Semantic Web Technologies

Semantic Web Services: Approaches

Jos de Bruijn
jos.debruijn@deri.org

Digital Enterprise Research Institute (DERI)
University of Innsbruck, Austria

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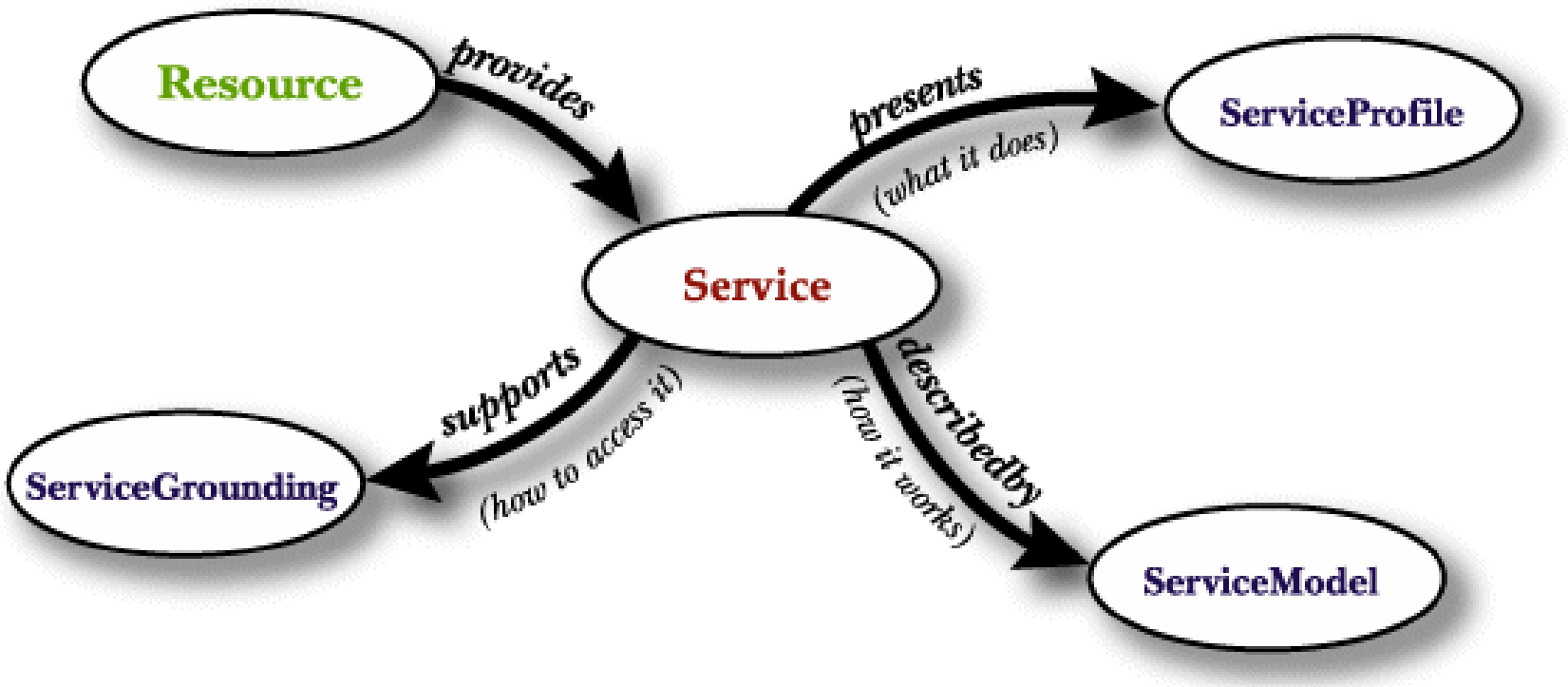
Outline

OWL-S: OWL-Services

- OWL Ontology for modeling Services
- Functionality of the service
- Non-functional properties
- Implementation (process) of the service
- Grounding: how to invoke service
  - Connection with WSDL

