Semantic Web Services and Semantic Service-Oriented Architectures

15th International Command & Control Research & Technology Symposium - 22 Jun 2010

Albert Frantz, Randall McIntyre
Computer Engineer, Scientist
Enterprise Information Management Branch
Air Force Research Laboratory

Overview

- Background
- Introduction to Web services
- Adding semantics to Web services
  - SAWSDL: Semantic Annotations for WSDL (Web Services Description Language) and XML (Extensible Markup Language) Schema
  - OWL-S: Semantic Markup for Web Services
  - WSMO: Web Service Modeling Ontology
- Conclusions

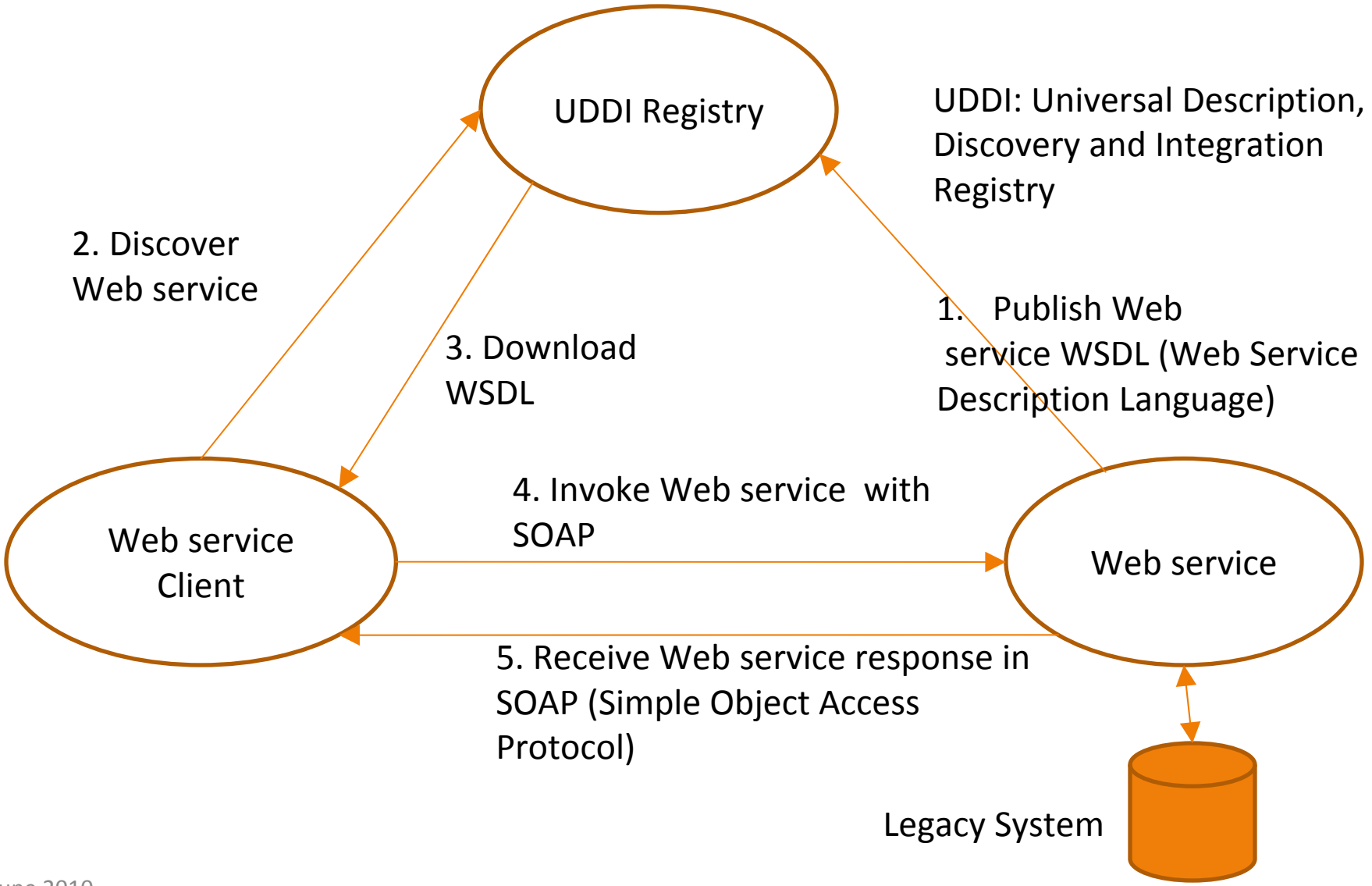
Background: Net-Centric Services

- **DoD Joint Vision 2020: Achieve Full Spectrum Dominance - key enabler Information Superiority**
  - **Full Spectrum Dominance: dominant maneuver, precision engagement, focused logistics, and full dimensional protection.**
  - **Information Superiority: The operational advantage derived from the ability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.**
