SAWSDL: Tools and Applications

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What does Semantics bring to the table?

- Better Reuse
  - Semantic descriptions of services to help find relevant services
- Better Interoperability
  - Beyond syntax to semantics, mapping of data exchanged between the services (very time consuming without semantics, just as XML in WSDL gives syntactic interoperability, SAWSDL gives semantic interoperability)
- Configuration/Composition
  - Enable dynamic binding of partners
- Some degree of automation across process lifecycle
  - Process Configuration (Discovery and Constraint analysis)
  - Process Execution (Addressing run time heterogeneities and exceptions)

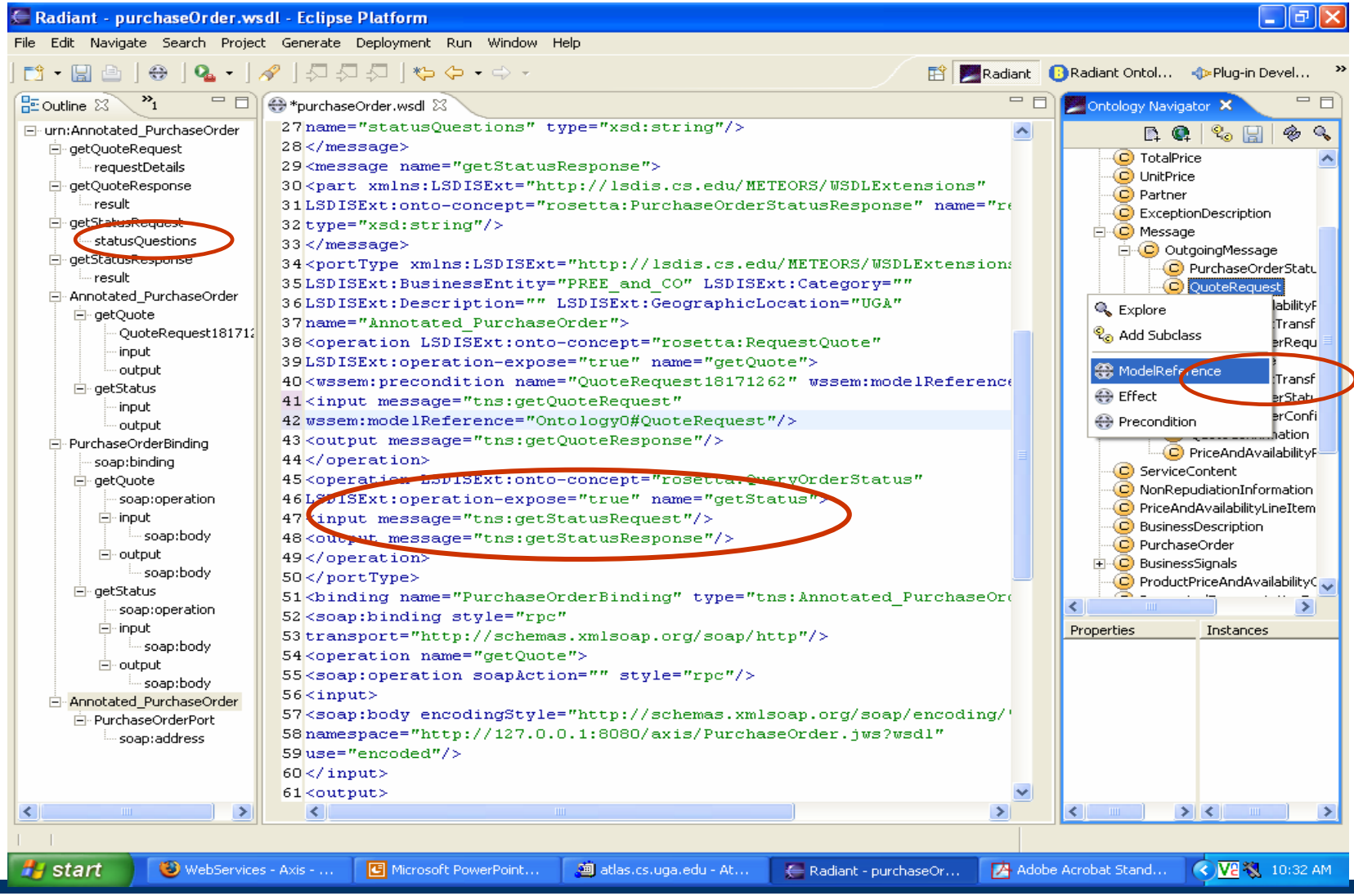
What can we support or demonstrate today

- API for handling SAWSDL documents: SAWSDL4J
- Tool for annotating WSDL services to produce SAWSDL: Radiant and for discovery: Lumina
- Using SAWSDL with UDDI for Discovery: SemBowser
- Using SAWSDL with Apache Axis for Data Mediation
- Using SAWSDL with WS-BPEL for run-time binding
- Early Examples of SAWSDL annotated services: biomedical research

