

# Semantic Web Services: Approaches and Applications

John Domingue  
Knowledge Media Institute,  
The Open University

The Sixth Summer School on Ontological Engineering and the Semantic Web (SSSW'08)

## Some Slides Adapted from

- Mary Rowlatt, Leticia Gutierrez
  - Essex County Council
- Amit Sheth
  - Kno.e.sis Center, Wright State University
- Kunal Verma
  - Accenture Technology Labs
- Jacek Kopecký
  - STI Innsbruck
- Stephan Haller
  - SAP

# Web Services

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## What's a Web Service?

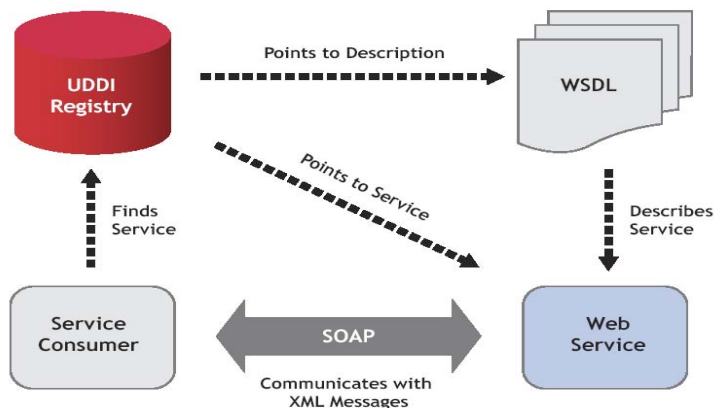
- A program programmatically accessible over standard internet protocols
- Loosely coupled, reusable components
- Encapsulate discrete functionality
- Distributed
- Add new level of functionality on top of the current web



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# Web Services Framework



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## The Future Internet: Towards a Web-based Service Economy

SAP

### NETWORK PARTICIPANTS



**GOVERNMENT**  
eGovernment, eEnergy,  
eHealth, Security



**BUSINESS/SCIENCE**  
Cluster / SME  
New Services & Business Models



**CITIZEN/CONSUMER/  
EMPLOYEE**  
"Digital Lifestyle", New Media,  
Communities

### OPEN PLATFORM FOR NETWORKS



**SECURE  
BROADBAND  
INFRASTRUCTURE**



**INTERNET  
of SERVICES**



**SERVICE-/USER-  
FRIENDLY IT**

### NETWORK ENABLER AND FOUNDATION



**MULTIMEDIA  
CONTENT**



**INTERNET  
of THINGS**



**SERVICE-ORIENTED  
SOFTWARE  
APPLICATIONS**

SAP RESEARCH

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## Welcome to Amazon Web Services

Amazon Web Services provides developers with direct access to Amazon's robust technology platform. Build on Amazon's suite of web services to enable and enhance your applications. We innovate for you, so that you can innovate for your customers. Browse developer innovations in our [Solutions Catalog](#) to see the possibilities!

**What's New?**

**High-CPU Instances Now Available** (May 29, 2008)  
A new family of Amazon EC2 instances types is now available: the High-CPU family. These instances have proportionally more CPU resources than RAM (compared to our Standard Instances) and are well suited for compute-intensive applications such as rendering, search indexing, and computational analysis. Since this was a popular feature request among EC2 developers, we are excited to offer these new instances to complement our existing instances sizes. [Read more about the Amazon EC2 Instance Types.](#)

**New Functionality Added to Amazon FPS Widgets** (May 13, 2008)  
Amazon FPS has released a new [Marketplace Widget](#), which allows developers to easily move money between two third parties, and a new Marketplace Fee feature enables them to charge a fee for doing so. In addition, new functionality has been added to the ["Pay Now" Widget](#) allowing developers to quickly integrate with Amazon FPS. This new functionality includes Reserve and Settle, Instant Payment Notification, Refund API, and more.

**OpenSolaris and MySQL Enterprise on Amazon EC2** (May 5, 2008)  
Sun Microsystems and Amazon Web Services are collaborating to offer two open source solutions on Amazon EC2: OpenSolaris and MySQL technical support. With OpenSolaris OS on Amazon EC2, you have access to a robust operating system on a scalable, cost-effective virtual computing environment. And now MySQL Enterprise customers can choose to deploy their database on Amazon

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### Podcast Academy 6

Thanks again to everyone who attended our sixth Podcast Academy event.

With an impressive list of presenters and a full room, it proved to be a valuable educational event to kick off the 2007, Podcast and New Media Expo.

Stay tuned for information on upcoming Podcast Academies.

### Our New Book

**PODCAST ACADEMY PRESENTS**  
**THE BUSINESS PODCASTING BOOK**  
*Learning, Marketing, and Reaching Your Potential*

Edited by Chief Michael W. Gough  
 by Greg Campbell  
 with Ben Ross  
 The Business Podcasting Experts

GigaVox Media

### Podcast Academy

The Podcast Academy is the longest running professional podcast training event in existence. Held at locations such as Duke University, the

### Consulting and Production

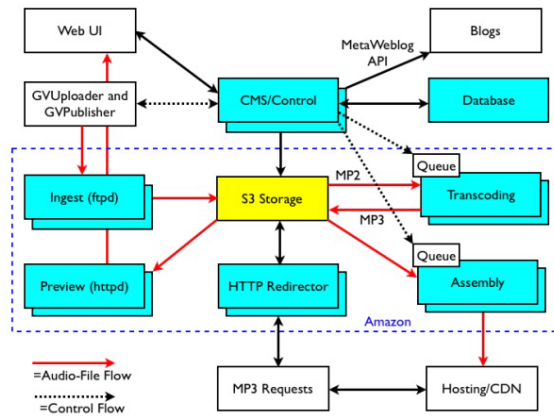
Need professional level guidance for your podcasting initiatives? Isn't it time you spoke with folks who have been involved since the beginning

### Technology

GigaVox is the leading podcast technology company. As reported on TechCrunch, we have sold the GigaVox Audio Lite technology to

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# GigaVox Architecture

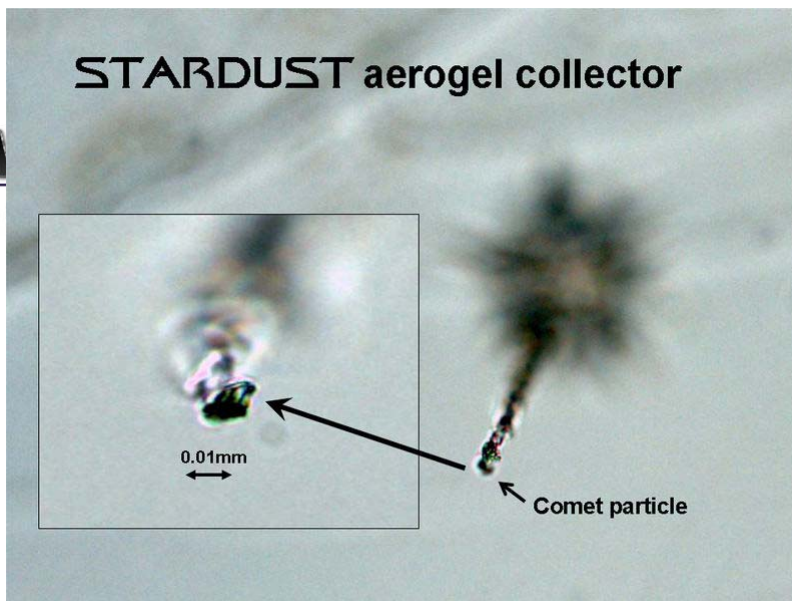


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## STARDUST aerogel collector