- **Net-Centric Services Strategy**
  - **military is moving toward a net-centric Service Oriented Architecture (SOA) based on Web services to achieve information superiority.**
  - **SOA: a paradigm for defining, organizing, and utilizing distributed capabilities in the form of loosely coupled software Web services**

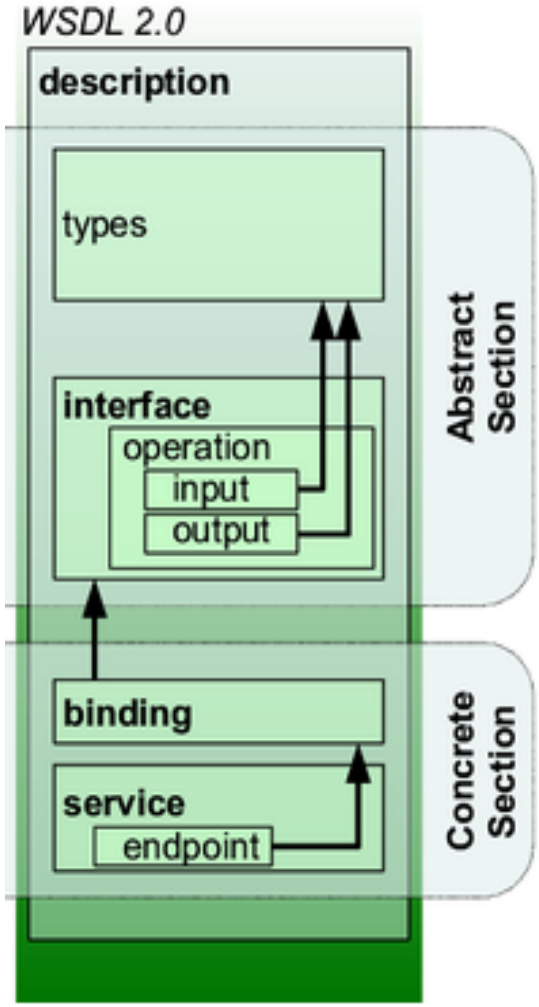
Introduction to Web Services

- **Web services - software applications that can be discovered, described, and accessed. They are based on XML (Extensible Markup Language) and standard Web protocols.**
- **Web services have distinct advantages:**
  - **Promote interoperability based on open XML standards and are machine, programming language and operating system independent**
  - **Communicate with SOAP (Simple Object Access Protocol) text messages over HTTP (Hypertext Transfer Protocol)**
  - **Promote reusability and can be combined (composed) to create more complex services**
  - **Can be interfaced to legacy information systems**