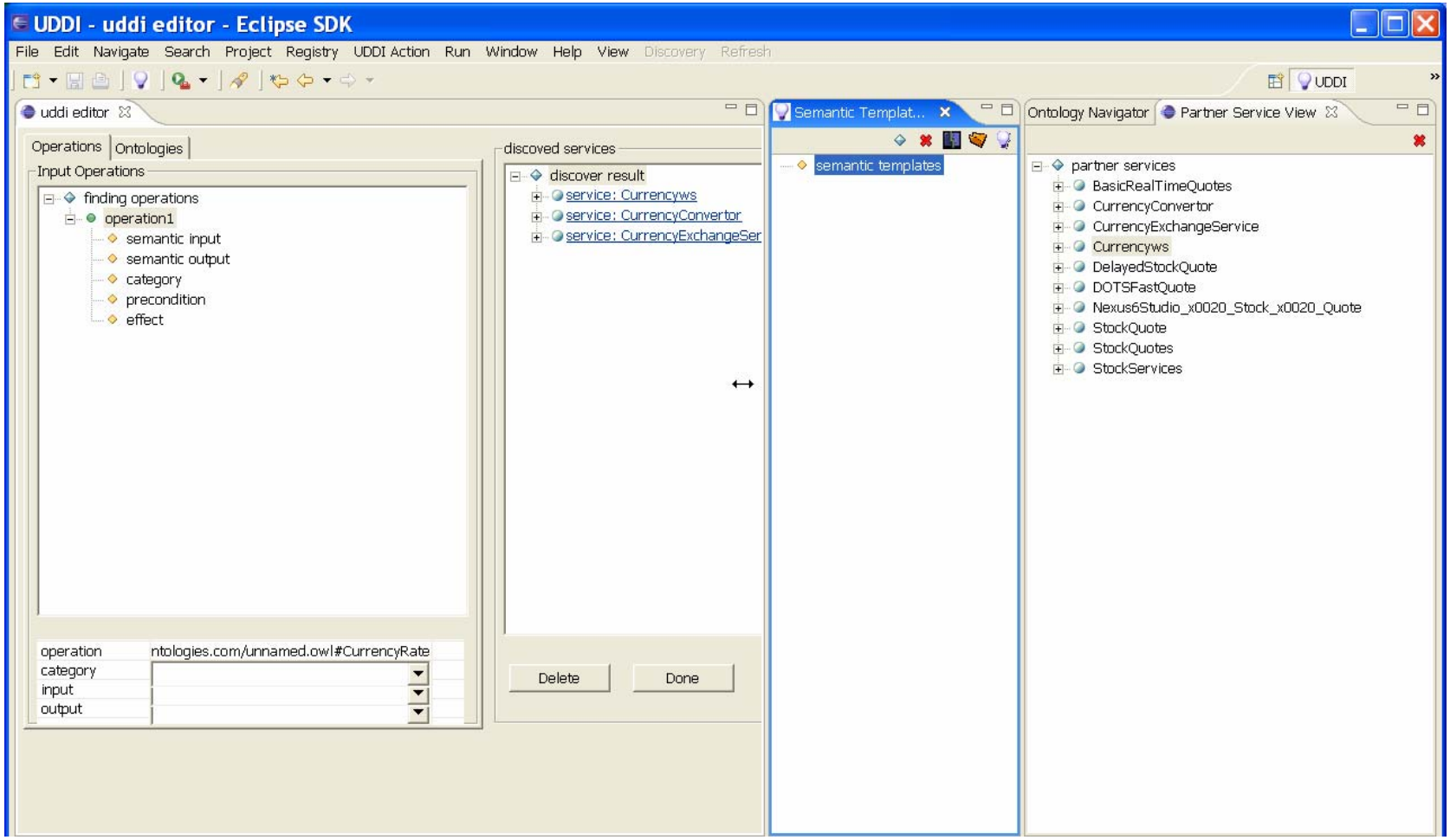
Also:

- Semantic Tools for Web Services by IBM alphaWorks
- WSMO Studio , more mentioned by Jacek

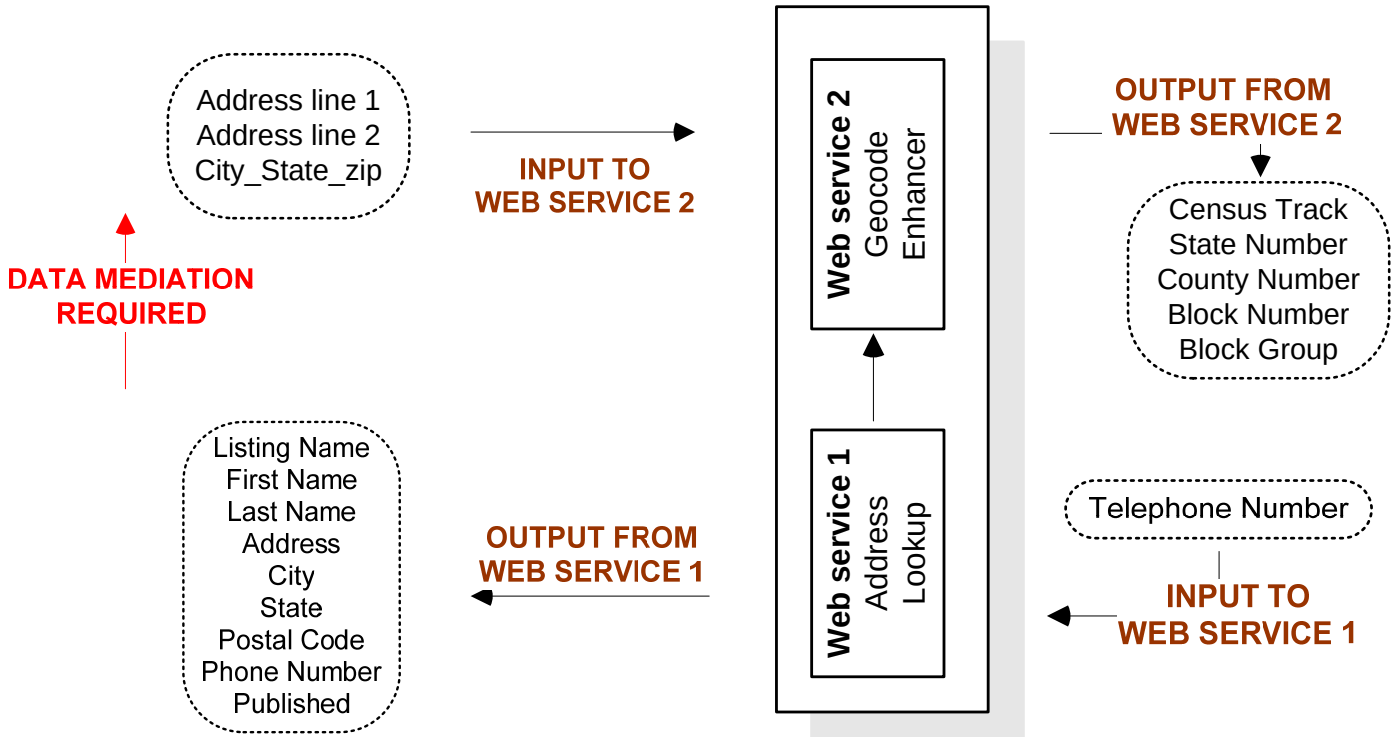
Semantic Annotation and Publication - Radiant