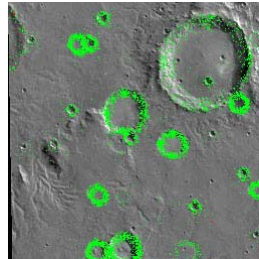
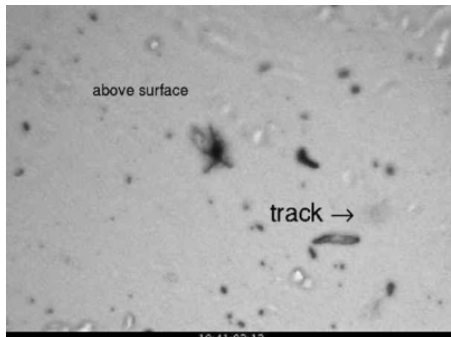
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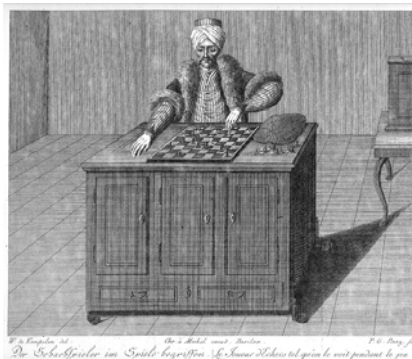
## ClickWorkers (2/2)



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## Artificial Artificial Intelligence



**amazon** **mechanical turk**  
 beta Artificial Artificial Intelligence



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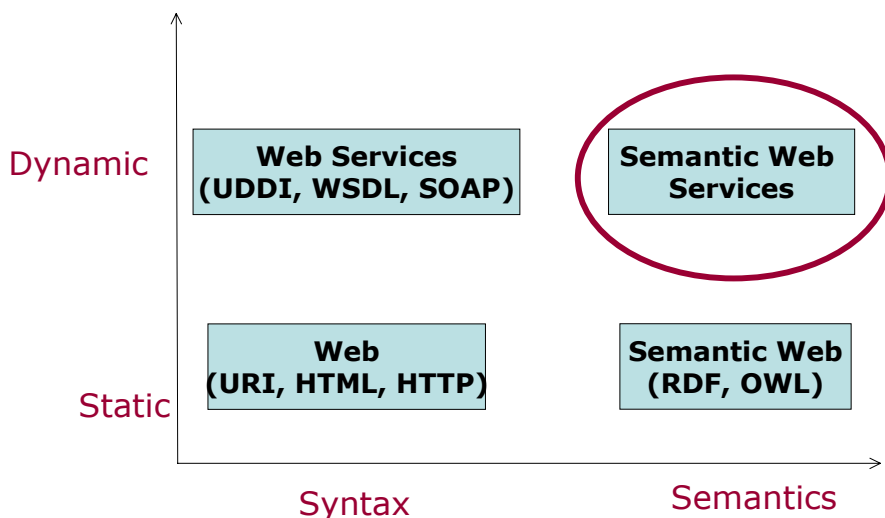


## Problems with Web Services Today

- Descriptions are syntactic
- All tasks associated with web services application development have to be carried out by humans:
  - discovery, composition and invocation
- Problems of scalability



## SWS Vision



# Semantic Web Services (is)

- Semantic Web Technology
  - Machine readable data
  - Ontological basis

Applied to

- Web Services Technology
  - Reusable computational resources

To automate all aspects of application development through reuse



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# Semantic Web Service Broker



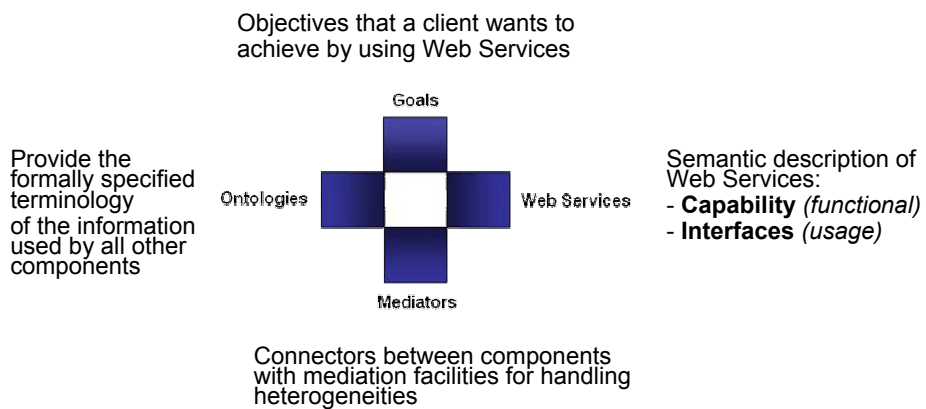
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# Web Service Modelling Ontology (WSMO)

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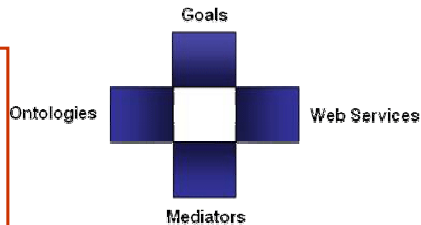
## WSMO Top Level Notions



# WSMO Top Level Notions

Objectives that a client wants to achieve by using Web Services

Provide the formally specified terminology of the information used by all other components



Semantic description of Web Services:

- **Capability** (*functional*)
- **Interfaces** (*usage*)

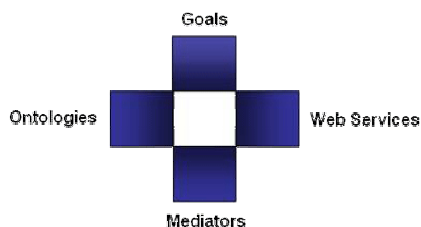
Connectors between components with mediation facilities for handling heterogeneities



