4-21-2005

Web Services to Semantic Web Processes: Investigating Synergy between Practice and Research

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Web Services to Semantic Web processes:
Investigating Synergy between Practice and Research

Keynote Address
The First European Young Researchers Workshop on Service Oriented Computing
April 21-22 - 2005, Leicester, U.K.

Amit Sheth
LSDIS Lab, University of Georgia

Special thanks: K. Verma, K. Gomadam, M. Natarajan
# LSDIS Lab (partial list)

<table>
<thead>
<tr>
<th>Name</th>
<th>Name</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Budak Arpinar^</td>
<td>Kemafor Anyanwu^</td>
<td>Aleman B.^</td>
</tr>
<tr>
<td>Karthik Gomadam*</td>
<td>Prof. Kys Kochut^~</td>
<td>Maciej Janik^</td>
</tr>
<tr>
<td>Angela Maduko^</td>
<td>Prof. John Miller*^</td>
<td>Willie Milnor^</td>
</tr>
<tr>
<td>Meena Natarajan*</td>
<td>Dev Palaniswami^</td>
<td>Matt Perry^</td>
</tr>
<tr>
<td>Cartic Ramakrishnan^</td>
<td>Satya Sahoo~</td>
<td>Prof. Amit Sheth*^~</td>
</tr>
<tr>
<td>Chris Thomas~</td>
<td>Samir Tartir^</td>
<td></td>
</tr>
<tr>
<td>Kunal Verma*</td>
<td>Zixin Wu</td>
<td>X. Yi~</td>
</tr>
</tbody>
</table>

* METEOR-S team, ^ SemDis Team, ~Glycomics Team
Introduction

• Increasing adoption/deployment of SOA with Web Services
  – Interop, standards, evolving business environment, buzz

• Academic Research in variety of topics related to Web Services

• Some Questions
  – Is academic research having any impact on Web services deployment in industry?
  – What does the industry need?
  – Are the academic research directions aligned with industry needs?
SOA Advantages

• Loose coupling
  – Easier to abstract out implementation
  – Ability to change partners and optimize

• Ubiquity
  – Interactions over the internet

• Interoperability (at system & syntactic levels)
  – SOAP messaging is XML based
Early adopters of SOA

- Companies that need high integration across divisions
- Current Users
  - Banking applications
    - JP Morgan Chase
  - Automotives
    - Daimler Chrysler, GM
  - Manufacturing
    - Dell
  - Telecom
    - Verizon
  - Supply Chain
    - IBM
Evolution of workflow realization infrastructure

As there is a growing need for better interoperability, dynamism and automation, there is a need for semantics at different levels.
Dynamism

This is one requirement where research might have most to offer.
Categorization of business interaction

- Architectures for process management can be categorized based on interaction of various stakeholders into
  - Process Portal
  - Process Vortex
  - Dynamic Trading Processes
Process Portal

- One stop shop for services
- A single entity—portal—is responsible for majority of actions
- Transactions are within the same organization or within well defined partners
- Processes are predominantly pre-defined.
Amazon as an example of process portal

Amazon web services

Developer

- Use the Amazon web service platform to develop new systems for
  - Vendors
  - Associates
- Seller Engine Software
  - Allows Amazon marketplace vendors to manage inventory, prices etc., in the Amazon marketplace.
  - http://www.sellerengine.com

Sellers and Vendors

- Use the Amazon web service platform to develop new systems for
  - Inventory management
  - Order creation and tracking
  - Refund management
  - Download competitive pricing
- AllDirect.com
  - One of the successful sellers to build on top of Amazon Web services.

Associates

- Retrieve pricing information in real time
- Create list of best selling products
- Add items to Amazon’s shopping cart from within your business.
- Use Amazon’s recommendations engine.