Semantic Web Services Discovery: Illumia

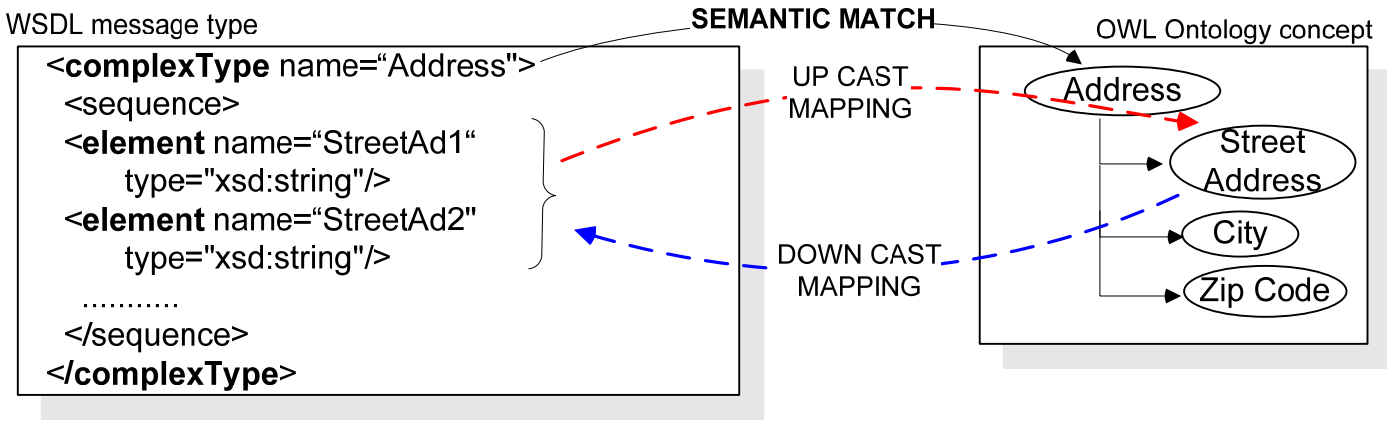


Syntactic and Semantic Match do not suffice



Mediation approach

- User specified mappings from Web service message element to semantic model concept (say OWL Ontology)
  - upcast : from WS message element to OWL concept
  - Downcast : from OWL concept to WS message element




```
<POOntology:has_StreetAddress rdf:datatype="xs:string">
{ fn:concat($a/streetAddr1 , " ", $a/streetAddr2 ) }
</POOntology:has_StreetAddress>
```