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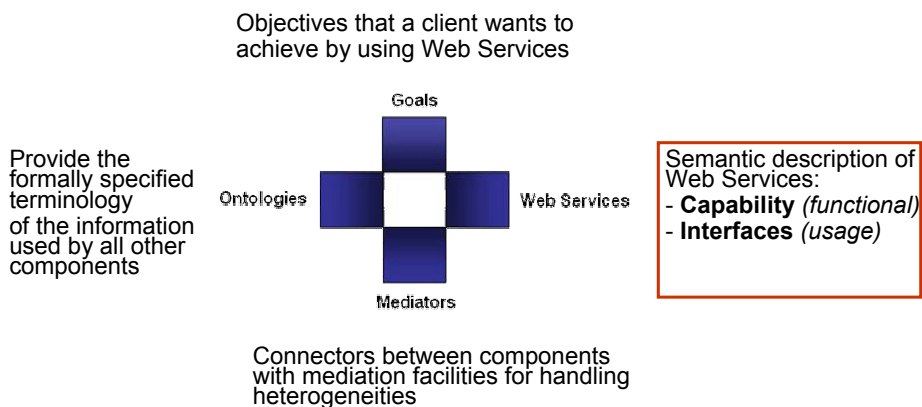


# Goals

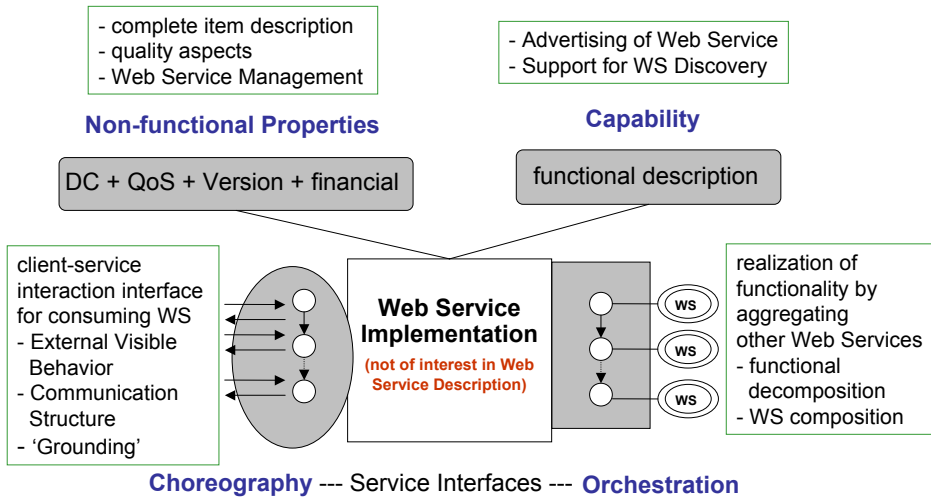
- Ontological De-coupling of Requester and Provider
- Derived from task / problem solving methods/domain model
- Structure and reuse of requests
  - Search
  - Diagnose
  - Classify
  - Personalise
  - Book a holiday
- Requests may in principle not be satisfiable
- Ontological relationships & mediators used to link goals to web services



# WSMO Top Level Notions



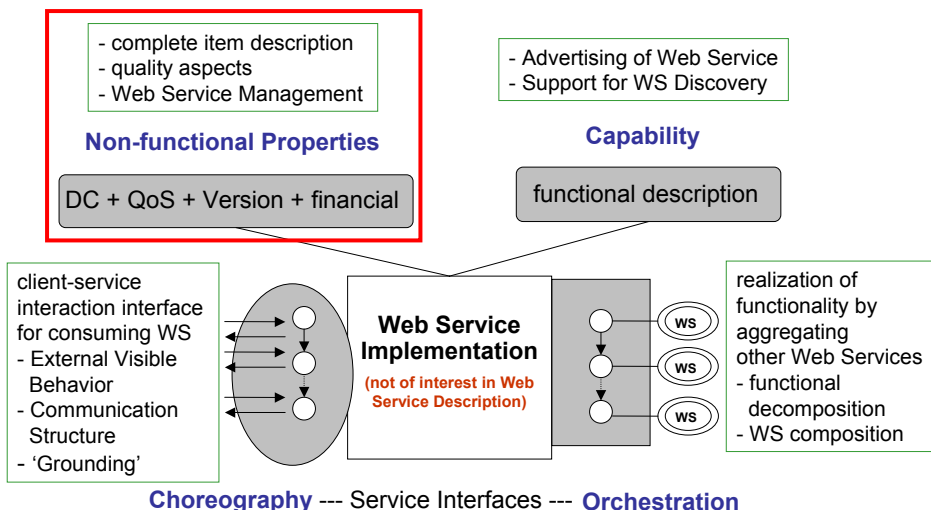
# WSMO Web Service Description



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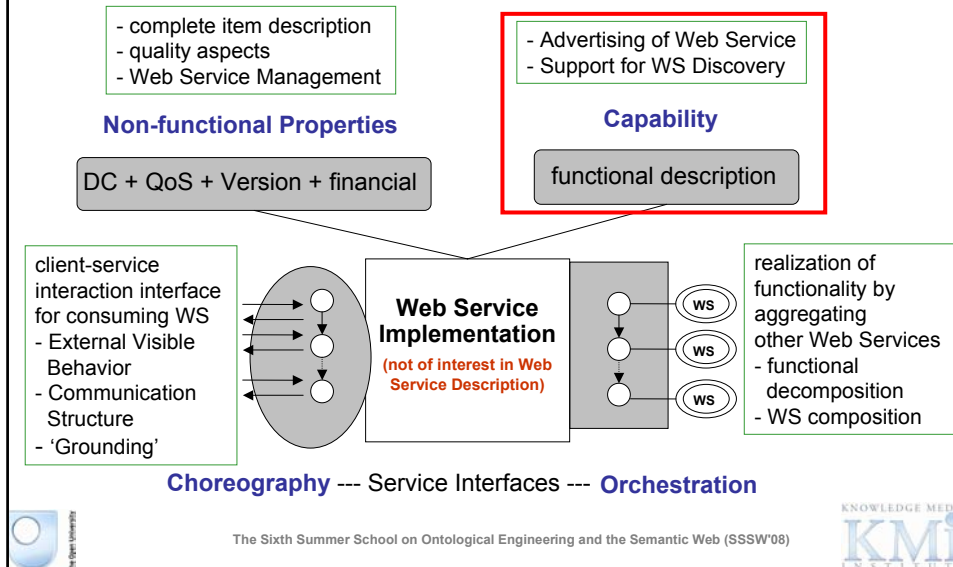
# WSMO Web Service Description