One stop shop for all resources
Process Vortex

- Interactions are not peer to peer; they are facilitated by a third party marketplace.
- Focus on specific products for specific markets.
- Provides organic support for business processes.
- Like a portal, the processes are predominantly pre-defined.
Integrated Shipbuilding Environment Consortium – Process Vortex in action

• Need for Data Integration of Supplier parts data with Shipbuilder product models
  – Growing number of suppliers and parts
    • Difficult to keep of suppliers, parts and costs
  – Even web based ordering can be difficult
    • Each supplier will have his own interfacing to the application
    • Need for familiarization with the look and feel

• Solution
  – Suppliers will soon publish part catalogs in private UDDI registry
  – Shipyards can replicate this and define a set of relevant partners
  – Real time parts cataloging will be enabled.
  – Shipyards and suppliers interact through a third party marketplace, in this case the private UDDI registry.

One of the case studies on IBM’s Web site
Dynamically trading processes

- Unlike portals and Vortex’s processes are not pre-defined
- Processes evolve (are constructed on the fly) based on customer needs and changing environment
- Focus across multiple product lines and markets
- Participants are semi-autonomous or autonomous groups
- An extreme form may have no coordinating authority; eg. Interactions may be governed by policies that collaborators subscribe to
Dynamism and challenges for realizing dynamically trading processes

- Businesses would like to have more flexibility, adaptability, automation
- Newer challenges need to be addressed to achieve more dynamism
  - Ability of discover partners
  - Need to create processes spawning several enterprises;
  - Ability to be able to optimize a business process;
  - To be able to achieve interoperability between heterogeneous data formats and types
- Discover, Negotiate, Compose, Configure, Optimize
- Research has a critical role ...
• Current SOA standards/specifications – Too many overlapping and non-interoperating structural and syntactic standards – What is needed to enable a process to satisfy all these concerns?

Need to go beyond syntax and to semantics

• What is needed to enable a process to satisfy all these concerns?
Challenges in Creating Dynamic Business Processes

- **Representation**
  - WSDL, OWL-S, WSDL-S, WSMO

- **Discovery**
  - UDDI, Ontology Based Discovery

- **Constraint analysis/ Optimization**
  - QoS Aggregation, Integer Linear Programming, Description Logics

- **Data heterogeneity/ Interoperability**
  - Annotating Web services with ontologies
# Web Services Research Roadmap

<table>
<thead>
<tr>
<th>Area/Year</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Execution</strong></td>
<td></td>
<td>BPWS4J</td>
<td>OWL-S VM</td>
<td>McIIraith – Dynamic BPEL Verma – Dynamic BPEL WSMX</td>
</tr>
<tr>
<td><strong>Modeling/Verification</strong></td>
<td>Aalst Petri Nets</td>
<td></td>
<td>McIlraith – Petri nets Fu – Formal verification Hull e-services</td>
<td>Fu Verification Xyi CPN OWL-S SPIN</td>
</tr>
<tr>
<td><strong>Constraint Analysis/QoS</strong></td>
<td></td>
<td>METEOR-S QoS Aggregation</td>
<td>Benatallah - QoS Based composition</td>
<td>METEOR-S Constraint Based Discovery</td>
</tr>
<tr>
<td><strong>Composition</strong></td>
<td></td>
<td>SWORD, Self-serv</td>
<td>BPEL, YAWL, MWSCF</td>
<td>Solanki compositional specification</td>
</tr>
<tr>
<td><strong>Discovery</strong></td>
<td>UDDI</td>
<td>OWL-S Matchmaker</td>
<td>MWSDI, Horrocks and Li</td>
<td>Federated UDDI, Model Based discovery</td>
</tr>
<tr>
<td><strong>Annotation/Development</strong></td>
<td>WSDL (XML), OWL-S (DL)</td>
<td>Sheth Keynote: Describe types of semantics</td>
<td>WSDL-S (XML + DL), WS-Policy</td>
<td>WSMO F-Logic</td>
</tr>
</tbody>
</table>
Representation
Representation and Discovery - Issues

• Industry solutions based on syntactic standards
  – WSDL, UDDI, SOAP
• Academic Research on logic based representation
  – OWL, F-logic
• Major issues
  – Expressiveness vs Computability
  – Mapping to industry standards
 Representation