OWL-S Upper Ontology of Services

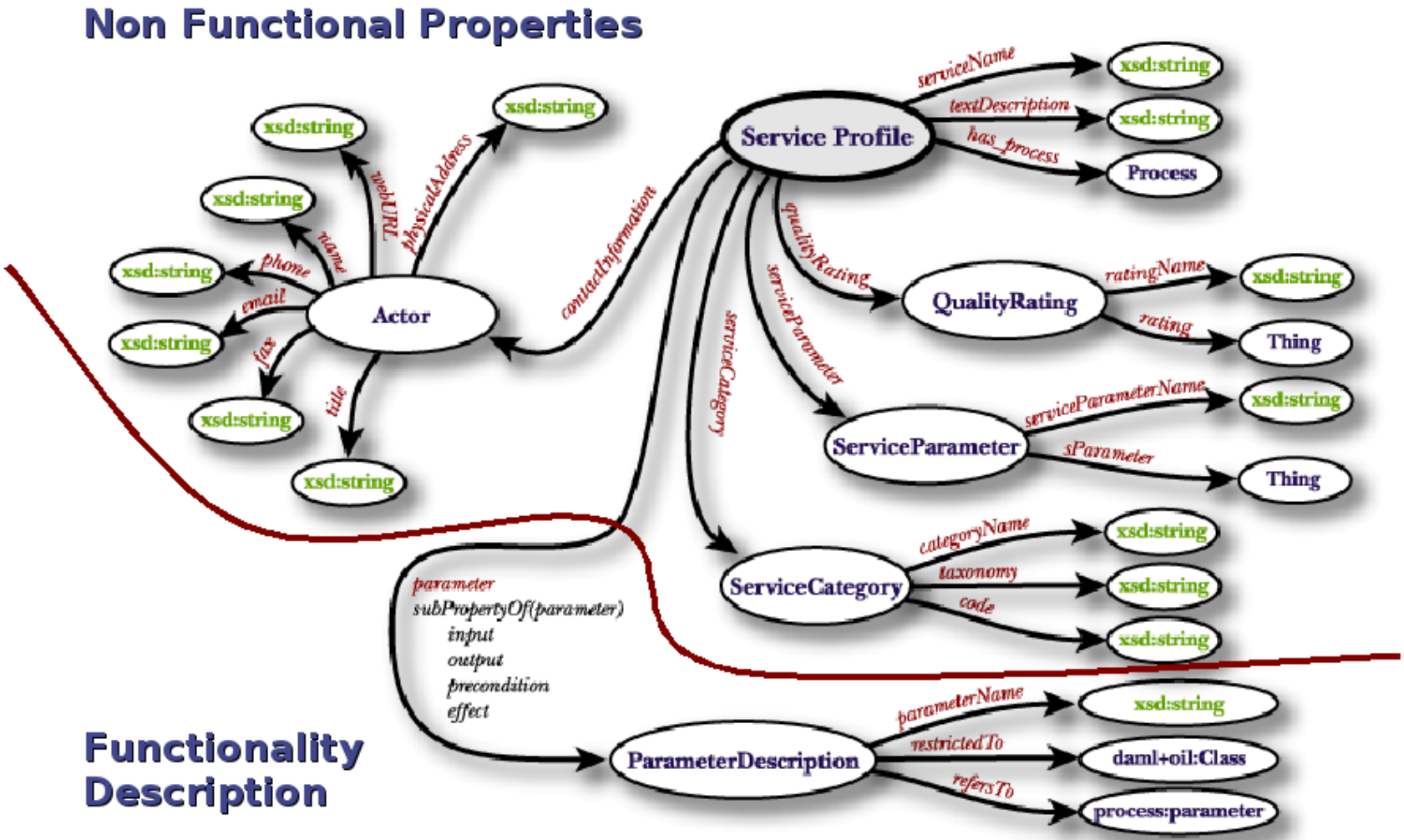


Based on slides by David Martin

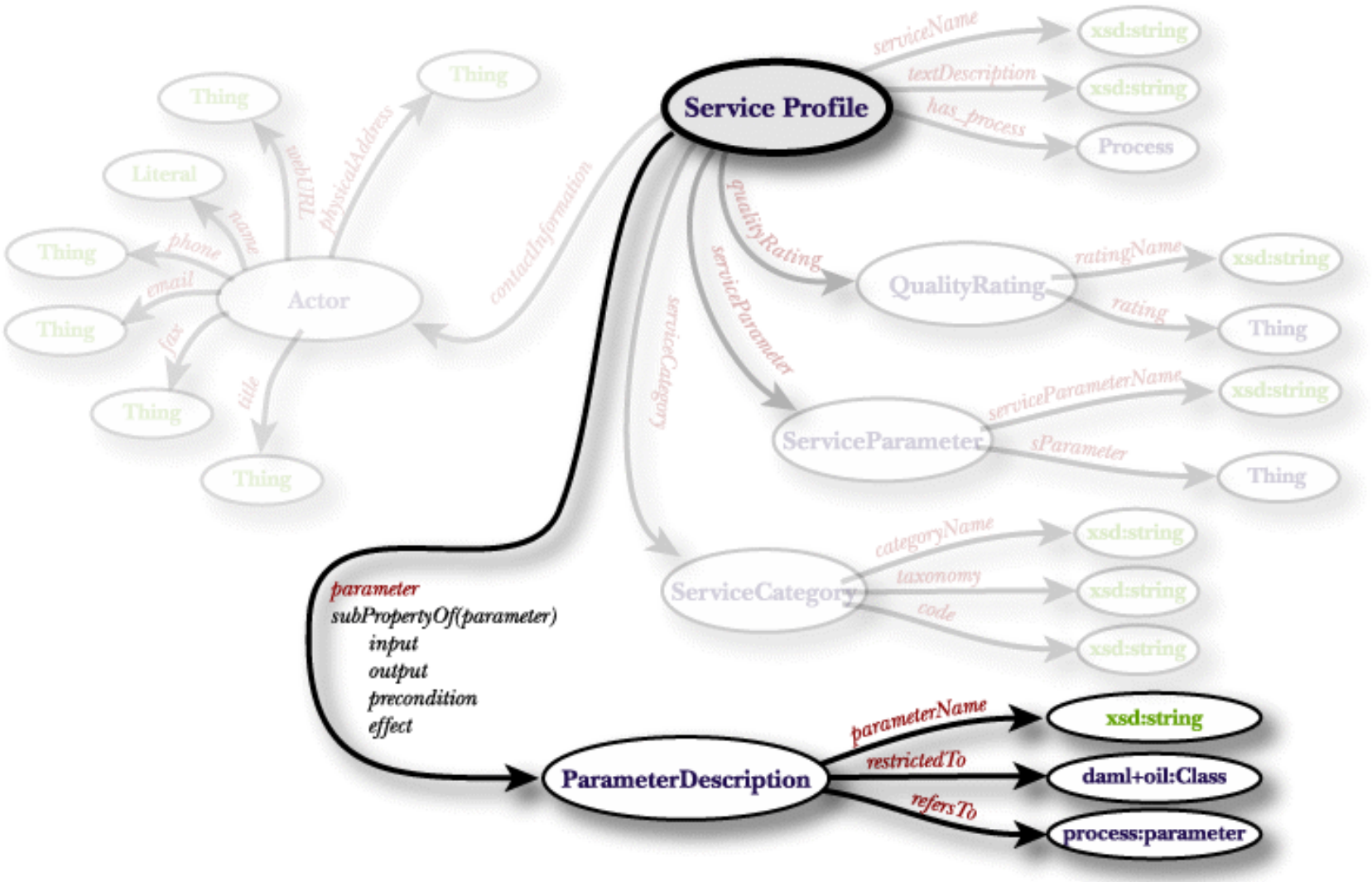
OWL-S Service Profile

- High-level description of service
  - Functional Description
  - Non-functional Description
- Used for
  - Advertising
  - Discovery
  - Selection

Service Profile



Functional Description



Functional Description

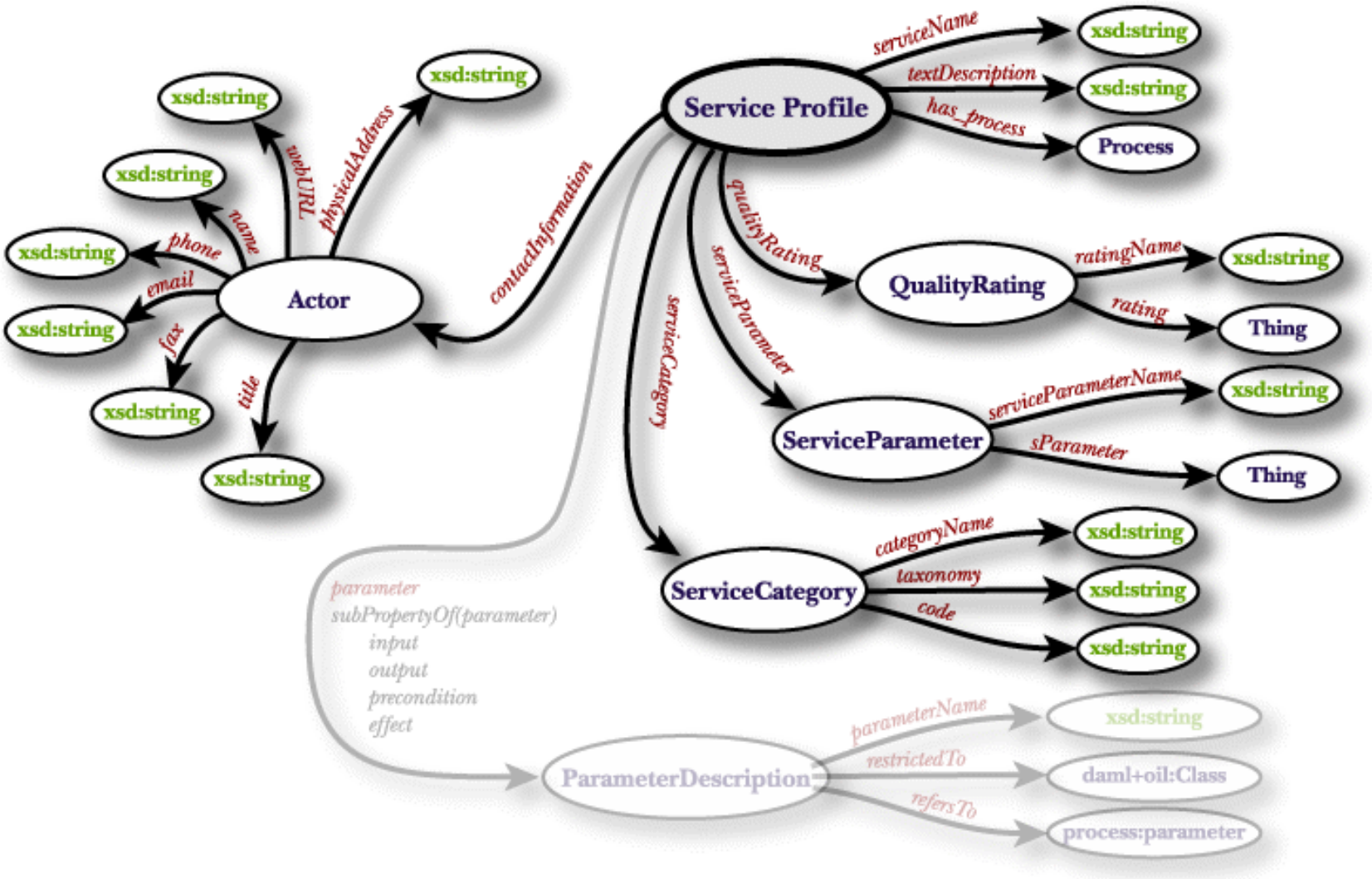
- What the service **provides**
- in terms of **IOPEs**

- Inputs
  - Typed input "variables"
  - Typing using OWL classes
- Outputs
  - Typed output "variables"
  - Typing using OWL classes
- Preconditions
  - Conditions over the input
  - Choice between different FOL-based formalisms
- Effects
  - Also **postconditions**
  - Conditions over the output
  - Effects of the service
  - Choice between different FOL-based formalisms