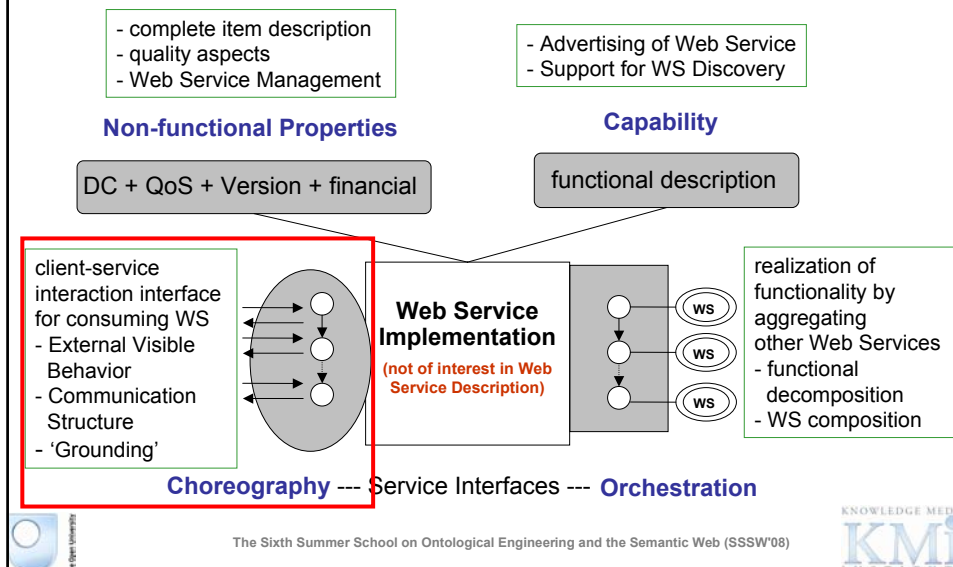
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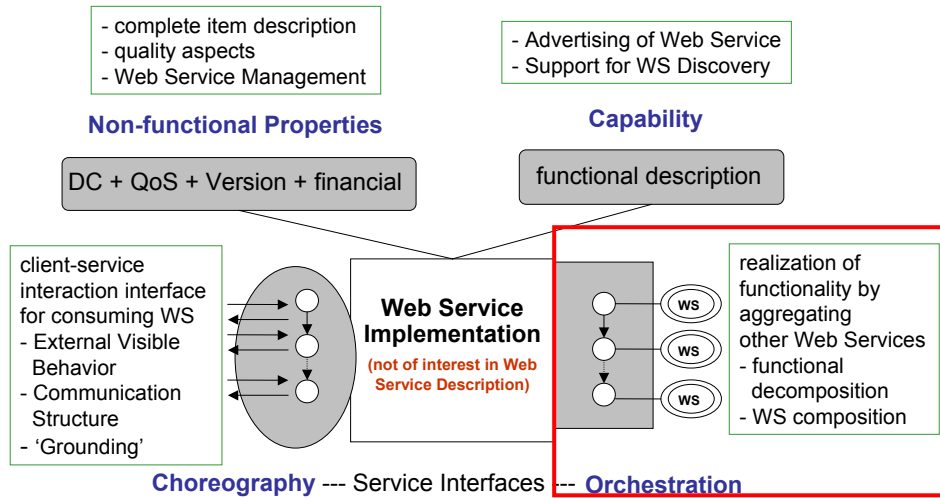
# WSMO Web Service Description



# WSMO Web Service Description



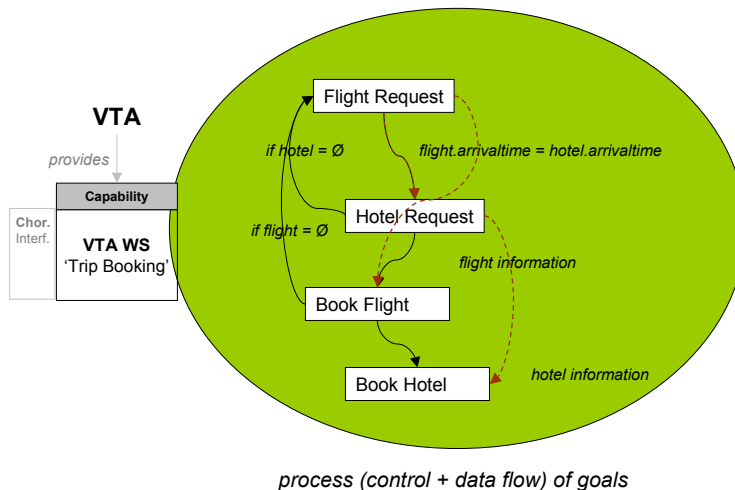
# WSMO Web Service Description



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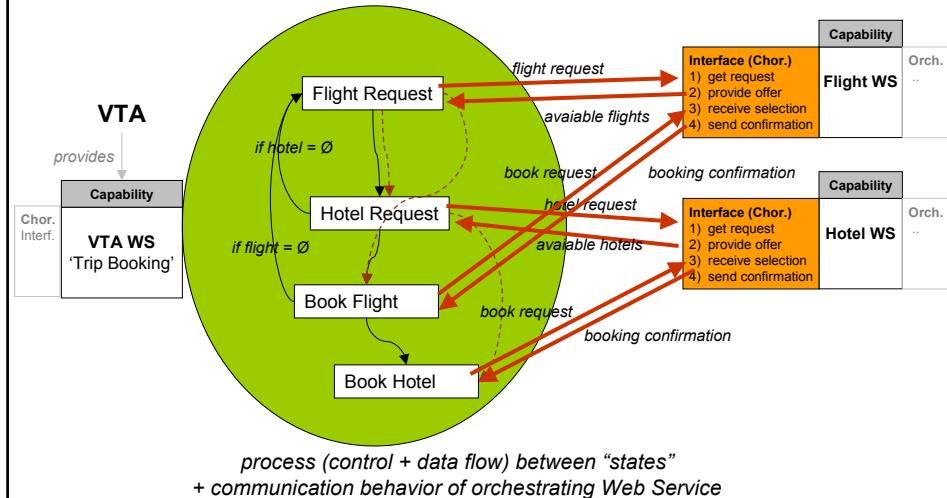
# Orchestration Definition



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# Runtime Orchestration

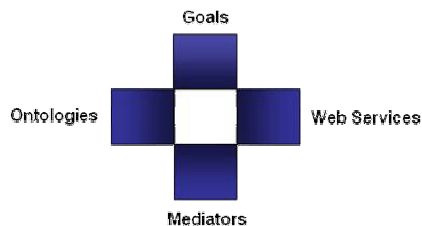


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Connectors between components with mediation facilities for handling heterogeneities

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# Mediation

- For 1\$ on programming, \$5 - \$9 on integration
- Mismatches on structural / semantic / conceptual / level
- Assume (nearly) always necessary
- Description of role