  - An extensible, platform independent XML language for “describing” services.
  - Provides functional description of Web services:
    - IDL description, protocol and binding details

- **OWL-S (2001+)**
  - Upper ontology of web services
  - Description Logics Based description of services
    - Inputs, Outputs, Preconditions and Effects
    - Process Model
    - Binding with WSDL added (2003)
Representation

- **WSDL-S (2003-2005)**
  - Use extensibility features in WSDL to associate semantics to it
  - Functions for mapping WSDL to ontologies
  - METEOR-S philosophy based on adding semantics to Web service standards

- **WSMO (2004+)**
  - F-Logic based description of Web services
  - Uses mediators for bridging
    - goals, capabilities, Web services, Ontologies
  - Petri-nets for execution semantics

Sivashanmugam, K., Verma, K., Sheth, A., Miller, J., Adding Semantics to Web Services Standards, ICWS 2003
http://www.wsmo.org
WSDL-S Metamodel

Can use XML, OWL or UML types

Action Attribute for Functional Annotation

Pre and Post Conditions
<xml version="1.0" encoding="UTF-8"?>
<definitions

...............  
xmlns:rosetta = " http://lsdis.cs.uga.edu/projects/meteor-s/wsdl-s/pips.owl " >
<interface name = "BatterySupplierInterface"
  description = "Computer PowerSupply Battery Buy Quote Order Status "
  domain="naics:Computer and Electronic Product Manufacturing" >

<operation name = "getQuote"  pattern = "mep:in-out"
  action = "rosetta:#RequestQuote" >
  <input messageLabel = "qRequest" element= "rosetta:#QuoteRequest" />
  <output messageLabel = "quote" element ="rosetta:#QuoteConfirmation" />
  <pre condition = qRequested.Quantity  > 10000" />
</operation>
</interface>
</definitions>
Representation – Issues and Future Research

• Need to represent different kinds of semantics
  – Data, Function/behavior, Execution, QoS

• Which representation is adequate
  – OWL
  – F-Logic
  – XML (WS-Standards based on it)

• At some point WS regardless of representation need to use SOAP
  – Issues of representation model heterogeneity
  – OWL → XML, F-Logic → XML and vice-versa
Data Interoperability (DI)
Web services and DI

• Loosely coupled nature of web services
  – Reduced inter dependence between components

• Tremendous increase in schema/data level heterogeneities
  – Heterogeneous schemas/structures
  – Heterogeneous data formats and representations

• Solution
  – Relate Web services to domain models
    • Domain models captured in OWL
    • Problem of mapping XML to OWL
Data mapping in workflows and web services

• One of the most important challenges of workflows
  – Data flow (mapping between components) more than control flow (workflow execution)

• Data mapping in Web services is more complex
  – more independently developed systems
  – Issue of annotations with multiple ontologies
Using Ontologies for WS Interoperation

- Use of Ontologies in Semantic Web Services
  - Automate service discovery, process composition
- However, for execution of a Web service/ Process
  - Only semantic annotation not enough
  - Need for mappings between possibly heterogeneous message elements
  - WSDL-S demonstrates complex type mapping using XQuery/XSLT
Using Ontology as a reference for interoperability

<table>
<thead>
<tr>
<th>Schema/Data Conflicts</th>
<th>Description / Example</th>
<th>Nature of mapping function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Representation conflict</td>
<td>Different data types / representations</td>
<td>The mapping function $f_2$ will largely depend on application / domain requirements.</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Ontology" /></td>
<td><em>Note: While mapping in the direction of $f_2$ can be well defined, $f_2^{-1}$ can not.</em></td>
</tr>
<tr>
<td></td>
<td>$1:1 f_1$</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ontology</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>StudentID(4 digit integer)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f_2$</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ontology</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>StudentID(9 digit integer)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f_1$</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ontology</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight (in pounds)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f_2$</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Ontology</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weights (in kilograms)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f_1$</td>
<td></td>
</tr>
</tbody>
</table>

Data Scaling conflict

- Representations using different units and measures
- The mapping function $f_2$ or its inverse $f_2^{-1}$ can be automatically generated using a look up table and are well defined.