Common Web Service Scenario



Web Services Description Language

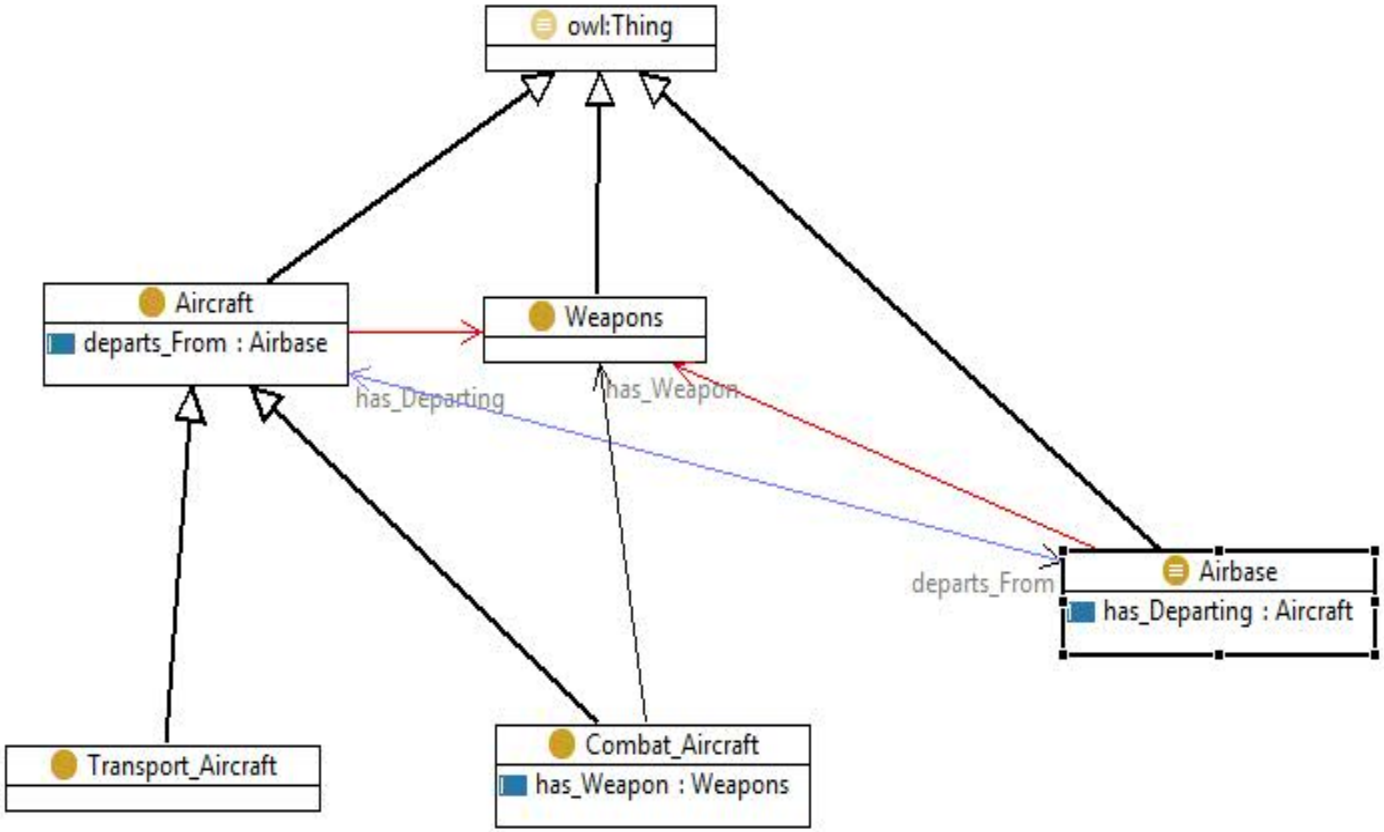


- *types* element describes the kinds of messages that the service will send and receive in XML Schema.
- *interface* element describes what abstract functionality the Web service provides, including the operations and types of messages the service can send and receive as part of that operation.
- *binding* element describes how to access the service, including the message format and transmission protocol details.
- *service* element describes where to access the service

Adding Semantics to Web Services

- The Semantic Web is an evolving development of the World Wide Web in which the meaning (semantics) of information and services on the web is defined, making it possible for the web to understand and satisfy the requests of people and machines to use the web content. Based on Web Ontology Language (OWL), Resource Description Framework (RDF) and RDF Schema (RDFS) – all based on XML.
- Semantics will make discovering, invoking, monitoring and composing Web services easier.
- An ontology provides a shared vocabulary, which can be used to model a domain – that is, the types of objects and/or concepts that exist, and their properties and relationships.
- Air Force Communities of Interest (COIs) are writing ontologies to establish standard vocabularies for information sharing within the domain of their community. These ontologies provide an excellent source of semantics for Web services.