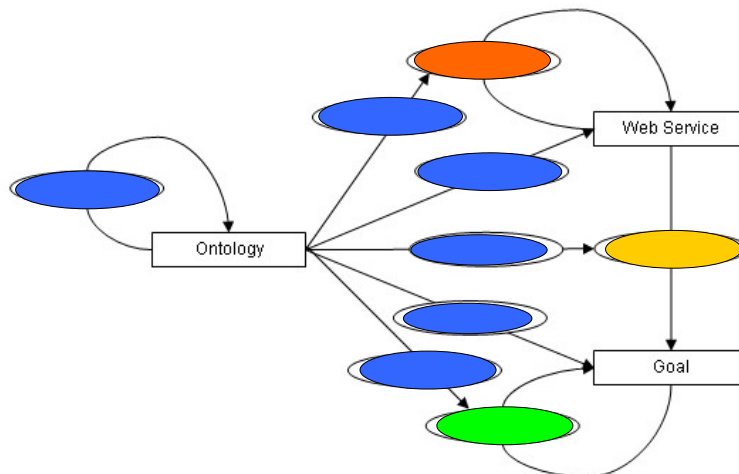
© IBM, Nelson Mattos



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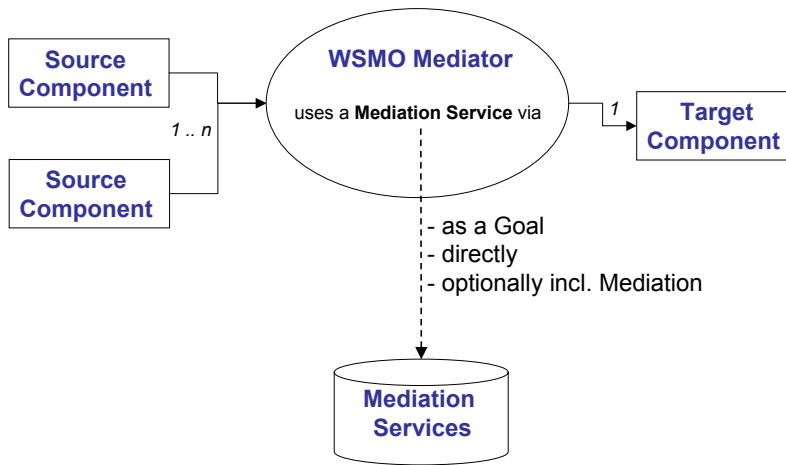
## WSMO Mediators Overview



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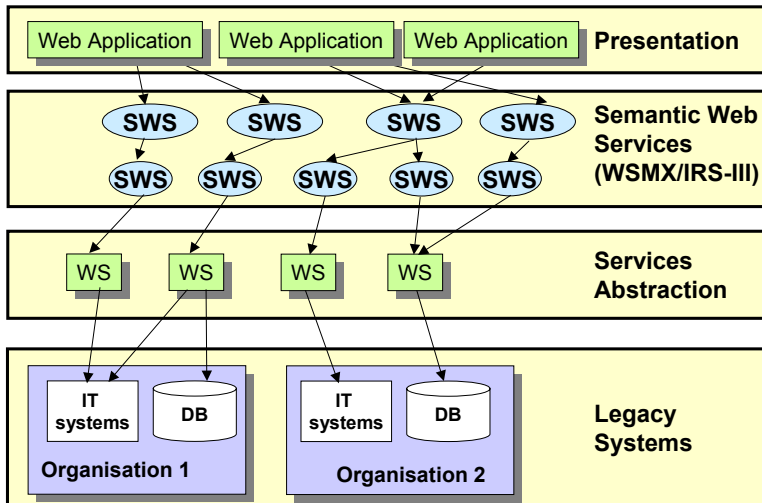


# Mediator Structure



# Building SWS Applications

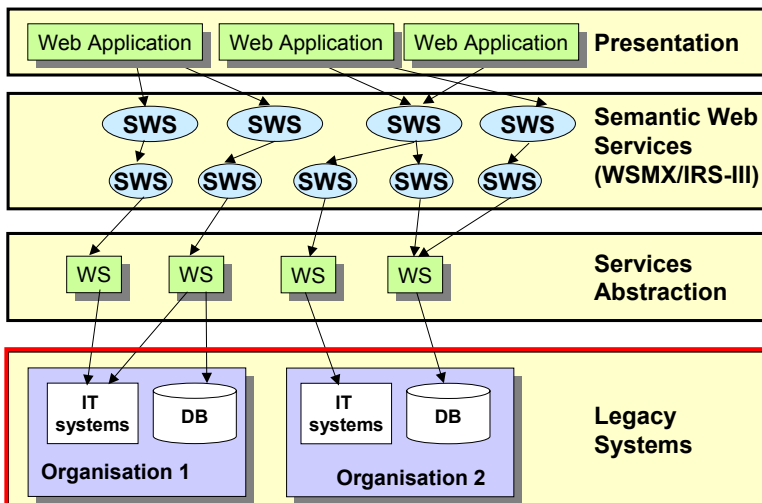
# Generic Application Structure



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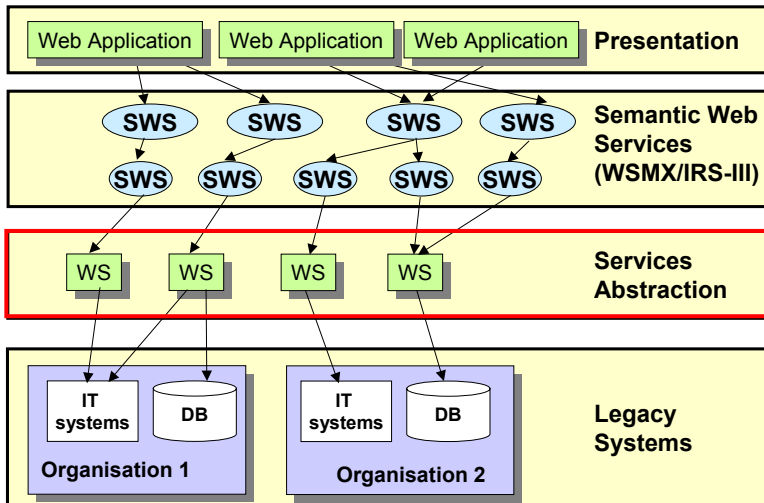
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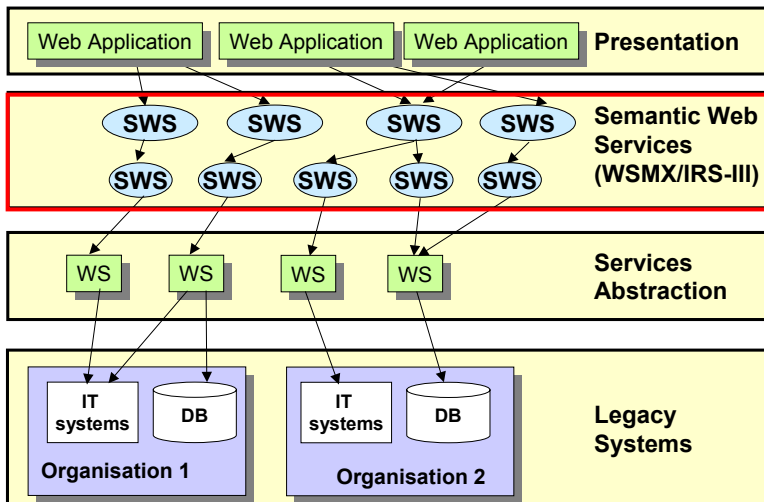
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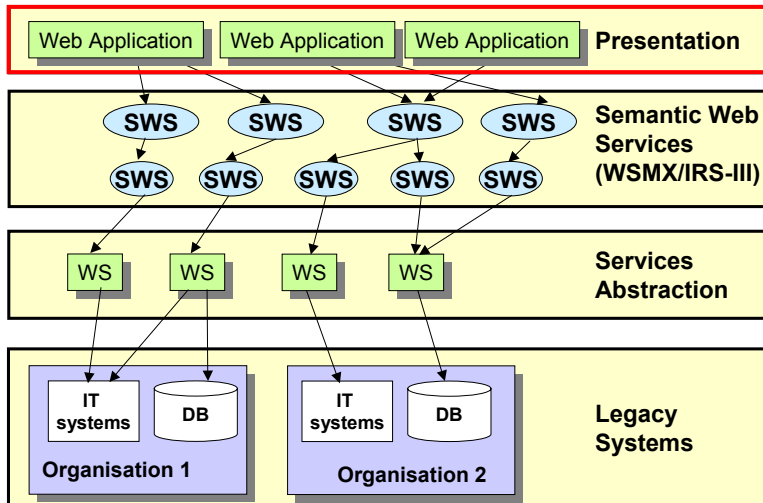
# Generic Application Structure