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<tr>
<td></td>
<td>Weights (in kilograms)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f_1$</td>
<td></td>
</tr>
</tbody>
</table>

Example schema / data conflicts: WSDL-S AppendixD


Won Kim Jungyun Seo: Classifying Schematic and Data Heterogeneity in Multidatabase Systems, 1991 and 1993
<xsd:complexType name="Address">
    <xsd:sequence>
        <xsd:element name="streetAddress1" type="xsd:string" />
        <xsd:element name="streetAddress2" type="xsd:string" />
        <xsd:element name="City" type="xsd:string" />
        <xsd:element name="State" type="xsd:string" />
        <xsd:element name="Country" type="xsd:string" />
        <xsd:element name="ZipCode" type="xsd:string" />
    </xsd:sequence>
</xsd:complexType>

<Address rdf:ID="Address1">
    <has_StreetAddress rdf:datatype="xs:string">
        { fn:concat($a/streetAddr1, " ", $a/streetAddr2) }
    </has_StreetAddress>
    <has_City rdf:datatype="xs:string">
        { fn:string($a/city) }
    </has_City>
    ...
    <has_ZipCode rdf:datatype="xs:string">
        { fn:string($a/zipCode) }
    </has_ZipCode>
</Address>
<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
</tr>
</thead>
</table>
| Early 80’s | **Relational Multi-databases:**  
* Witold Litwin: MALPHA: A Relational Multidatabase Manipulation Language  
* Dennis Heimbigner, Dennis McLeod: A Federated Architecture for Information Management |
| 1985 -    | **Database Schema Integration:**  
* Witold Litwin, Abdelaziz Abdellatif: Multidatabase Interoperability  
* Batini, Navathe, Lenzerini, “A comparative analysis of methodologies for database schema integration”  
* A. P. Sheth and J. A. Larson. Federated Database Systems for Managing Distributed, Heterogeneous, and Autonomous Databases |
| 1989 -    | **Recognizing the need for using real world semantics in schema integration:**  
* A. Sheth and S. Gala, "Attribute Relationships: An Impediment in Automating Schema Integration”  
* Mediator architecture introduced by Gio Wiederhold “Mediators in the Architecture of Future Information Systems”  
* Amit P. Sheth, Vipul Kashyap: So Far (Schematically) yet So Near (Semantically)  
* Amit P. Sheth, Sunit K. Gala, Shamkant B. Navathe: On Automatic Reasoning for Schema Integration  
* Kashyap and Sheth, Semantic and schematic similarities between database objects: a context-based approach |
<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
</tr>
</thead>
</table>
| 1990’s | **Schema integration using Ontologies and multi-ontology integration:**<br>  * Vipul Kashyap, Amit P. Sheth: Semantics-Based Information Brokering  
  * ISI’s SIM’s system (Arens & Knoblock): on use of ontology for information integration.<br>  * Mena et al., OBSERVER: An Approach for Query Processing in Global Information Systems based on Interoperation across Pre-existing Ontologies  
  * Mena et al. Imprecise Answers In Distributed Environments: Estimation Of Information Loss For Multi-Ontology Based Query Processing |
| 2000   | **Model Management:**<br>  * Phil Bernstein, Sergey Melnik http://research.microsoft.com/db/ModelMgt/  
Schema/Data Integration Tool
Prototype Implementations

- Berdi – Bellcore, 1991
- SemInt – Northwestern Univ.
- LSD – Univ. of Washington
- SKAT – Stanford Univ.
- TransScm – Tel Aviv Univ.
- DIKE – Univ. of Reggio Calabria
- ARTEMIS – Univ. of Milano & MOMIS
- CUPID – Microsoft Research
- CLIO – IBM Almaden and Univ. Of Toronto
- COMA - A system for flexible combination of schema matching approaches - Do, H.H.; Rahm, E.
- Delta - MITRE
- Tess (schema evolution) – Univ. Of Massachusetts, Amherst
- Tree Matching - NYU
Research Issues