A Simple Ontology



Ontologies can be read by humans and computers.

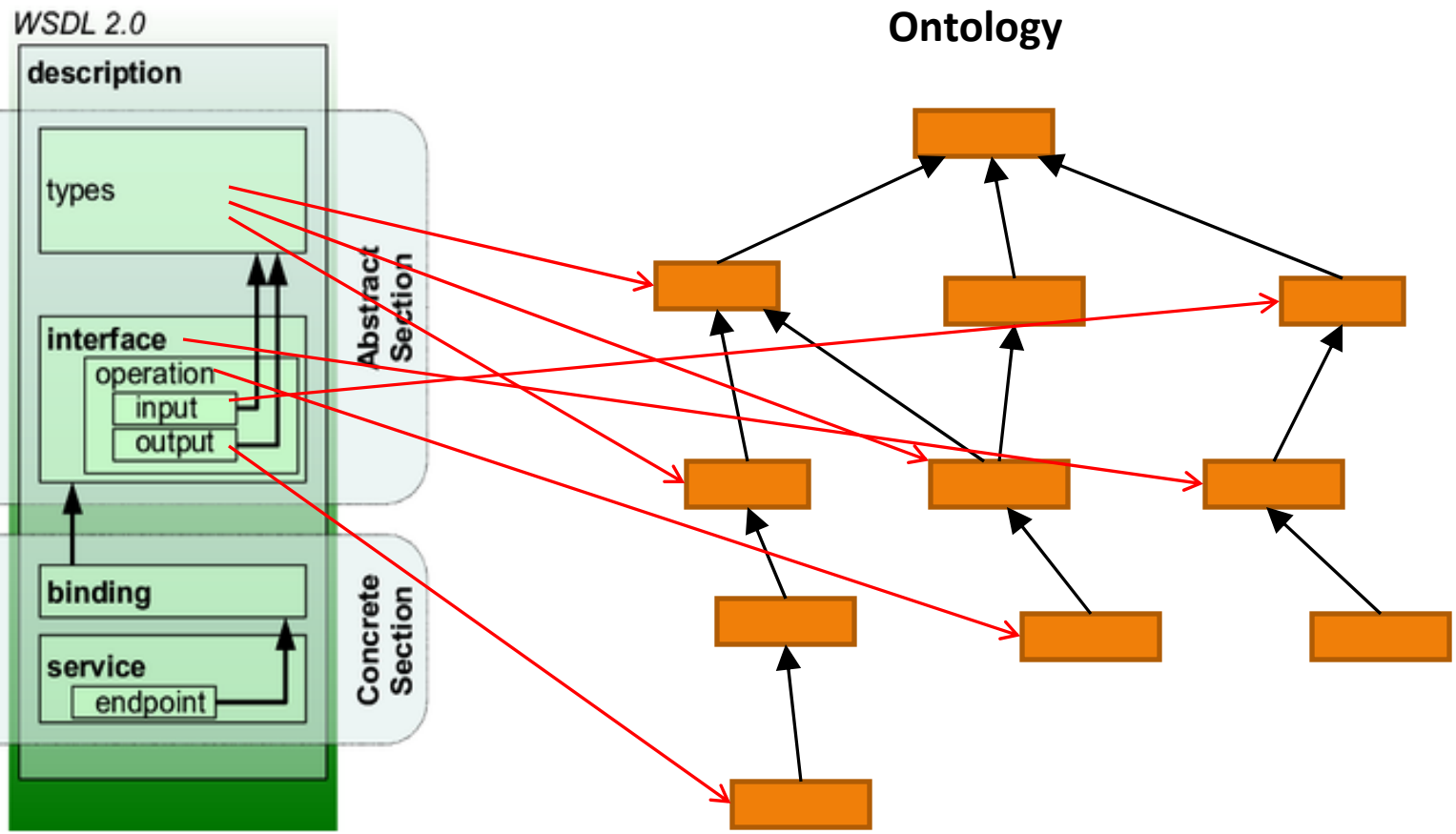
Three Main Proposed Approaches for Semantic Web Services