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# Generic Application Structure



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## Supporting Emergency Planning for Essex County Council

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# Essex County Council



- A large local authority in South East England
- Comprised of 13 boroughs
- Population of 1.3M.



# Emergency Planning Context

[CATEGORIES](#)
[TV](#)
[RADIO](#)
[COMMUNICATE](#)
[WHERE I LIVE](#)
[INDEX](#)
[SEARCH](#)

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**BBC NEWS**

**News Front** Friday, 31 January, 2003, 10:27 GMT

Page  
World

**UK**

England  
N Ireland  
Scotland  
Wales  
Politics  
Business  
Entertainment  
Science/Nature  
Technology  
Health  
Education

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**Talking Point**

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Country  
Profiles  
In Depth

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## 'My 20-hour battle through the snow'



Motorists have been stuck in lengthy jams

While motorists across Britain have been struggling in to work along icy roads, few have suffered as much as those stuck on the M11 in Cambridgeshire.

Adam Harley, who pulled on to

WATCH/LISTEN

ON THIS STORY

**The BBC's Samantha Simmonds**  
"Hundreds of passengers are still stranded at Heathrow and Gatwick airports"

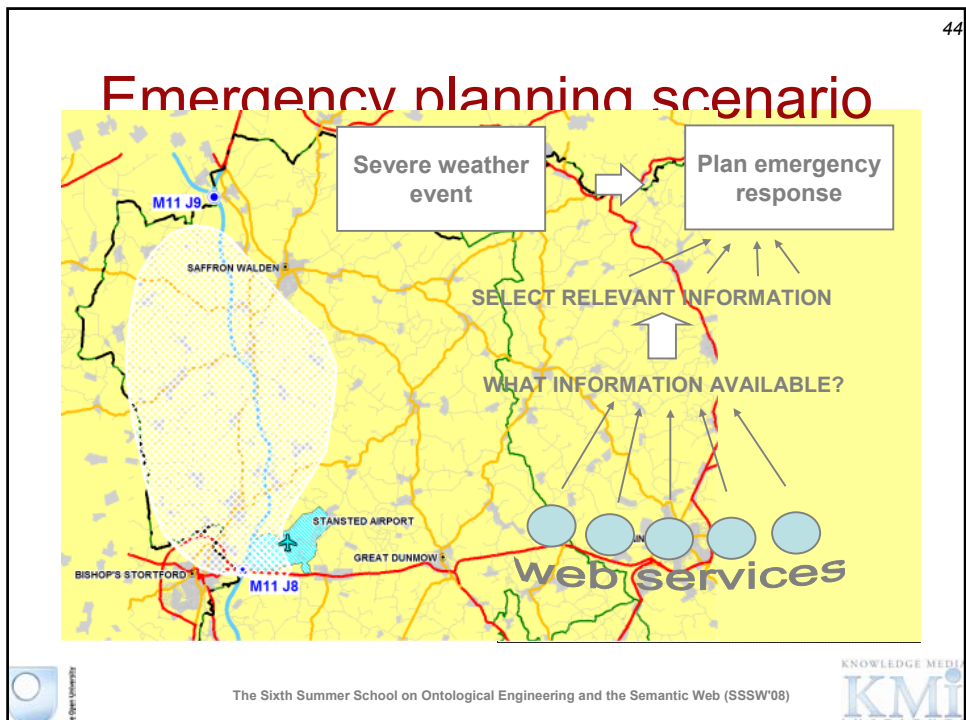
**Jonathan Smith, E. Midlands Electricity**  
"We've 30,000 customers without electricity"

**Rebecca Rees, AA**  
"People have spent the whole night in their cars"

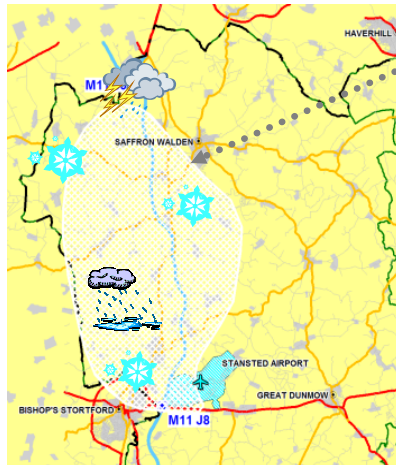
TALKING POINT

**Snow storm**

Your



# Emergency planning scenario



Severe weather event  
forecast in the area by  
Met Office

get event details

Met Office



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# Emergency planning scenario



Identify most  
appropriate rest centres

get centre  
contact details

get facilities  
kitchen, showers,  
number of beds,  
cookers, heaters...