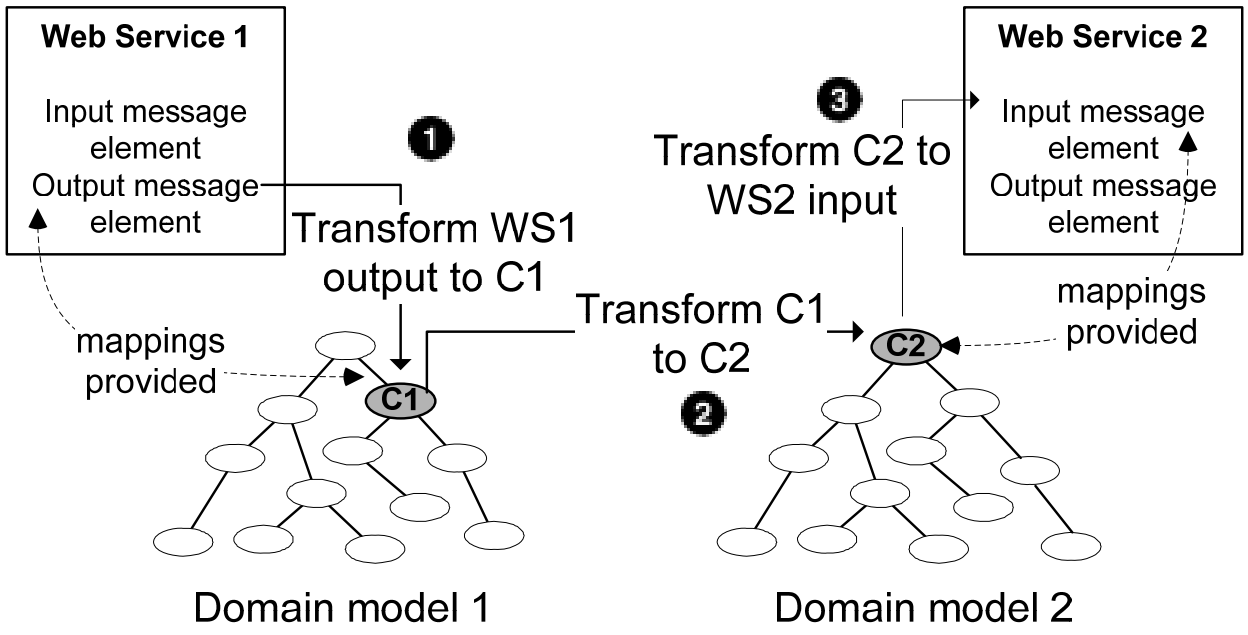
Matching & Mapping

Heterogeneities / Conflicts	Examples - conflicted elements shown in color	Suggestions / Issues in Resolving Heterogeneities
Domain Incompatibilities – *attribute level differences that arise because of using different descriptions for semantically similar attributes*		
Naming conflicts Two attributes that are semantically alike might have different names (synonyms) Two attributes that are semantically unrelated might have the same names (homonyms)	***Web service 1*** Student(Id#, Name) ***Web service 2*** Student(SSN, Name) ***Web service 1*** Student(Id#, Name) ***Web service 2*** Book (Id#, Name)	A semantic annotation on the entities and attributes (provided by *WSDL-S:modelReference*) will indicate their semantic similarities.
Data representation conflicts Two attributes that are semantically similar might have different data types or representations	***Web service 1*** Student(Id#, Name) Id# defined as a 4 digit number ***Web service 2*** Student(Id#, Name) Id# defined as a 9 digit number	* Mapping WS2 Id# to WS1 Id# is easy with some additional context information while mapping in the reverse direction is most likely not possible.
Data scaling conflicts Two attributes that are semantically similar might be represented using different precisions	***Web service 1*** Marks 1-100 ***Web service 2*** Grades A-F	* Mapping WS1 Marks to WS1 Grades is easy with some additional context information while mapping in the reverse direction is most likely not possible.
Entity Definition – *entity level differences that arise because of using different descriptions for semantically similar entities*		
Naming conflicts Semantically alike entities might have different names (synonyms) Semantically unrelated entities might have the same names (homonyms)	***Web service 1*** EMPLOYEE (Id#, Name) ***Web service 2*** WORKER (Id#, Name) ***Web service 1*** TICKET (TicketNo, MovieName) ***Web service 2*** TICKET(FlightNo, Arr. Airport, Dep. Airport)	A semantic annotation on the entities and attributes (provided by *WSDL-S:modelReference*) will indicate their semantic similarities.
Schema Isomorphism conflicts Semantically similar entities may have different number of attributes	***Web service 1*** PERSON (Name, Address, HomePhone, WorkPhone) ***Web service 2*** PERSON (Name, Address, Phone)	* Mapping in both directions will require some additional context information.
Abstraction Level Incompatibility – *Entity and attribute level differences that arise because two semantically similar entities or attributes are represented at different levels of abstraction*		
Generalization conflicts Semantically similar entities are represented at different levels of generalization in two Web services	***Web service 1*** GRAD-STUDENT (ID, Name, Major) ***Web service 2*** STUDENT(ID, Name, Major, Type)	* WS2 defines the student entity at a much general level. A mapping from WS1 to WS2 requires adding a Type element with a default 'Graduate' value, while mapping in the other direction is a partial function.
Aggregation conflicts Semantically similar entities are represented at different levels of generalization in two Web services	***Web service 1*** PROFESSOR (ID, Name, Dept) ***Web service 2*** FACULTY (ID, ProfID, Dept)	* A set-of Professor entities is a Faculty entity. When the output of WS1 is a Professor entity, it is possible to identify the Faculty group it belongs to, but generating a mapping in the other direction is not possible.
Attribute Entity conflicts Semantically similar entity modeled as an attribute in one service and as an entity in the other	***Web service 1*** COURSE (ID, Name, Semester) ***Web service 2*** DEPT(Course, Sem, .., ..)	* Course modeled as an entity by WS1 is modeled as an attribute by WS2. With definition contexts, mappings can be specified in both directions.

*** Interoperation between services needs transformation rules (mapping) in addition to annotation of the entities and/or attributes indicating their semantic similarity (matching).**

Mediation approach continued...

- Web services interoperate by re-using these mappings.
  - Ontologies now a vehicle for Web services to resolve message level heterogeneities