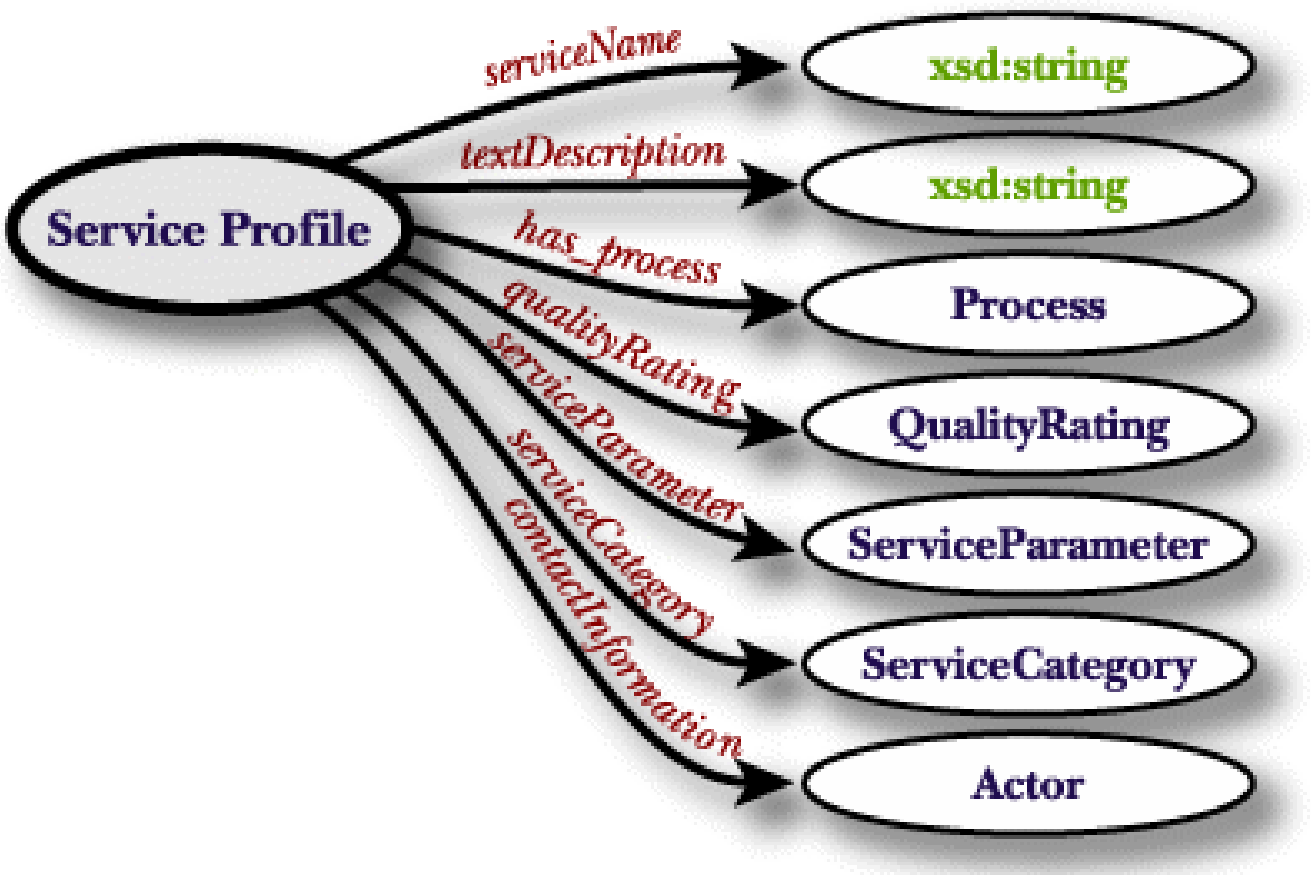
Functional Description (cont'd)

- DL-based Discovery
  - Matching inputs, outputs
  - DL-based reasoning
- Using preconditions, effects
  - Precondition, effect are closed formulas
  - Impossible to quantify over both
    - $\forall x(\mathit{precondition}(x) \Rightarrow \mathit{effect}(x)$
  - Not possible to relate input and output
  - Consider simple case of addition: $x + y = z$, with x, y inputs, z output

Non-Functional Description



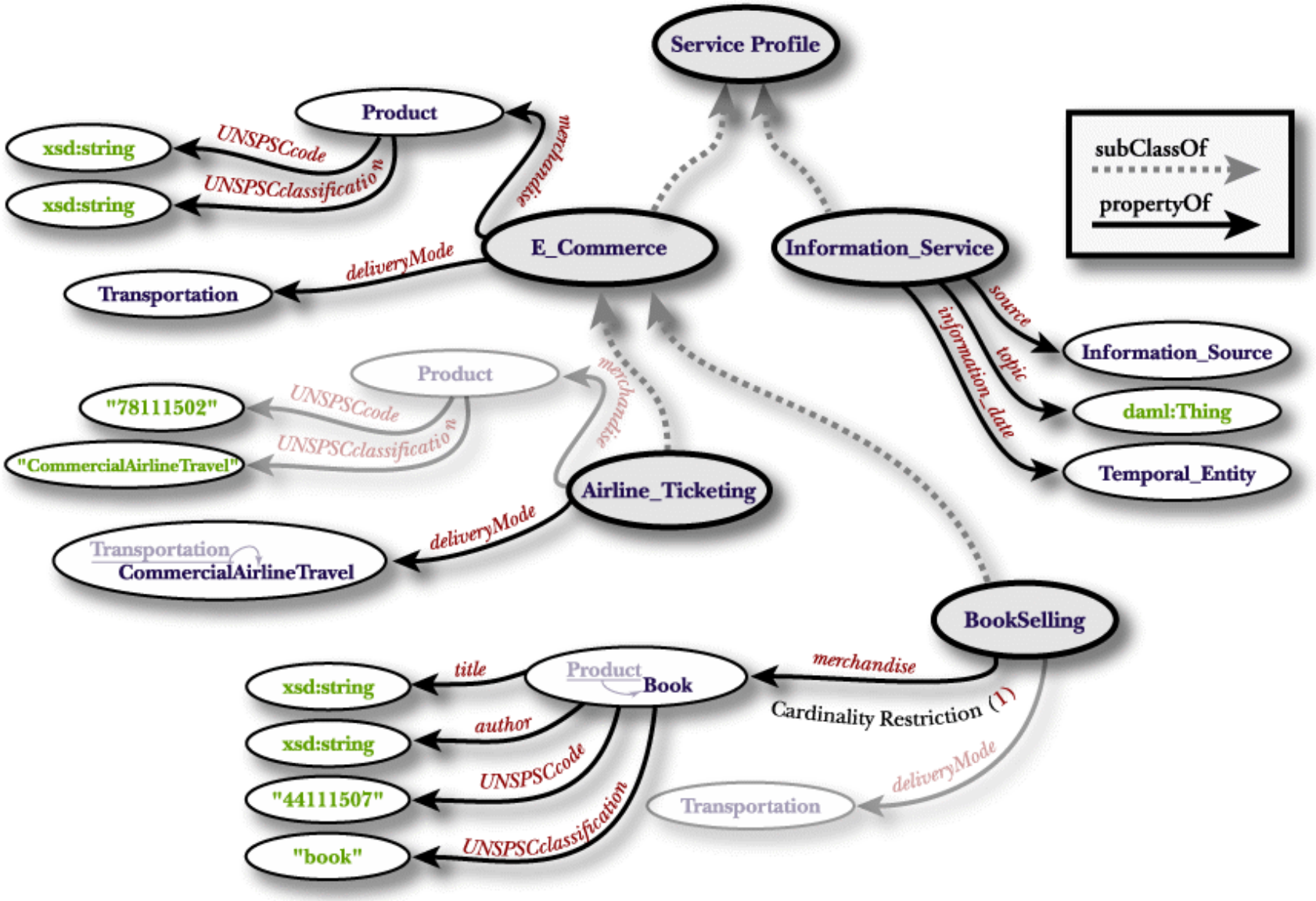
Non-Functional Description (cont'd)