get  
capacity

ViewEssex  
spatial data

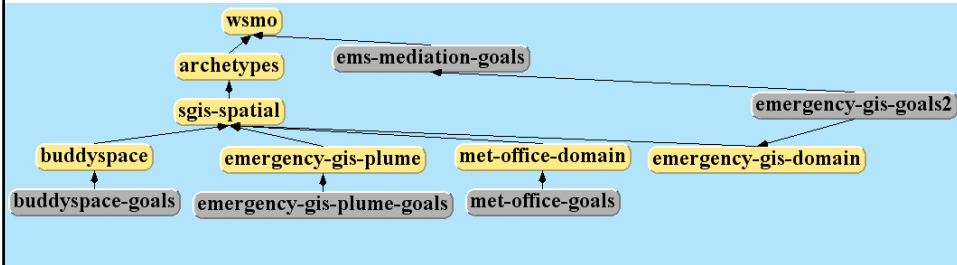
District data



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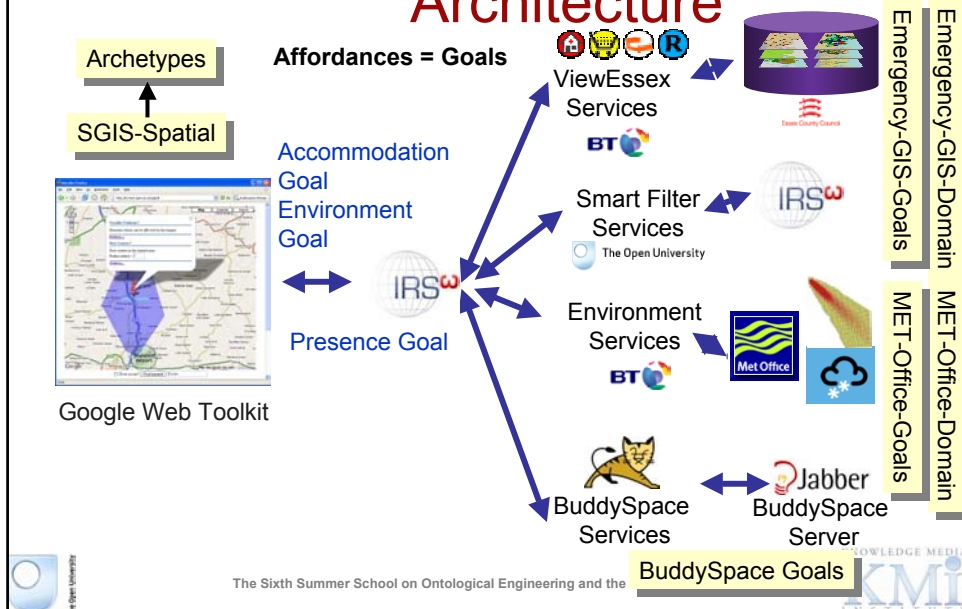
# eMerges Ontologies



## Demonstration of Emergency Planning (GIS) Prototype V1

# EMerges Prototype Architecture

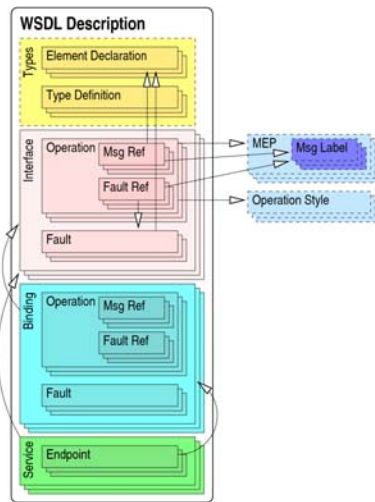
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## SAWSDL and WSMO-Lite

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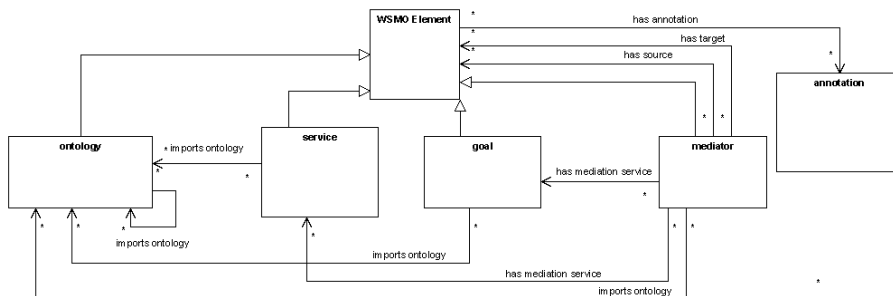
# WSDL



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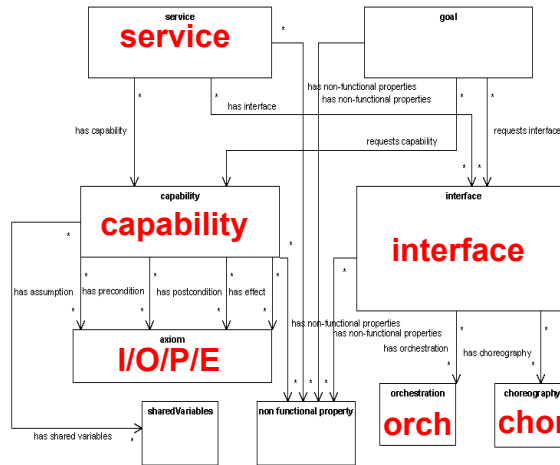
# WSMO



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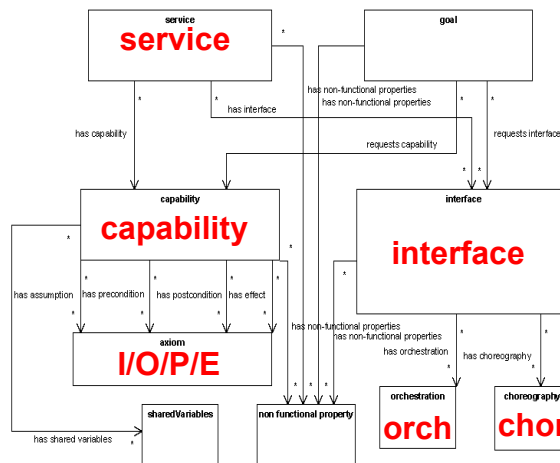
# WSMO Service (& Goal)



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# WSMO Service (& Goal)