DM Architecture components

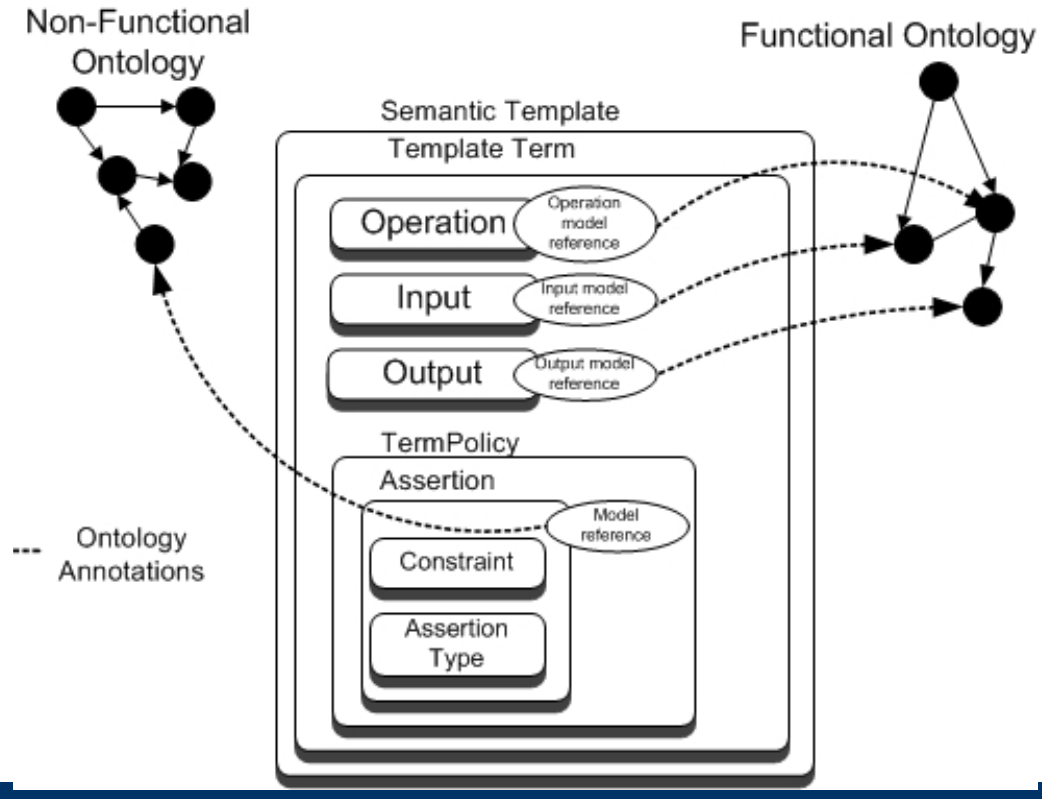
- METEOR-S Middleware
  - EPR handler – End Point Resolution handler
    - For clients to use the middleware
    - Reroute SOAP messages to middleware
  - DM handler – Data Mediation handler
    - Main component for facilitating data mediation
    - Works with the EPR handler + a mapping processing engine (SAXON for XQuery / XSLT)
- Uses extensibility support offered by Axis 2 (handlers)

Semantic Templates

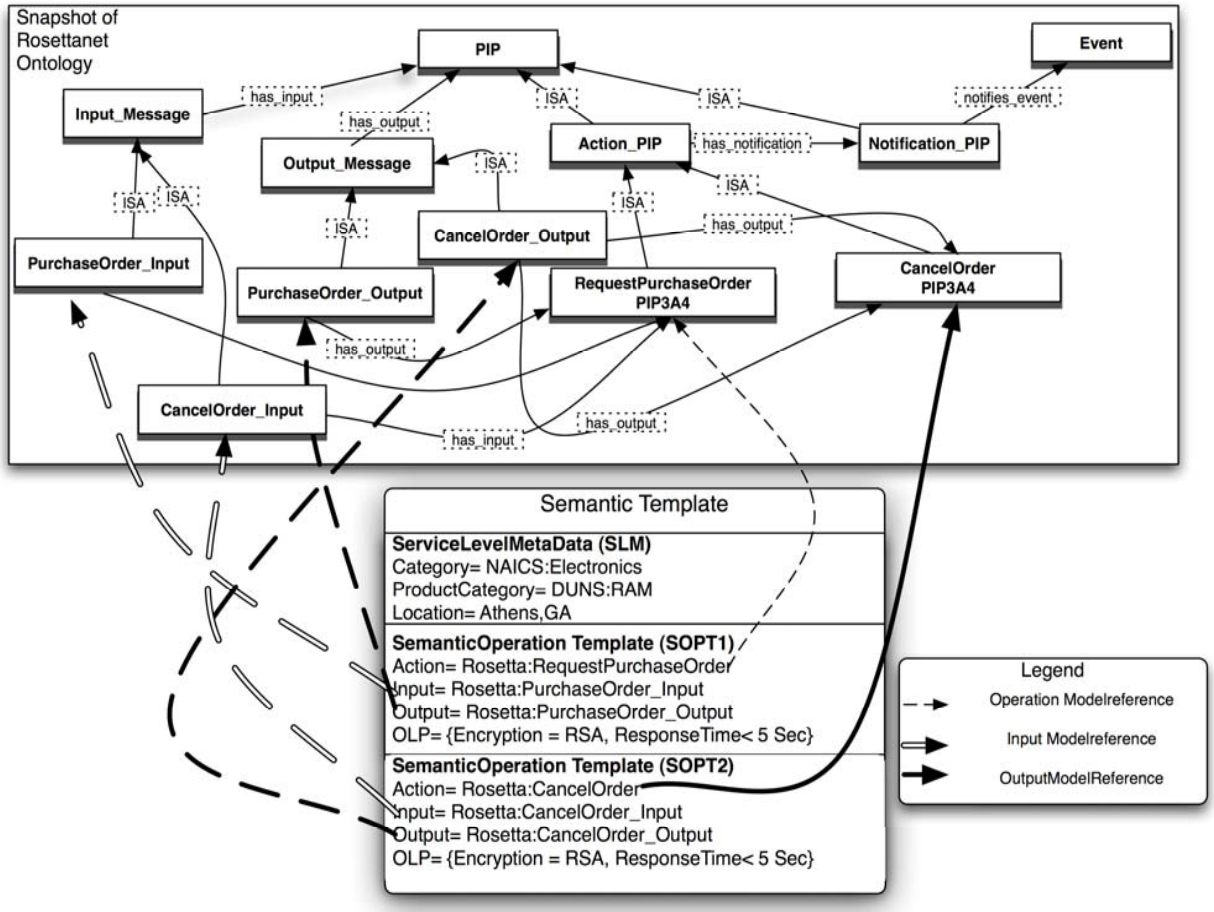
- SAWSDL + Enhanced policy descriptions to model the data, functional and non-functional semantics at the various tiers
  - Business Process Tier: Capture process level requirements
  - Implementation Tier: Capture partner level requirements
- Non-functional semantics captured at template and operation levels.
- XML representation for interoperability.