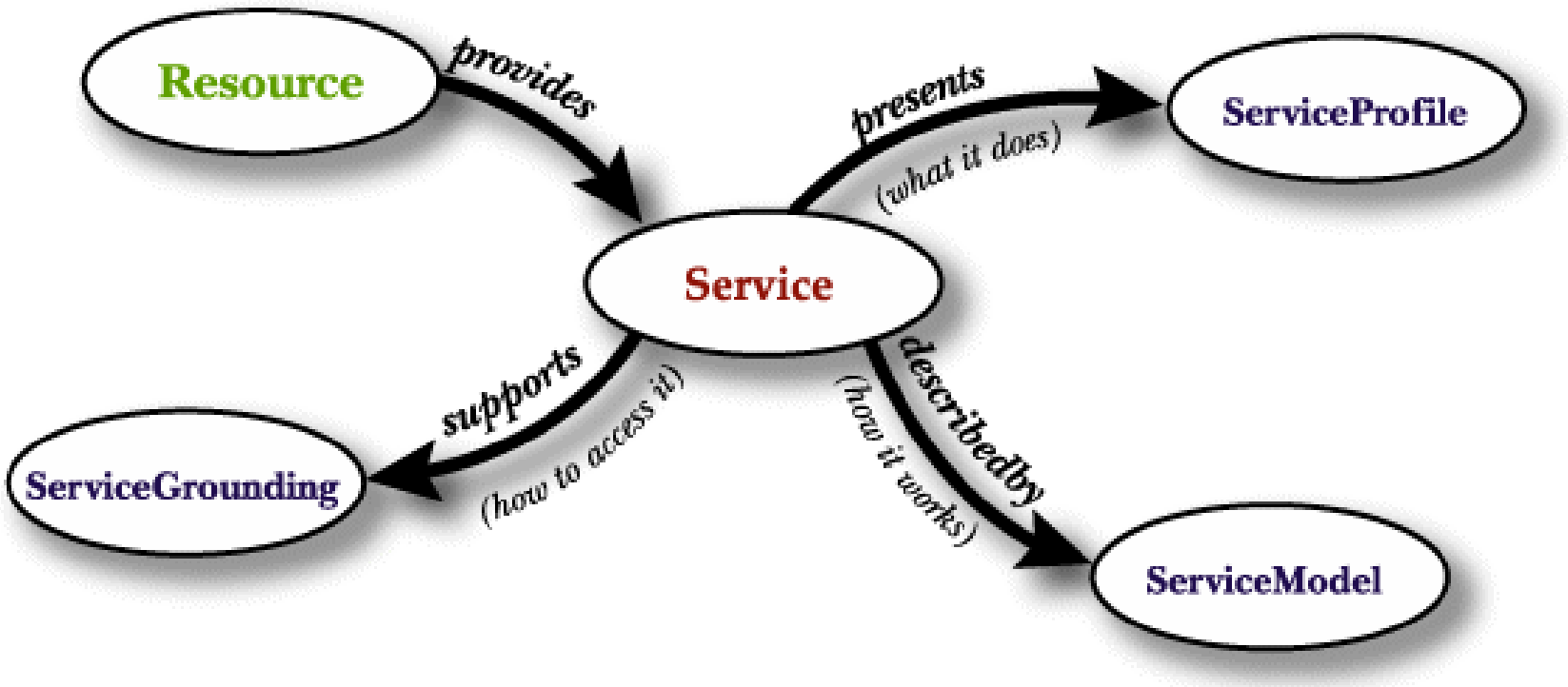
Usage of Profiles

- Class-hierarchical yellow pages
  - Implicit capability characterization
  - Arrangement of attributes on class hierarchy
  - Can use multiple inheritance
  - Relies primarily on non-functional properties
- "Summary" of Functionality of service
  - IOPE
  - Advertising
  - Discovery