• Web service are autonomously developed applications
  – Data model can have different kinds of heterogeneity
  – Using ontologies as a reference can facilitate interoperation

• Annotating with ontologies leads to new problems
  – Representation heterogeneity problem - Mapping XML to more expressive OWL
  – Need normalized representations e.g schemaGraph or machine learning

[HK04] Andreas Hess and Nicholas Kushmerick: ASSAM - Automated Semantic Service Annotation with Machine Learning
Discovery
Discovery

• Industrial Pull
  – UDDI
  – Static discovery based yellow/green pages
  – Not suited to automated discovery

• Research Push
  – Use Ontology based reasoning (e.g., OWL-S, WSMO, SWSA, …)
  – METEOR-S proposes P2P based ontology management for UDDI Registries
UDDI
Discovery - 2000

1. SW companies, standards bodies, and programmers populate the registry with descriptions of different types of services

2. Businesses populate the registry with descriptions of the services they support

3. UBR assigns a programmatically unique identifier to each service and business registration

4. Marketplaces, search engines, and business apps query the registry to discover services at other companies

5. Business uses this data to facilitate easier integration with each other over the Web

Acknowledgement: UDDI_Overview presentation at uddi.org
Problems with UDDI

- Centralized registry model (UBR) not very popular
  - Private registries prevalent

- Discovery requires solving two problems
  - Finding appropriate registry
  - Finding services in the registry
Finding Appropriate Registry

Verma et al., 2005, METEOR-S WSDI: A Scalable Infrastructure of Registries for Semantic Publication and Discovery of Web Services
Sivashanmugam, et al 2004 Discovery of Web Services in a Federated Registry Environment
Semantic Discovery (early work)

- Use subsumption for deciding degree of match between service request and advertisement
- Based on inputs and outputs

**Exact**: subclassOf, assume that provider commits to give consistent outputs of any subtype of OutA

**Plug in**: Weaker relation between OutA and OutR

**Subsumes**: Provider does not completely fulfills the goal, but may work

```plaintext
degreeOfMatch(outR, outA):
    if outA=outR then return exact
    if outR subclassOf outA then return exact
    if outA subsumes outR then return plugIn
    if outR subsumes outA then return subsumes
    otherwise fail
```
Use of ontologies enables shared understanding between the service provider and service requestor.

Semantic Discovery (METEOR-S, 2003)

For simplicity of depicting, the ontology is shown with classes for both operation and data.
Similarity based on Data, Function and QoS Semantics

Web Service Web Service

Syntactic Similarity

\[ \text{SynSim}() = \frac{\omega_1 \cdot \text{SyntNS}(\text{ST}, \text{SO}) + \omega_2 \cdot \text{SyntDS}(\text{ST}, \text{SO})}{\omega_1 + \omega_2} \]

\( \omega_1, \omega_2 \in [0..1] \)

QoS Similarity

\[ \text{OpSim}() = \sqrt[3]{\text{QoSdim}(\text{ST}, \text{SO}, \text{time}) \cdot \text{QoSdim}(\text{ST}, \text{SO}, \text{cost}) \cdot \text{QoSdim}(\text{ST}, \text{SO}, \text{reliability})} \]

Cardoso, Sheth: Web Semantics, 2004

Functional & Data Semantic Similarity
Discovery in WSMO

- **WSMO**
  - *Two different views*
    - Requester’s view: **GOAL**
    - Provider’s view: **WS CAPABILITY**
  - *Links between the two views:*
    - wgMediators

- Vocabulary for requesters
- Vocabulary for providers
- Links between both to fill the gap between requester’s needs and provider’s offers
Discovery in WSMO