- **SAWSDL: Semantic Annotations for WSDL (Web Services Description Language) and XML (Extensible Markup Language) Schema**
  - **A World Wide Web Consortium (W3C) Recommendation (standard)**
- **OWL-S: Semantic Markup for Web Services**
- **WSMO: Web Service Modeling Ontology**

Advantages of SAWSDL Semantic Web Services

- **Semantic annotations will make classifying, discovering, matching, monitoring, composing and invoking Web services easier, sometimes automatic.**
- **Easier Discovery: finding ontology names of Web services with SAWSDL annotations can be done by software agents.**
- **Easier to Invoke: Have computer understandable annotations to get correct operations and inputs to invoke Web service**
- **Easier to Compose: match some outputs of one Web service to the inputs of another Web service.**
- **SAWSDL provides a mechanism called *modelReference* to annotate the WSDL with semantic information.**

How SAWSDL Works



sawsdl:modelReference – XML Annotations pointing to ontology

WSDL Example

```
:description
tNamespace="http://org1.example.com/wsdl/CheckAvailabilityRequestService/"
s="http://org1.example.com/wsdl/CheckAvailabilityRequestService/"
s:wsdl="http://www.w3.org/ns/wsdl"
s:xsd="http://www.w3.org/2001/XMLSchema">

l:types>
:schema targetNamespace="http://org1.example.com/wsdl/CheckAvailabilityRequestService">
l:element name="CheckAvailabilityRequestServiceRequest">
sd:complexType>
xsd:sequence>
<xsd:element name="itemCode" type="xsd:string"/>
<xsd:element name="date" type="xsd:string"/>
<xsd:element name="qty" type="xsd:float"/>
/xsd:sequence>
xsd:complexType>
sd:element>
l:element name="CheckAvailabilityRequestServiceResponse" type="itemConfirmation"/>
l:simpleType name="itemConfirmation">
sd:restriction base="xsd:boolean"/>
sd:simpleType>
sd:schema>
dl:types>

l:interface name="CheckAvailabilityRequestService">
dl:operation name="CheckAvailabilityRequestOperation" pattern="http://www.w3.org/ns/wsdl/in-out">
sdl:input element="CheckAvailabilityRequestServiceRequest"/>
sdl:output element="CheckAvailabilityRequestServiceResponse"/>
sdl:operation>
dl:interface>
l:description>
```

SAWSDL Example

```
:interface name="CheckItemAvailabilityRequestService"
sawsdl:modelReference="http://www.w3.org/2002/ws/sawsdl/
   spec/examples/taxonomy/
   POServiceClassification#ItemAvailabilityCheck">

l:interface>
```