Profile Hierarchy



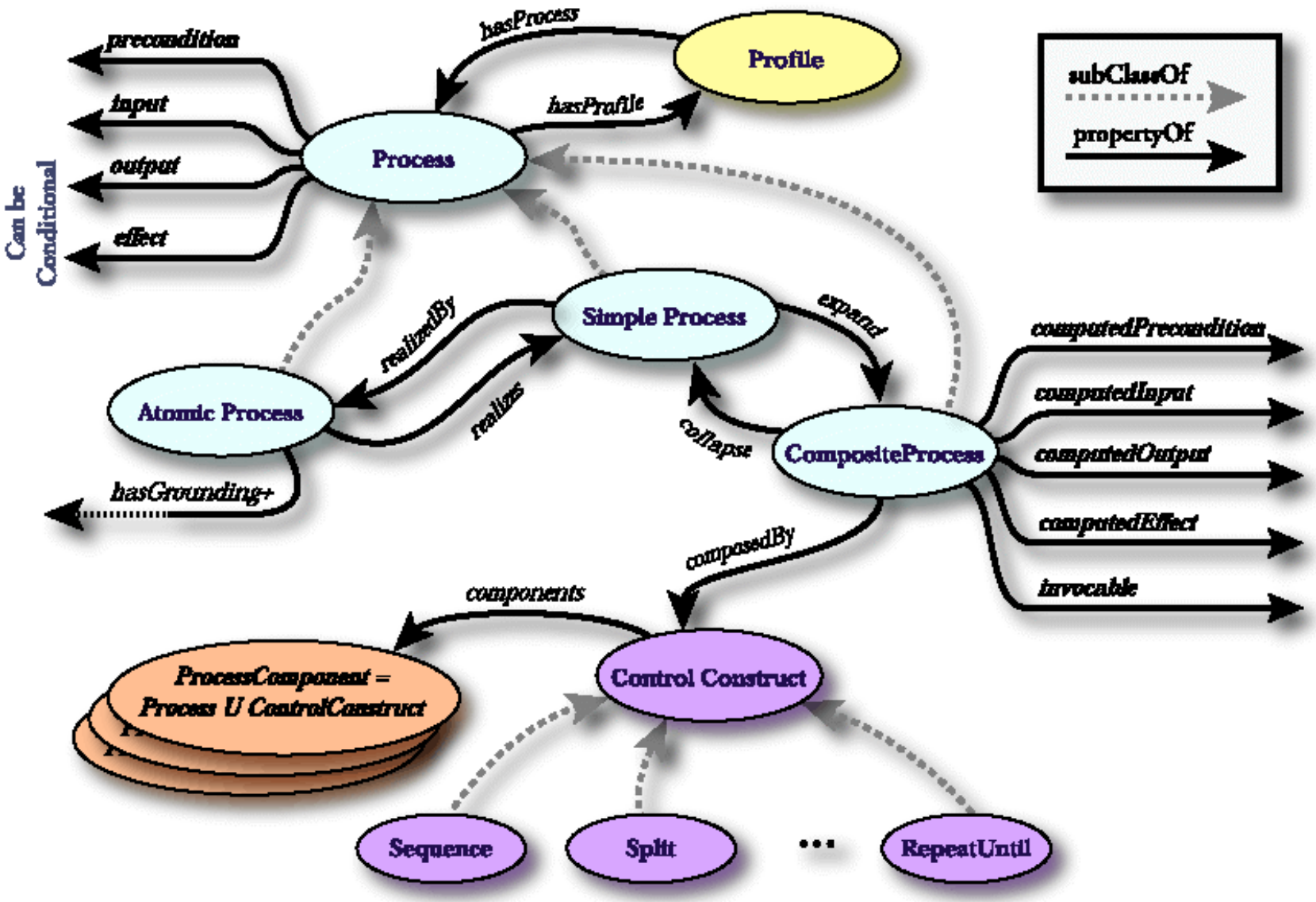
OWL-S Upper Ontology of Services



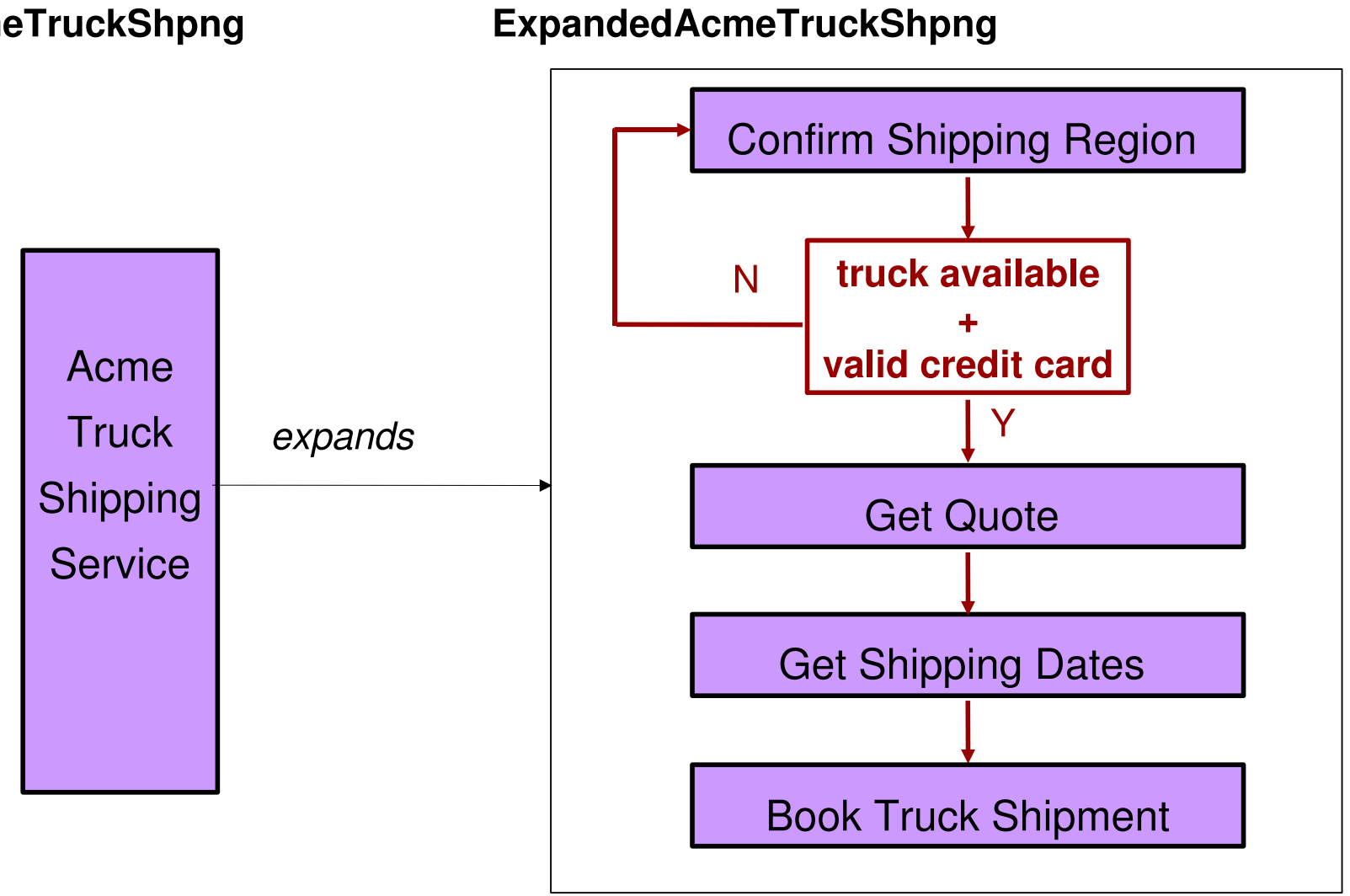
Service/Process Model

- Process
  - Description of service provider's behavior
  - Tells service user how and when to interact (read/write messages)
- & Process control
  - Ontology of process state; supports status queries
  - (stub at present)
  - Monitoring
- Used for:
  - Service **invocation, planning/composition, interoperation, monitoring**
- All processes have
  - Inputs, outputs, preconditions and effects
- Composite processes
  - Control flow
  - Data flow