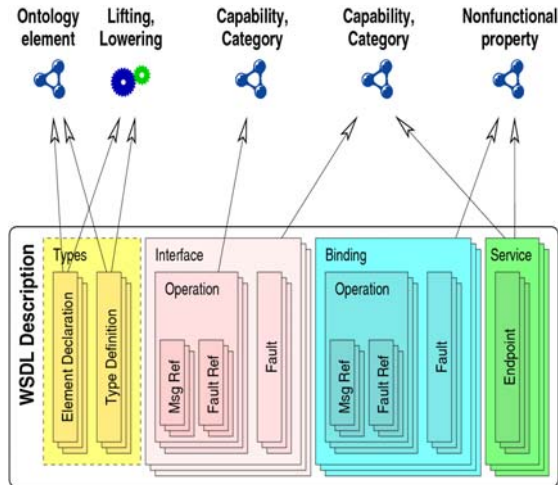
**WSDL  
grounding**



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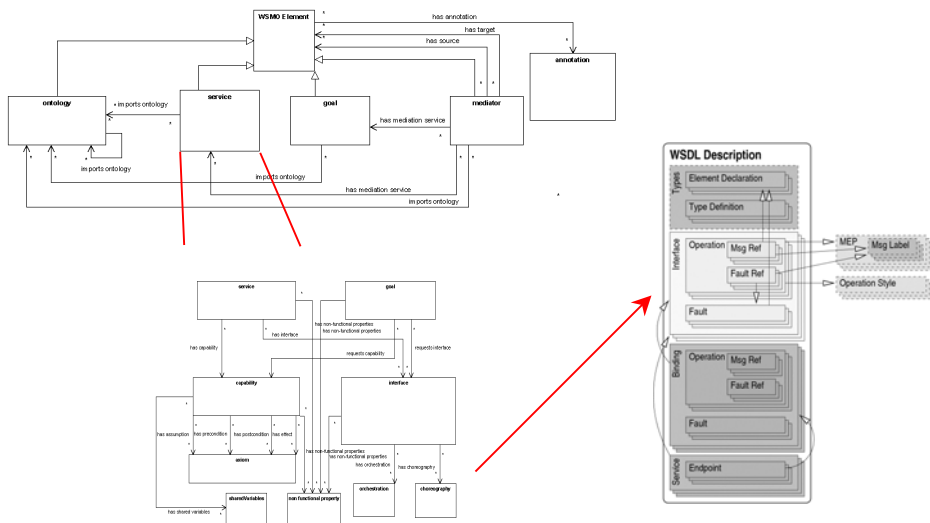
# WSMO-Lite in WSDL



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# WSMO + WSDL



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# Types of Service Semantics

- Functional
  - What the service does
- Nonfunctional
  - Implementation or running env. information
- Behavioral
  - How to talk to the service
- Information
  - What the exchanged data means

(adapted from Amit Sheth)



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# WSMO-Lite Example

```

<wsdl:description>
  <wsdl:types> <xs:schema>
    <xs:element name="ReservationRequest"
      sawsdl:modelReference="&ex;Reservation"
      sawsdl:loweringSchemaMapping="&ex;ResMapping.xsparql" ... />
  </xs:schema> </wsdl:types>
  <wsdl:interface name="HotelReservations"
    sawsdl:modelReference=
      "&ex;AccommodationReservationService">
    <wsdl:operation name="searchForRooms"
      sawsdl:modelReference="&wsdlx;SafeInteraction">
      ...
    </wsdl:operation>
    ...
  </wsdl:interface>
  <wsdl:service name="RomaHotels" interface="HotelReservations"
    sawsdl:modelReference="&ex;RomaHotelReservationPrecondition
      &ex;ReservationFee" ... />
</wsdl:description>

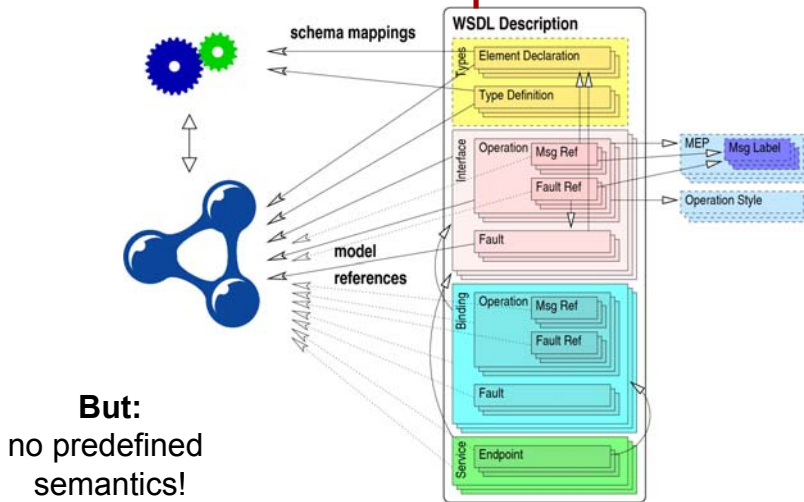
```



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# SAWSDL – Help From W3C



## WSMO-Lite vs. WSMO

- WSMO-Lite service model from WSDL
- Goals out of scope
- Ontologies imported
- Mediators out of scope
- No new syntaxes, just a few terms
  - Using the simplest parts of RDFS
- WSMO-Lite is an application of SAWSDL



# WSMO-Lite Terms

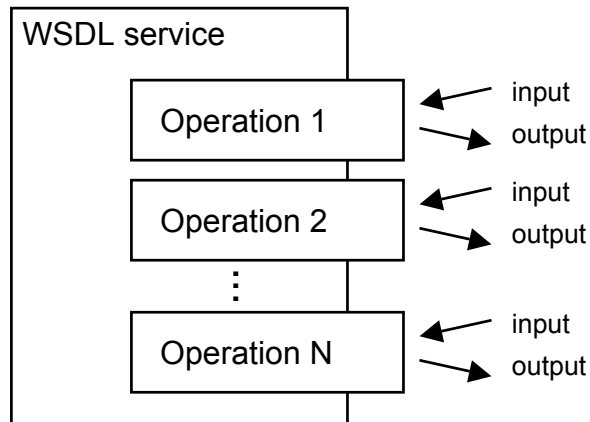
wl:Ontology	rdf:type	rdfs:Class;
	rdfs:subClassOf	owl:Ontology.
wl:ClassificationRoot	rdfs:subClassOf	rdfs:Class.
wl:NonFunctionalParameter	rdf:type	rdfs:Class.
wl:Condition	rdfs:subClassOf	wl:Axiom.
wl:Effect	rdfs:subClassOf	wl:Axiom.
wl:Axiom	rdf:type	rdfs:Class.

- Allows different types of semantics on a single component
- E.g. functionality and nonfunc. property on a service



# MicroWSMO

## WS-\* Service Model



## What are RESTful WS?

- Like Web applications, but for machines
- Or like WS-\*, but with more resources
- A RESTful Web service is:
  - A set of Web resources
  - Interlinked
  - Data-centric, not functionality-centric
  - Machine-oriented (no more HTML-scraping)



## Summary

- Semantic Web Services
  - Applies SW to automate application development through reuse of Web services
- WSMO
  - ontology describing Web services
  - Goals, web services, mediators
- Supporting Emergency Planning
- WSMO-Lite
- SAWSDL
- MicroWSMO



## Relevant URLs (1/2)

- WSMO
  - <http://www.wsmo.org/>
- IRS-III
  - <http://kmi.open.ac.uk/projects/irs/>
- DIP
  - <http://dip.semanticweb.org/>
- Emergency Planning Use Case
  - <http://irs-test.open.ac.uk/sgis-dev/>



## Relevant URLs (2/2)

- Conceptual Models of Services
  - <http://cms-wg.sti2.org/home/>
- OWL-S
  - <http://www.daml.org/services/owl-s/>
- SAWSDL
  - <http://www.w3.org/2002/ws/sawSDL/>



# Thanks

KNOWLEDGE MEDIA

KMi  
I N S T I T U T E



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