Semantic Templates

- SAWSDL for data and functional semantics
- Semantic Policy Descriptions for non-functional semantics



Example of a semantic template in the supply chain domain



Semantic Discovery

- Finds actual services matching semantic templates
- Implemented as a layer over UDDI
- Current implementation based on ontological representation of operations, inputs and outputs.
- Returns ranked of services for each semantic template

USING SAWSDL WITH WS-BPEL FOR RUN-TIME BINDING

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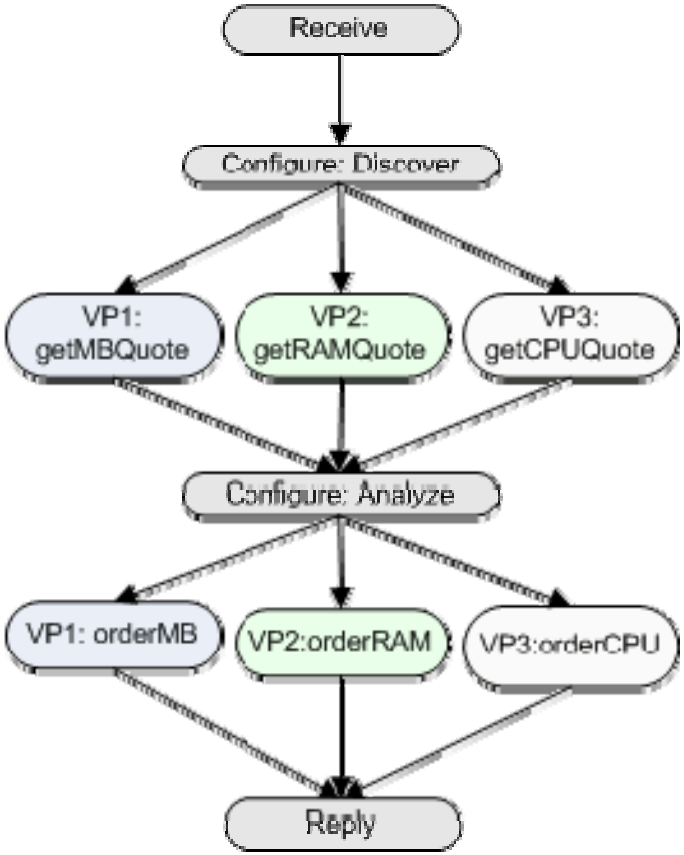


Dynamic configuration Problem

Find optimal partners for the process based on process constraints – cost, supply time, etc.