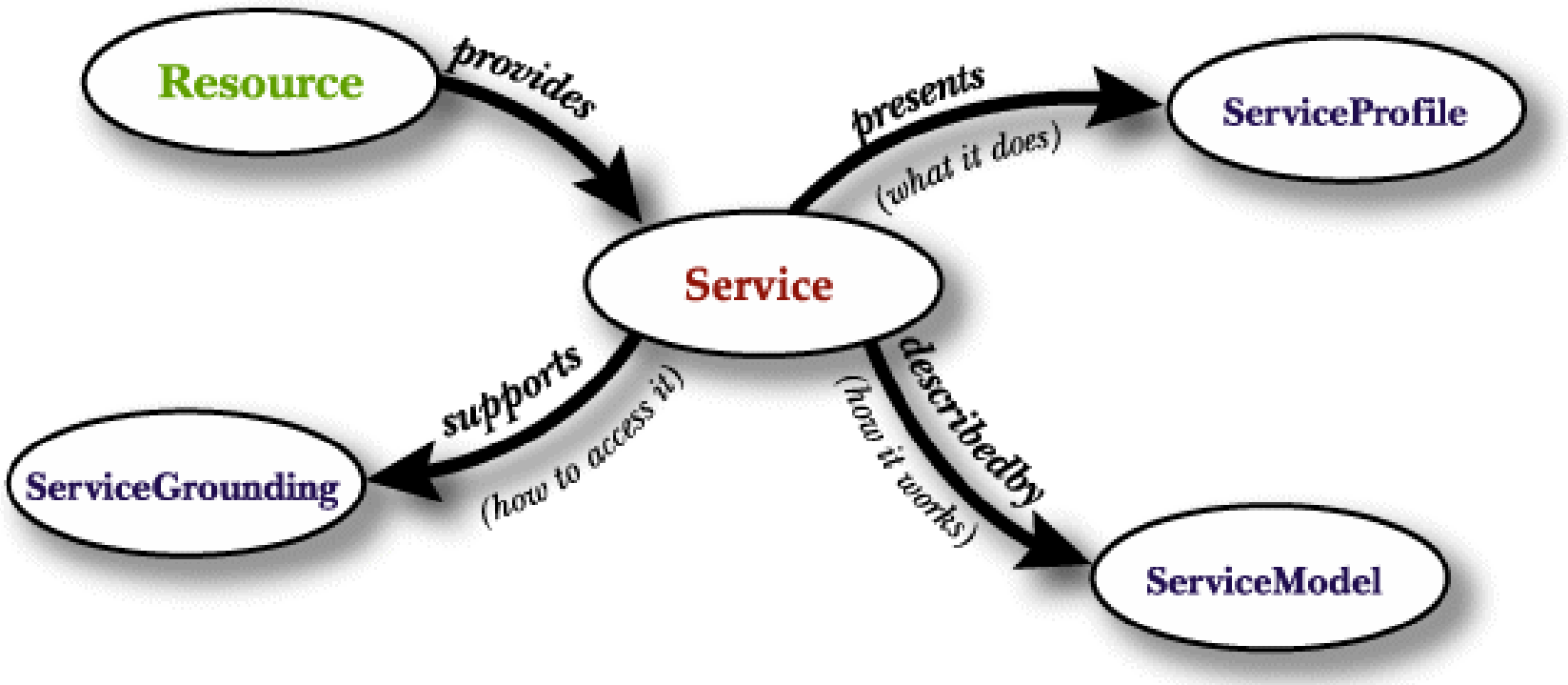
Process Model



Process Example



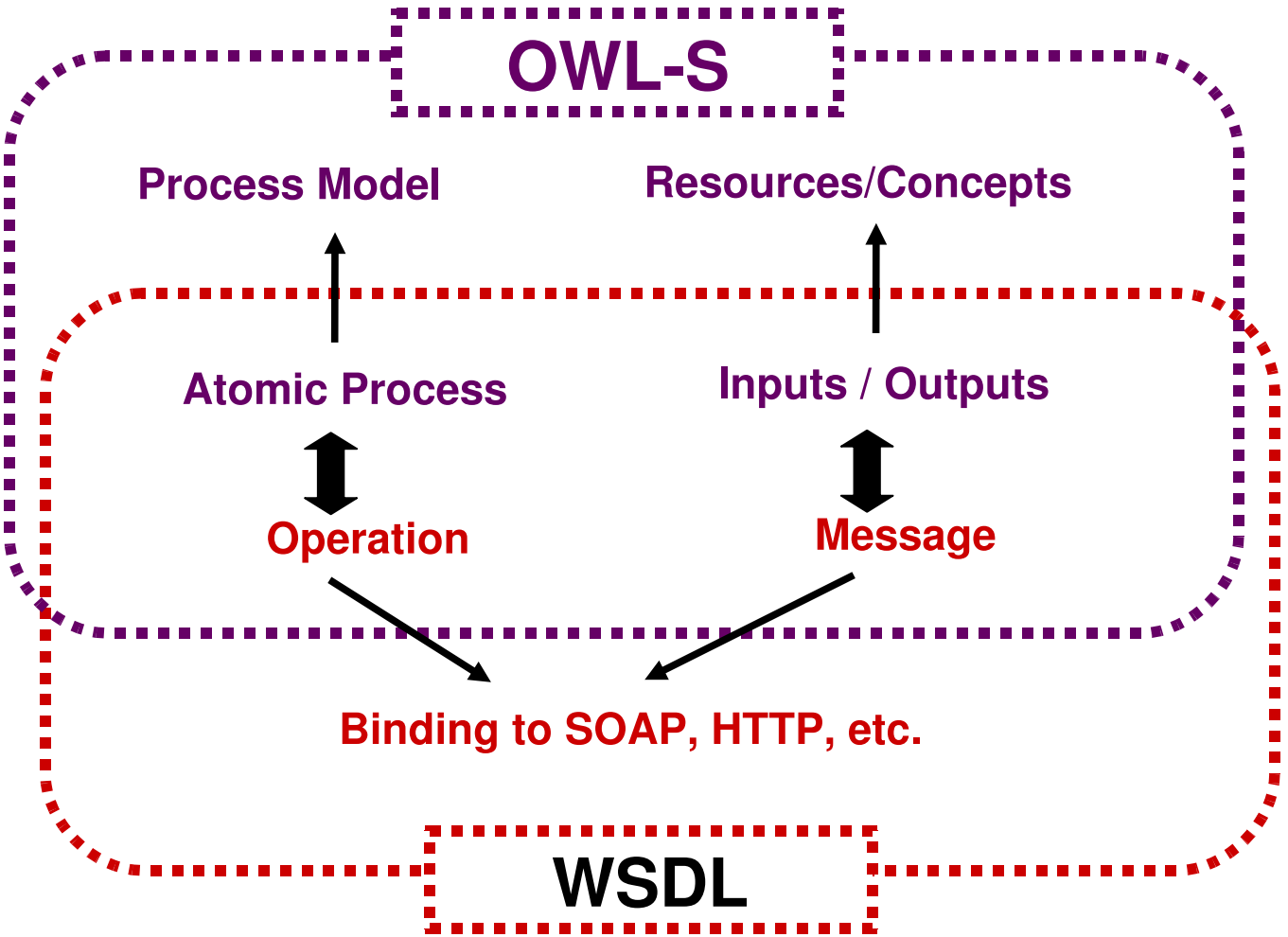
OWL-S Upper Ontology of Services



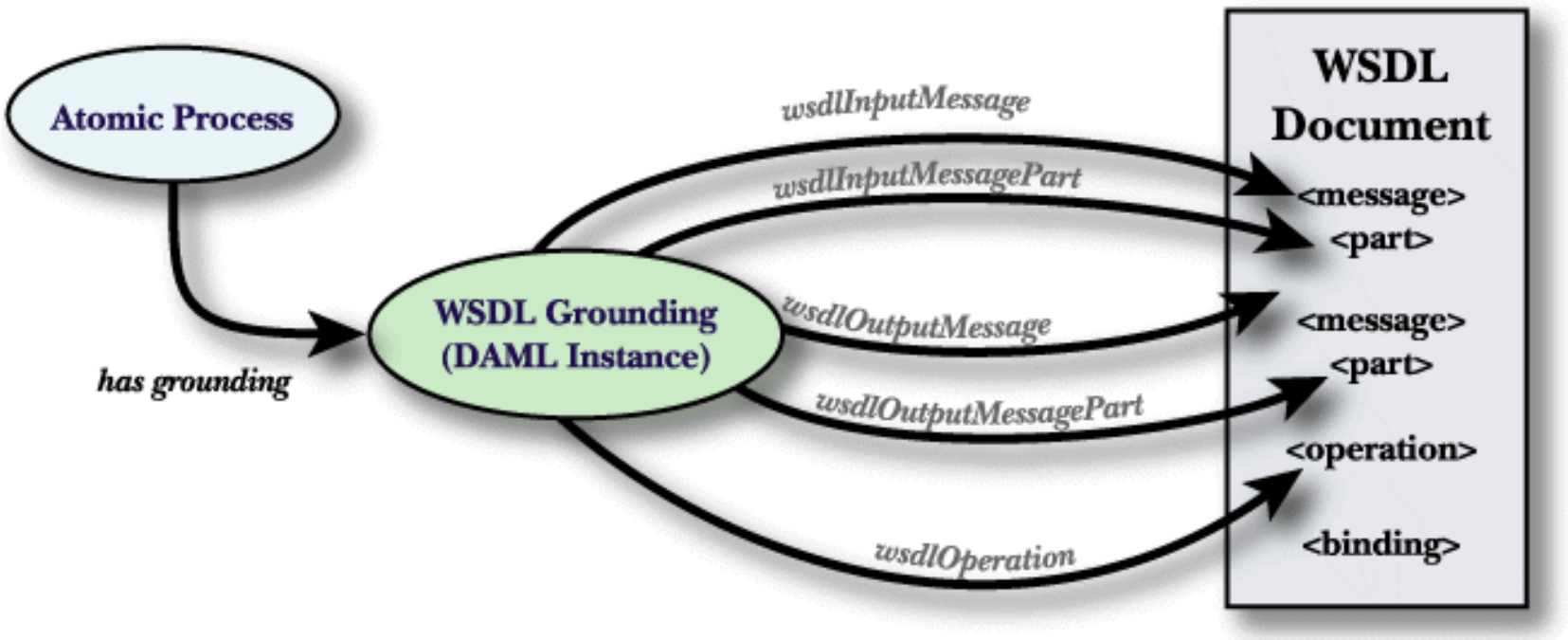
OWL-S Grounding

- Implementation-specific
  - Message format
  - Transport mechanisms
  - Protocols
  - Serializations of types (OWL Classes)
- Service Model describes interaction
- Grounding describes how to interact
- Grounding builds upon WSDL