- Goal modelling
  - Buy a train itinerary from Innsbruck to Frankfurt on July, 17th 2004, for Tim Berners-Lee
  - Postcondition: get the description of the itinerary bought
  - Effect: have a trade with the seller for the itinerary, paying by credit card and the bill and ticket have to be delivered to Tim Berners-Lee’s address
postcondition

axiom buyATicketForItinerary

non-functional-properties
dct:description "The goal postcondition is represented as a fact, in this case the fact is only specified partly, e.g. for the time of departure the minute and seconds are not specified.
It represents that 'Tim Berners-Lee' wants to go from InnsbruckHbf to FrankfurtHbf departing from InnsbruckHbf at 17.07.2004 18h"

logical-expression

"somelinerary memberOf tc:itinerary[
  tc:passenger hasValue _# memberOf prs:person[
    prs:firstName hasValue "Tim",
    prs:lastName hasValue "Berners-Lee",
    prs:email hasValue "timbl@w3.org"
  ],
  tc:trip hasValue _# memberOf tc:trainTrip[
    tc:start hasValue tc:innsbruckHbf,
    tc:end hasValue tc:frankfurtHbf,
    tc:departure hasValue _# memberOf dt:dateAndTime[
      dt:date hasValue _# memberOf dt:date[
        dt:dayOfMonth hasValue 17,
        dt:monthOfYear hasValue 7,
        dt:year hasValue 2004
      ]
      dt:time hasValue _# memberOf dt:time[
        dt:hourOfDay hasValue 18
      ]
    ]
  ]
]"
Discovery in WSMO

effect

axiom havingTradeForTrip

non-functional-properties

dc:description "The goal effect is represented as a fact
It represents that 'Tim Berners-Lee' wants to have a trade
with a provider (not specified) for the itinerary given;
the ticket should be delivered to his address and he wants
to pay by creditcard"

logical-expression

"someTrade memberOf po:trade[
    po:items hasvalues {sometinerary},
    po:buyer hasvalue _# memberOf po:buyer[
        po:shipTo hasvalue TimsAddress memberOf loc:address[
            loc:roomNumber hasvalue "3",
            loc:streetAddress hasvalue "Tims street",
            loc:city hasvalue loc:boston,
            loc:state hasvalue massachusetts,
            loc:zip hasvalue "02103"
        ],
        po:billTo hasvalue TimsAddress
    ],
    po:payment hasvalue _# memberOf po:creditCard[
        po:member hasvalue "Tim Berners-Lee",
        po:expMonth hasvalue 9,
        po:expYear hasvalue 2007,
        po:type hasvalue "MasterCard"
    ]
]."
Discovery in WSMO

- Capability modelling
  - Sells train itineraries for a date after the current date, with start and end in Austria or Germany, and paid by credit card
  - Precondition: Buyer information, his purchase intention has to be a train itinerary (after the current date, with start and end in Austria or Germany). Payment method of the buyer has to be a non-expired credit card
  - Postcondition: Information about the itinerary bought, for which the start and end locations, departure date, and passenger have to be the same
  - Effect: A trade with the buyer in the precondition for the itinerary in the postcondition, using the credit card of the buyer given in the precondition
Discovery in WSMO

web.service http://www.wsmo.org/2004/d3/d3.2/v0.1.20040526/resources/cta-ws1.wsml

namespace
default=http://www.wsmo.org/2004/d3/d3.2/v0.1.20040526/resources/cta-ws1.wsml#
tc=http://www.wsmo.org/2004/d3/d3.2/v0.1.20040531/resources/tc.wsml#
dc=http://purl.org/dc/elements/1.1#
wsml=http://www.wsmo.org/2004/d16/d16.1/v0.2/20040418/#

non-functional-properties
dctitle "ÖBB Online Ticket Booking Web Service"
dc:creator "DERI International"
dcs:subject
dct:description "web service for booking online train tickets for Austria and Germany"
dc:publisher "DERI International"
dc:contributor "Michael Stollberg"
dc:date "2004-06-03"
dctype http://www.wsmo.org/2004/d2/v0.3/20040329/#/L3966
  comment: MIME type according to [RFC2646,RFC2046]
dc:format "text/plain"
  comment: language definition according [RFC3066, ISO639]
dc:language "en-us"
dc:relation http://www.wsmo.org/2004/d3/d3.2/v0.1/20040524/resources/tc.wsml,
  http://www.wsmo.org/2004/d3/d3.2/v0.1/20040524/resources/tdo.wsml
dc:coverage tc:austria, tc:germany
dc:rights http://deri.at/privacy.html
version "1.0"