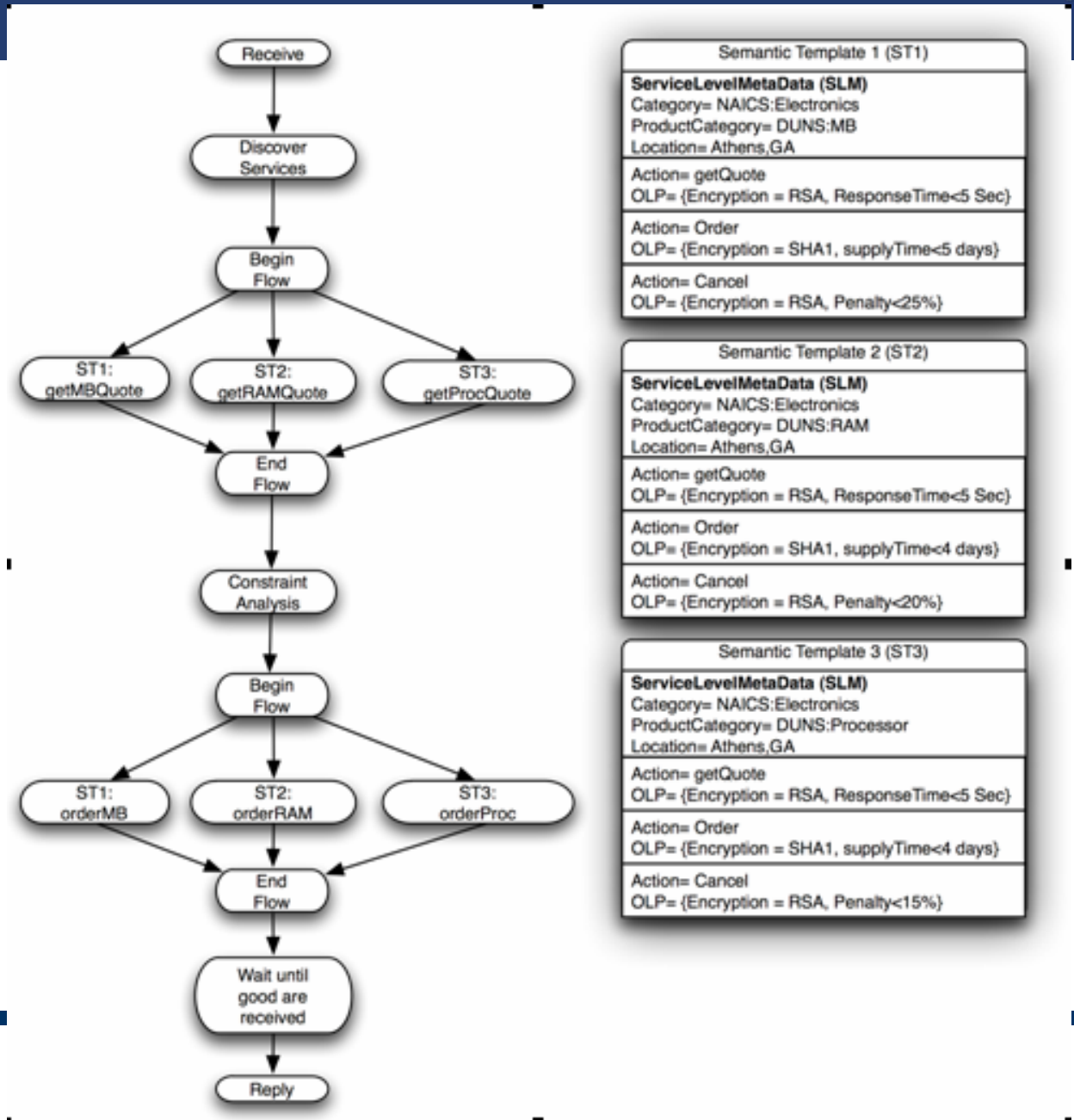
Conceptual Approach

1. **Create framework to capture represent domain knowledge**
2. **Represent constraints on the domain knowledge**
3. **Ability to reason on the constraints and configure the process**

Dynamic Binding: Guiding principles

- Semantic templates to capture the requirements for each partner.
- Partners are selected during the run time of the process and the process is configured
  - Semantically Enhanced UDDI Registries for discovery of partners.
  - Approaches to match enhanced policies (Sem-Pol) and agreements (SWAPS)
- Execution environment supporting discovery, configuration and invocation.

Example of a process with semantic templates



Semantic Biological Web Services Registry

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        - Category Domain
      - SAWSDL Framework
        - Operation
        - Input Message
        - Output Message
  - Publish

Web services discovery using task name

This allows the user to search for Web services with given 'Task Name'.This requires a exact match between the user defined term and task concept of the service

Task Name: RAW to mzXML

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Name	WSDL Location	Business Entity
SysJavaRawmzXMLService	http://192.168.168.100:8080/axis/PWF/SysCommv0.21/SysJavaRawmzXML.jws	glycomics

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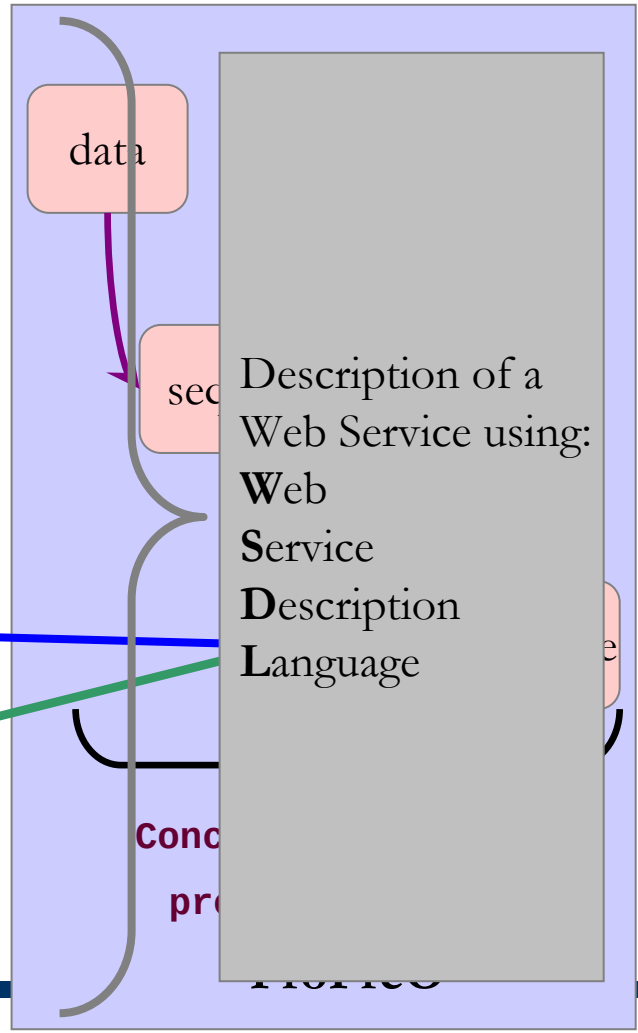
Semantic Web Services

- Formalize description and classification of Web Services using ProPreO concepts