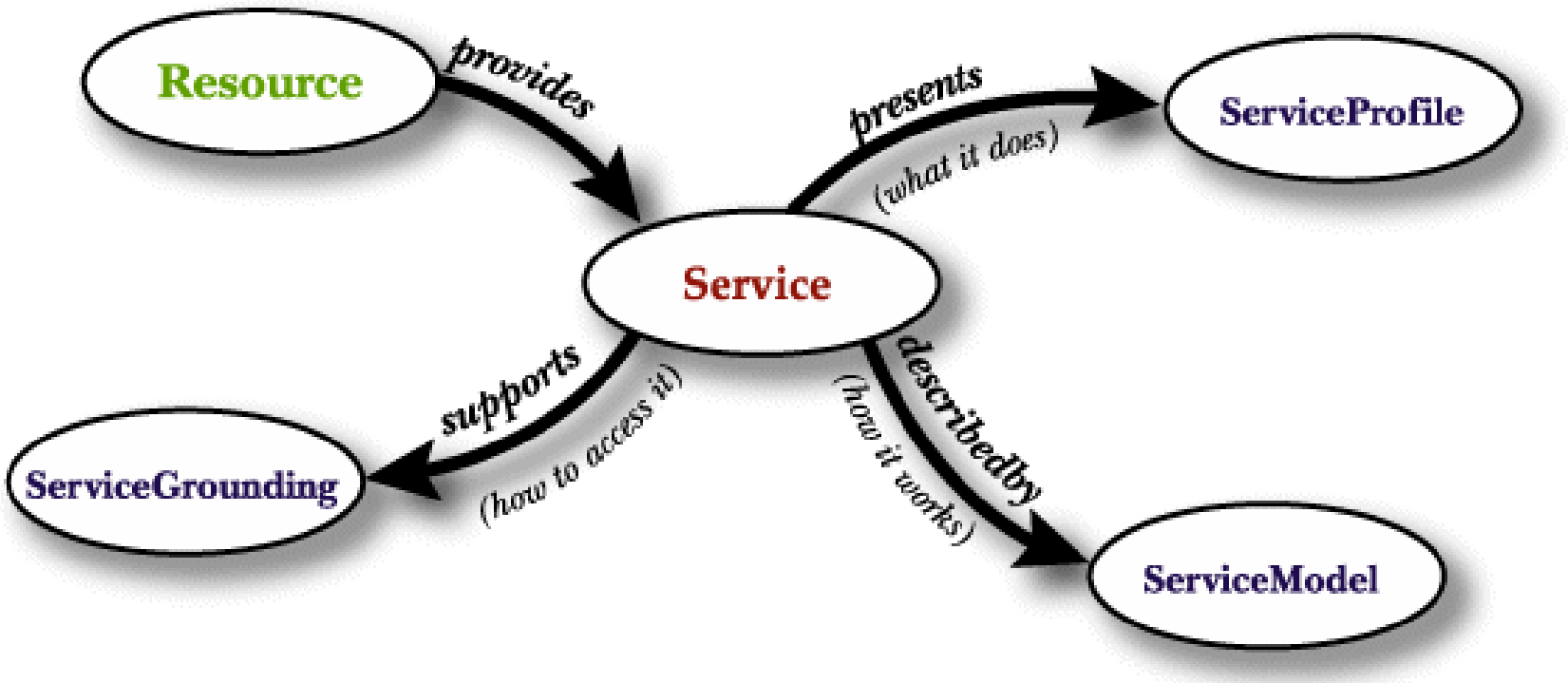
OWL-S/WSDL Grounding



OWL-S/WSDL Grounding (cont'd)



Review: OWL-S Upper Ontology of Services

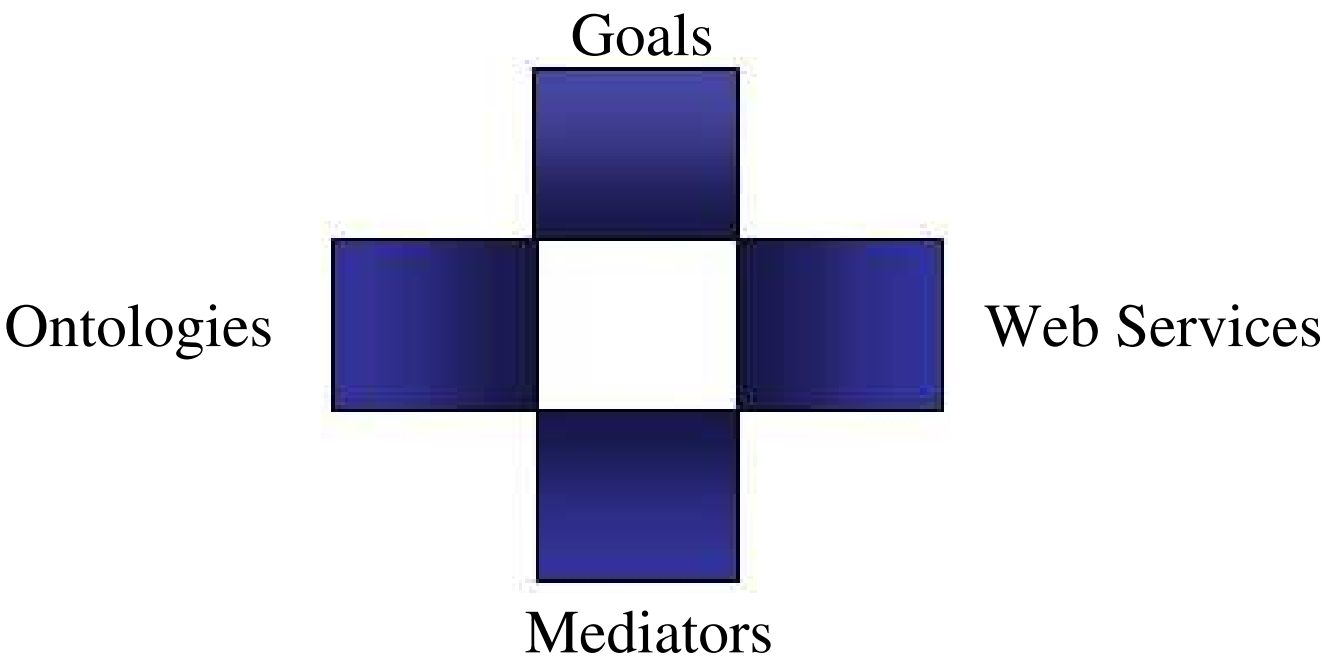


The Web Service Modeling Ontology WSMO

Introduction

- An ontology for Semantic Web Services
- Provides conceptual model for SWS
- Based on the Web Service Modeling Framework WSMF
- Principles of WSMO:
  - Ontology-based descriptions
  - Strict decoupling of components
  - Strong mediation between components
  - Interface vs. Implementation

The Web Service Modeling Ontology WSMO



The Web Service Modeling Ontology WSMO

Ontologies

- Provide terminology for:
  - Data exchanged between service requesters and providers
  - Description of other WSMO elements
- Ontologies consist of:
  - Concepts
    - Attributes
  - Relations
  - Functions
  - Instances
  - Axioms

The Web Service Modeling Ontology WSMO

Web Service descriptions

- Functionality offered by the Web Service
- Functional description, in the form of a **capability**:
  - Assumptions
    - Cannot be checked
    - Usually indicate dependency on real world
  - Preconditions
    - Conditions over the input
  - Effects
    - Changes in the real world as a result of execution of the Web Service
  - Postconditions
    - Relation between the input and the output

The Web Service Modeling Ontology WSMO

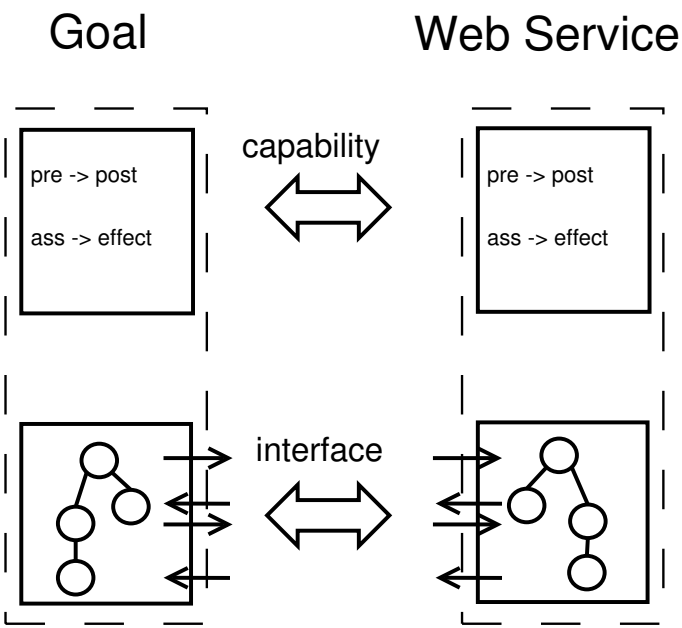
Web Service descriptions (cont'd)