usedMediators

capability
Discovery in WSMO

precondition

axiom CapPrecondition

non-functional-properties

description "the input has to be the buyer information, for which the purchase intention is in itinerary with start and end locations in Austria or Germany and the departure date has to be after the current date. In addition, the payment method has to be a credit card and the expiration date after the current date."

logical-expression

"inputBuyer memberOf po:buyer[
purchaseIntention hasValue BuyerAddress memberOf loc:address,
purchaseIntention hasValue _# memberOf tc:trip
  to trip hasValue _# memberOf tc:itinerary[
    to: start hasValue _# memberOf tc:station[
      to:locatedIn hasValue StartCountry
    ],
    to: end hasValue _# memberOf tc:station[
      to:locatedIn hasValue EndCountry
    ],
    to: departure hasValue _# memberOf dt:dateTime[
      dt: date hasValue DepartureDate
    ]
  ]
],
purchaseIntention Payment memberOf po:creditCard
] and (StartCountry =to: austria or StartCountry =to: germany) and (EndCountry =to: austria or EndCountry =to: germany) and DepartureDate > currentDate and (CurrentDate date:year = Payment.expYear) or (CurrentDate date:year = Payment.expYear) and (CurrentDate date:monthOrYear = Payment.expMonth) or (CurrentDate date:monthOrYear = Payment.expMonth))."

postcondition

axiom CapPostcondition

non-functional-properties

description "the output of the service is an itinerary with a trainTrip for which the start and end locations, and the departure date, are the ones in the precondition. The constraints on the start and end locations, and on the departure date, are, therefore, the ones in the precondition."

logical-expression

"outputItinerary memberOf tc:itinerary[
  trip hasValue inputBuyer.purchaseIntention.trip
]."
Discovery in WSMO

```xml
<axiom name="CapEffect">
  <non-functional-properties>
    <dc:description>
      "there is a trade for the trainTrip specified in the capability postcondition with the buyer in the precondition."
    </dc:description>
  </non-functional-properties>
  <logical-expression>
    "effectTrade memberOf po:trade[
      po:items hasvalues {outputItinerary},
      po:buyer hasvalue inputBuyer,
      po:hasPayment hasvalue inputBuyer.payment
    ]"
  </logical-expression>
</axiom>

<intface name="Interface">
  <non-functional-properties>
    <dc:description>
      "link to Interface of Web Service"
    </dc:description>
  </non-functional-properties>
</intface>
```
Discovery in WSMO

• Matching simple
Michael Kifer
Discovery – Issues and Future Research

• How to capture functionality of a Web service
  – Inputs/Outputs
  – Function (Preconditions and Effects) and QoS
  – Expressivity vs. Computability vs. Usability

• DL based Queries (OWL-S)
  – Not expressive enough, but easier to create

• DL + quantitative approaches (METEOR-S)
  – Difficult to optimally configure discovery parameters

• F-Logic Queries (WSMO)
  – Expressive, but can a user create such queries
  – Quantitative criteria?