WSDL annotation added to the CheckAvailabilityRequestService

SAWSDL Schema Mapping

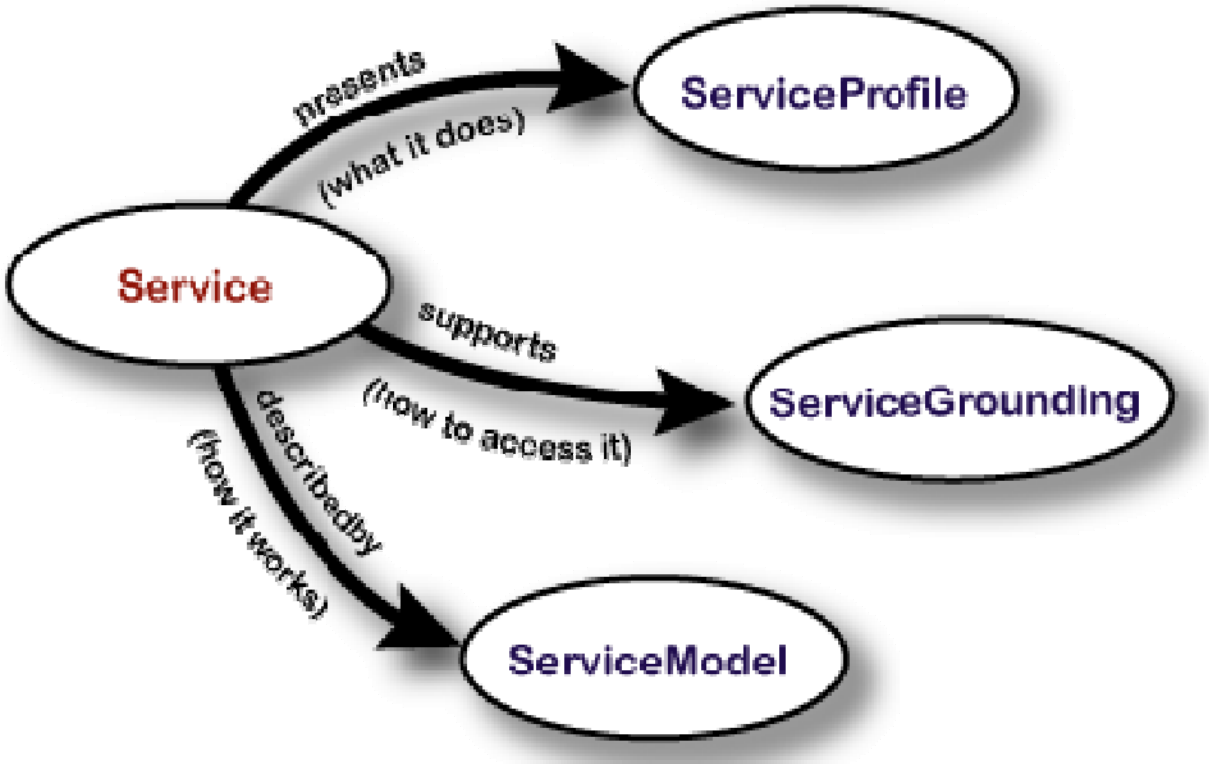
Provides a mechanism to facilitate data transformations for Web services.

***liftingSchemaMapping* - takes as input XML data (that adheres to a given XML Schema) and produces semantic data that adheres to a semantic model - usually uses Extensible Style Language Transformations (XSLT)**

***loweringSchemaMapping* - performs the opposite; mapping semantic data to XML data – often uses the SPARQL Query Language for RDF (SPARQL)**

Semantic Markup for Web Services
OWL-S

OWL-S: Semantic Markup for Web Services in the Universal Description Discovery and Integration (UDDI) registry



Web Service Modeling Ontology - WSMO

WSMO: Web Service Modeling Ontology - part of the Triple Space technology.

WSMO is a total approach to Semantic Service-Oriented Architecture consists of the WSMO ontology, Web Service Modeling Language (WSML) and the Web Services Execution Environment (WSMX)

WSMO is an entire vision to achieve semantic Service-Oriented Architectures.

Parts of WSMO are continuing primarily in Europe.

Conclusions

- As the DoD moves toward a net-centric service oriented architecture, there will likely be tens of thousands of Web services.
- Semantic Web services are still evolving, but any semantics that can be added to Web services will be a significant addition to automating Web service discovery, invocation, composition and monitoring.
- With the acceptance of SAWSDL as a W3C recommendation, it offers an excellent starting point for adding semantics to Web services until more complex semantic Web technologies evolve.

Questions?