides a publicly available WS
- OWL-S was derived automatically using WSDL2DAML-S
- OWL-S VM used to interact with Amazon Web Service




*Process Model for Amazon.com*

# Performance

- DAML-S VM client on browsing+reserving task
- Analyzed data by computing:
  - Time required by DAML-S VM to execute Process Model
  - Time required for data transformation to fit Amazon requirements
  - Time required to invoke an operation on Amazon
- 98 runs total over 4 days in varying load conditions
- Results in milliseconds




| | VM | Data Trsfm | Invocation |
|---|---|---|---|
| **Average** *percentage* | 83 *3%* | 156 *5%* | 2797 *92%* |
| **Strd dev** | 107 | 146 | 1314 |

# Conclusion

- Good number of tools available or under construction
- Transition to OWL-S already undergoing
- A number of early adopters both from DAML program and outside