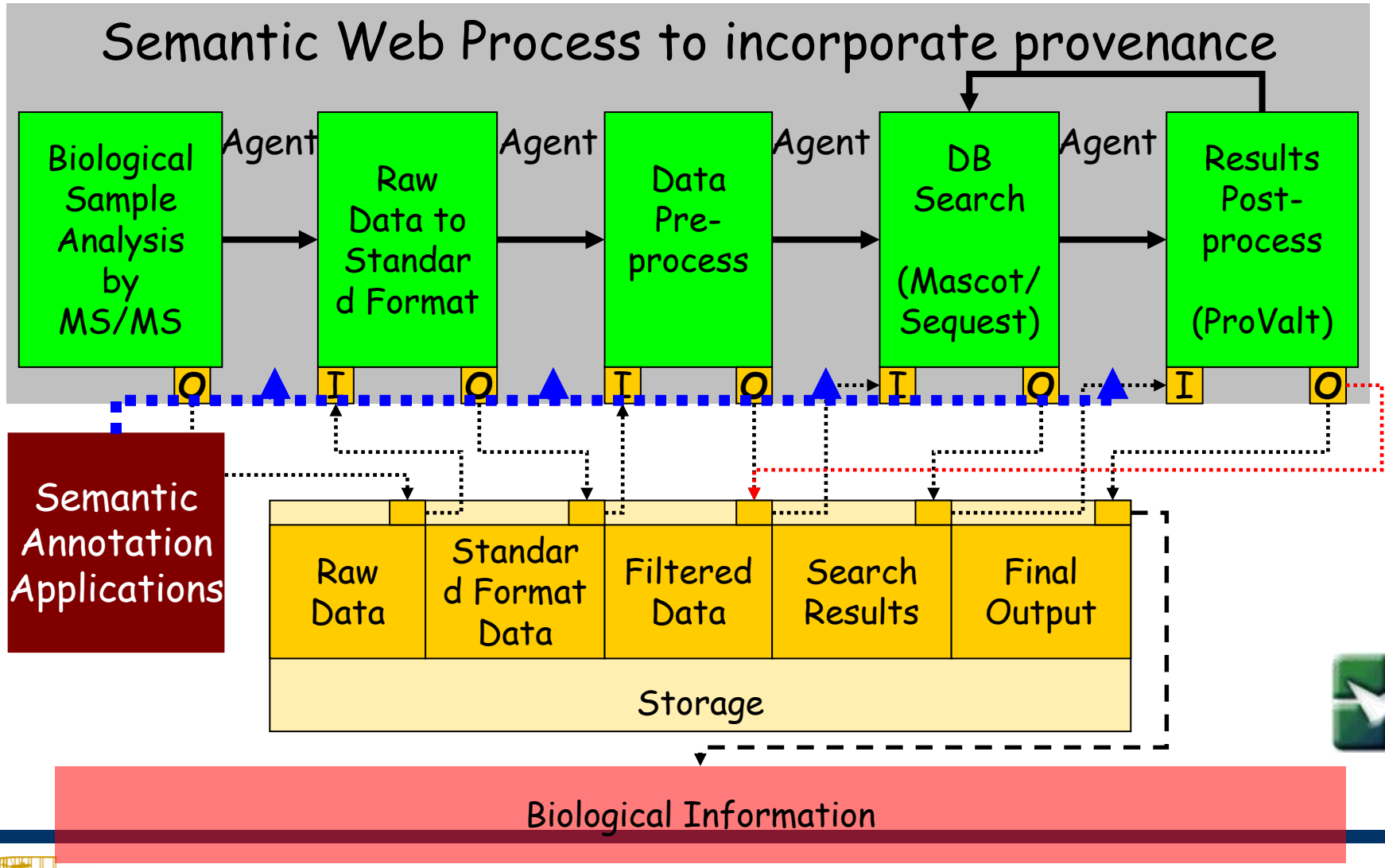
```
<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions targetNamespace="urn:ngp"
……
xmlns:
wssem="http://www.ibm.com/xmlns/WebServices/WSSemantics"
 xmlns:
ProPreO="http://lsdis.cs.uga.edu/ontologies/ProPreO.owl" >

<wsdl:types>
  <schema targetNamespace="urn:ngp"
    xmlns="http://www.w3.org/2001/XMLSchema">
……
</complexType>
  </schema>
 </wsdl:types>
   <wsdl:message name="replaceCharacterRequest"
wssem:modelReference="ProPreO#peptide_sequence">
      <wsdl:part name="in0" type="soapenc:string"/>
      <wsdl:part name="in1" type="soapenc:string"/>
      <wsdl:part name="in2" type="soapenc:string"/>
   </wsdl:message>
```



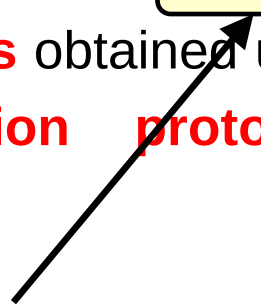
WSDL ModifyDB process Ontology

ISiS – Integrated Semantic Information and Knowledge System



Semantic Annotation Facilitates Complex Queries

- *Evaluate the specific effects of changing a biological parameter:* Retrieve **abundance** data for a given **protein** expressed by three different **cell types** of a specific **organism**.
- *Retrieve raw data supporting a structural assignment:* Find all the **raw ms data files** that contain the **spectrum** of a given **peptide sequence** having a specific **modification** and **charge state**.
- *Detect errors:* Find and compare all **peptide** lists identified in **Mascot output files** obtained using a similar **organism**, **cell-type**, **sample preparation protocol**, and **mass spectrometry** conditions.



A Web Service
Must Be Invoked

ProPreO concepts highlighted in red

Some Relevant Papers

- Kunal Verma, Amit P. Sheth, Semantically Annotating a Web Service, IEEE Internet Computing, March/April 2007, Volume 11(2), pp. 83-85.
- Meenakshi Nagarajan, Kunal Verma, Amit P. Sheth, John A. Miller, Jonathan Lathem. "Semantic Interoperability of Web Services - Challenges and Experiences", IEEE International Conference on Web Services (ICWS 2006).
- N. Oldham et al., "Semantic WS-Agreement Partner Selection," *Proc. 15th Int'l World Wide Web Conf. (WWW 06)*, ACM Press, 2006, pp. 697–706
- K. Verma, *Configuration and Adaptation of Semantic Web Processes*, PhD thesis, Dept. of Computer Science, Univ. of Georgia, Aug. 2006
- K. Verma, K. Sivashanmugam, A. Sheth, A. Patil, S. Oundhakar and John Miller, METEOR-S WSDI: A Scalable Infrastructure of Registries for Semantic Publication and Discovery of Web Services, JITM, Jan 2005
- Karthik Gomadam, Kunal Verma, Amit P. Sheth, John A. Miller: Demonstrating Dynamic Configuration and Execution of Web Processes. ICSOC 2005: 502-507
- K. Sivashanmugam, Kunal Verma, Amit Sheth, John A. Miller, Adding Semantic to Web Service Standards, ICWS 2003

Stargate Portal: SemBowser and example SAWSDL service:
http://glycomics.ccrc.uga.edu/stargate/index.jsp