• Is complete automation necessary? Is it possible?
Constraint analysis/ Optimization
Constraint analysis / Optimization - Issues

- Academic research in optimization and constraint analysis
  - METEOR-S
  - Self-Serv
- Example challenges ....
  - Modeling QoS of services and processes
  - Capturing domain constraints
  - Optimizing processes based on QoS
  - Combining logic based solutions with quantitative solutions
Stochastic Workflow Reduction (SWR) Algorithm

Mathematically model aggregation of Quality of Service of workflows

Stochastic Workflow Reduction (SWR) Algorithm

Reduction of a Sequential System

\[ T(t_{ij}) = T(t_i) + T(t_j) \]
\[ C(t_{ij}) = C(t_i) + C(t_j) \]
\[ R(t_{ij}) = R(t_i) \cdot R(t_j) \]
\[ F(t_{ij}) . a_r = f(F(t_i), F(t_j)) \]

Reduction of a Parallel System

\[ T(t_{ln}) = \text{Max}_{1 \leq i \leq n} \{ T(t_i) \} \]
\[ C(t_{ln}) = \sum_{1 \leq i \leq n} C(t_i) \]
\[ R(t_{ln}) = \prod_{1 \leq i \leq n} R(t_i) \]
\[ F(t_{ln}) . a_r = f(F(t_1), F(t_2), \ldots, F(t_n)) \]
Quality Driven Web Services Composition

- Uses SWR like algorithm to aggregate QoS of Web services.
- Use linear programming for optimizing Web services based on Quality of Service metrics.

\[
\text{Max} \left( \sum_{l=1}^{2} \left( \frac{Q_{l}^{\text{max}} - Q_{i,l}}{Q_{l}^{\text{max}} - Q_{l}^{\text{min}}} \ast W_{l} \right) + \sum_{l=3}^{5} \left( \frac{Q_{i,l} - Q_{l}^{\text{min}}}{Q_{l}^{\text{max}} - Q_{l}^{\text{min}}} \ast W_{l} \right) \right)
\]
On Accommodating Inter Service Dependencies in Web Process Flow Composition

- Use description logics to capture domain constraints
- E.g. parts of supplier 1 do not work with parts of supplier 2
- Use domain constraints to validate selection of services for a process
Constraint Driven Web Service Composition (METEOR-S)

- User defines High level goals
  - Abstract BPEL process (control flow without actual service bindings)
  - Process constraints on QoS parameters
    - Generic parameters like time, cost, reliability
    - Domain specific parameters like supplyTime
- Domain constraints captured in ontologies
  - E.g preferred suppliers, technology constraints
Working of Constraint Analyzer

Service Template 1 → Service Template 2 → Abstract Process Specifications → Discovery Engine

Service templates and service constraints:
- ST=2, C=100
- ST=3, C=250
- ST=3, C=200
- ST=1, C=300
- ST=4, C=200
- ST=3, C=180
- ST=1, C=250

Domain constraints in ontologies:
- Supply-time <= 4
- Cost <= 200
- Network Adaptor

Optimizer (ILP):
- Process constraints:
  - Supply-time <= 3
  - Cost <= 300
  - Battery

Objective Function and Process constraints:
- Min (supply-time + cost)

Most optimal set cannot be chosen because of inter service dependencies:
- Network Adaptor from supplier 1 does not work
- Battery from supplier 2

Ranked Set:
- ST=4
  - C=200
- ST=3
  - C=180
- ST=4
  - C=200
- ST=3
  - C=180

Research Issues

• Develop formal methodology for representing constraints and Quality of Service

• Multi-paradigm solutions needed
  – Optimization (ILP)
  – Workflow reduction (Graph Algorithms)
  – Constraint Analysis (DL)
  – Policies (First Order Logic / SWRL / RuleML)
Conclusions

• Industry slowly moving towards more dynamic processes
  – process portal → process vortex → dynamic trading processes

• Greater level of dynamism enforces greater emphasis on specifications
  – Result – WS*
  – Syntax → Semantics move necessary

• Today, we looked at the use of semantics at different stages in process lifecycle
  – Representation, Discovery, Constraint Analysis, Data interoperability
  – Other issues (exception handling, verification)
Use of semantics helps us address challenges related to
- Discovery
- Representation
- QoS and optimization
- Data interoperability
More information at:

http://swp.semanticweb.org/
http://lsdis.cs.uga.edu/Projects/METEOR-S/

WSDL-S (joint IBM-UGA technical note:
http://lsdis.cs.uga.edu/Projects/METEOR-S/WSDL-S/

Questions? Comments?