- Behavioral description, in the form of an **interface**:
  - Choreography
    - How to interact with the service
  - Orchestration
    - Use of external Web Service to realize the functionality
  - Both choreography and orchestration are decompositions of the capability

The Web Service Modeling Ontology WSMO

Goals

- Functionality requested from the Web Service
- Description symmetric to Web Service description:
  - Capability
  - Interface



The Web Service Modeling Ontology WSMO

Mediators

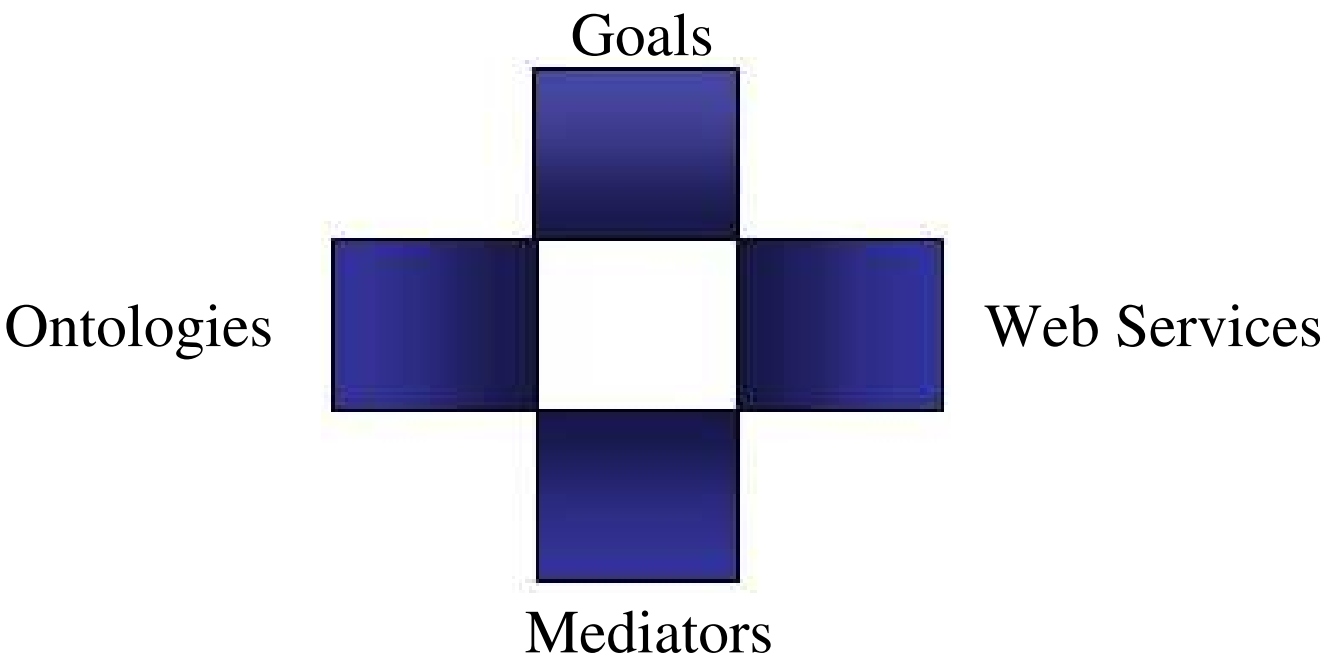
- Connect heterogeneous components
- Resolve heterogeneity in different levels
  - Data - differences in data representation
  - Protocol - differences in interaction styles
  - Process - differences in business processes

The Web Service Modeling Ontology WSMO

Types of Mediators

- OO Mediators
  - Connect ontologies to any other component (including mediators)
  - Resolve mismatches conflicts between ontologies
- WW Mediators
  - Link Web Services to services they depend on
  - Resolve representation differences through OO Mediators
- WG Mediators
  - Link Goals and Web Services
  - Resolve differences in data, protocol and process between requester and provider
- GG Mediators
  - Connect generic and refined Goals

Review of WSMO



Idea of WSDL-S

- OWL-S, WSMO comprehensive approache for WS description
  - top-down approach
- WSDL-S extends existing standards
  - WSDL known standard
  - provide minimal extension
- WSDL-S agnostic about language/model for WS description
  - allow to use OWL-S, WSMO, ...
  - OWL, OCL, ...
- choice of language/model **outside** of WSDL-S
- WSDL-S takes as standardization of Semantic Web Services

WSDL-S Extension of WSDL (I)

- Interface
  - **modelReference**: reference to semantic model
  - **category**: placing WS in taxonomy
- Operation
  - **modelReference**: reference to semantic model
  - **precondition**
    - **name**
    - either **modelReference**: definition of precondition in semantic model, or
    - **expression**: expression defining the precondition in chosen representation language
  - **effect**
    - **name**
    - either **modelReference**: definition of effect in semantic model, or
    - **expression**: expression defining the effect in chosen representation language

WSDL-S Extension of WSDL (II)

- XML Schema elements
  - **modelReference** at elements in XML Schema
  - **schemaMapping**: defines translation of XML to semantic representation language

WSDL-S: Interface

```
<interface name="PurchaseOrder">
   <!--Category is added as an extensible element of
     an interface-->
   <wssem:category name="Electronics"
     taxonomyURI="http://www.naics.com/"
     taxonomyCode="443112" />
</interface>
```

WSDL-S: Operation

```
<operation name="processPurchaseOrder"
    pattern="wsdl:in-out"
    wssem:modelReference="Rosetta:RequestPurchaseOrder" >
  <input messageLabel ="processPurchaseOrderRequest"
    element="tns:processPurchaseOrderRequest"/>
  <output messageLabel ="processPurchaseOrderResponse"
    element="processPurchaseOrderResponse"/>
  <!--Precondition and effect are added as extensible
      elements on an operation-->
  <wssem:precondition name="ExistingAcctPrecond"
    wssem:modelReference="POOntology#AccountExists"/>
  <wssem:effect name="ItemReservedEffect"
    wssem:modelReference="POOntology#ItemReserved"/>
</operation>
```

WSDL-S: XML Schema mapping

```
<complexType name="POAddress"
 wssem:schemaMapping="http://.../POAddress.xsl"
 wssem:modelReference="POOntology#Address" >
  <all>
    <element name="recipientInstName" type="string" />
    <element name="streetAddr1" type="string" />
    <element name="streetAdd2" type="string" />
    <element name="city" type="string" />
    <element name="state" type="string" />
    <element name="zipCode" type="string" />
    <element name="country" type="string" />
  </all>
</complexType>
```

WSDL-S: XML Schema mapping (cont'd)

```
<?xml version='1.0' ?>
<xsl:transform version="2.0"
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<xsl:template match="/">
  <Address rdf:ID="Address1">
    <has_Receiver rdf:datatype="xs:string">
     <xsl:value-of select="POAddress/recepientInstName"/>
     <has_StreetAddress rdf:datatype="xs:string">
       <xsl:value-of select="concat(...)"/>
     </has_StreetAddress >
     ....
    <has_Receiver>
   </Address>
</xsl:template>
```

Summary

OWL-S

- Service Profile
- Service Model
- Service Grounding

WSMO

- Ontologies
- Web Services
- Goals
- Mediators

WSDL-S

Further reading

- OWL-S specification: `http://www.daml.org/services/owl-s/1.1/`
- WSMO specification: `http://www.wsmo.org/TR/d2/`
- WSDL-S specification: `http://www.w3.org/Submission/WSDL-S/`
- D. Roman, U. Keller, H. Lausen, R. Lara, J. de Bruijn, M. Stollberg, A. Polleres, C. Feier, C. Bussler, and D. Fensel. Web service modeling ontology. Applied Ontology, 1(1):77-106, 2005.
- J. de Bruijn, D. Fensel, U. Keller, and R. Lara. Using the web service modelling ontology to enable Semantic eBusiness. Communications of the ACM, special issue on the semantic e-business vision, 48(12):43-47, December 2005.