Semantic Web Services: Application Areas

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Knowledge Media Institute,
The Open University,
UK
Contents

• Emergency planning
  – eGovernment use case within the DIP project
• Applying semantic Web services to business process modelling in the Super project
• Applying semantic Web services to eLearning in the Luisa project
DIP

• 3 Year 17M Euro project
  – Finished end of 2006
  – Involved 21 partners

• Focus on Semantic Web Services

• One (of 3) use case was on eGovernment
DIP Consortium

• Research partners
• Industry partners
• Use case partners
Supporting Emergency Planning for Essex County Council
Essex County Council

• A large local authority in South East England
• Comprised of 13 boroughs
• Population of 1.3M.
Emergency Planning Context
'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
Emergency planning scenario

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Emergency planning scenario

Severe weather event forecast in the area by Met Office

get event details

Met Office
Emergency planning scenario

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eMerges Ontologies
Generic Application Structure
Generic Application Structure

- Web Application
- Web Application
- Web Application

Presentation

Semantic Web Services (WSMX/IRS-III)

Services Abstraction

Legacy Systems

Organisation 1
- IT systems
- DB

Organisation 2
- IT systems
- DB
Generic Application Structure

- Web Application
- Web Application
- Web Application
- Presentation

Semantic Web Services (WSMX/IRS-III)

Services Abstraction

IT systems
DB
Organisation 1

IT systems
DB
Organisation 2

Legacy Systems
Generic Application Structure

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Demonstration of Emergency Planning (GIS) Prototype V1
EMerges Prototype Architecture

Archetypes
SGIS-Spatial

Affordances = Goals

Accommodation Goal
Environment Goal
Presence Goal

ViewEssex Services
Emergency-GIS-Domain
Emergency-GIS-Goals
BuddySpace Services
BuddySpace Goals
Smart Filter Services
IRS
Environment Services
MET-Office-Domain
MET-Office-Goals
Jabber
BuddySpace Server

Google Web Toolkit
SWS and Business Process Modelling
Super Project

Super is a 3-year 17M EU funded project
- Started in April 2006
- 19 partners
SUPER Consortium
Motivation
Querying the Process Space

“In which of our food manufacturing machines are we processing meat or raw eggs?”

“How many inventory management methods are currently in use?”

“Do we have a cost approval process for items below $200?”
The Critical IT / Process Divide

Business Experts’ Perspective: Processes

Querying the Process Space

Manual Labor

Process Implementation

IT Implementation Perspective

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The Critical IT / Process Divide

Business Experts’ Perspective: Processes

Mechanized Mediation based on Machine Reasoning

Machine-Accessible Representation of Processes, Process Fragments, and IT Infrastructure as Semantic Web Services

IT Implementation Perspective

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What Are My Services?

Here is my business process!
I think this solves my business problem nicely...

A¹ → A² → A³ → A⁴

Nice try, but it won’t run...
You need to specify the services that perform each step!
What Are My Services?

I don’t understand about these technical details!
This is my view on the process...

A¹ → A² → A³ → A⁴

o.k. no problem, I will help you...

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What are my services?

This is cumbersome!
Why do I always need IT staff to solve my business problems?

It takes too long to get these folks, they use different terminology than I do...

I am happy to describe what the activities do in my terms. Can the system be smart enough and find the right services itself???
Matching Activities and Port Types Based on Semantics

Semantic Web Services
Supporting Business Users Better

Why do I have to draw everything?
Why do I have to use “expressions” and that technical stuff at all?
Why isn’t my description sufficient?
Matching Model Representations & Semantics

Here is my business process!

Business Representation

IT Representation

Wow! This is perfect – nothing left to do for me!

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The SUPER Stack
### Modelling Stack

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>Making sense of a domain \ problem</td>
<td>Solution maps, Mind maps, Ad-hoc modelling techniques</td>
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<tr>
<td></td>
<td>Communication tool</td>
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<td></td>
<td>What is it all about ?</td>
<td></td>
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<tr>
<td>Middle</td>
<td>Visualizing \ specifying business process</td>
<td>Business Scenario Maps, Event-driven process chains, Flowchart techniques, BPMN</td>
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<td></td>
<td>Focus : Business Problem</td>
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<td></td>
<td>Who does what, when, how and why ?</td>
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<td>Usually multiple layers</td>
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<tr>
<td>Bottom</td>
<td>Process execution specification</td>
<td>BPEL, WS*</td>
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<tr>
<td></td>
<td>Formal, clearly specified grammar</td>
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<td></td>
<td>Focus : Implementation</td>
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<td>Which component is called when, how, by whom with which data ?</td>
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<td>Web service encapsulation</td>
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<td>Focus : Implementation</td>
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<td>Which components can and should be exposed as services ?</td>
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<td>Implementation of components</td>
<td>Programming languages</td>
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Modelling Stack

- Making sense of a domain/problem
- Communication tool
- What is it all about?
- Solution maps
- Mind maps
- Ad-hoc modelling techniques
- ...

- Visualizing/specifying business process
- Focus: Business Problem
- Who does what, when, how and why?
- Usually multiple layers
- Business Scenario Maps
- Event-driven process chains
- Flowchart techniques
- BPMN
- ...

- Process execution specification
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- ...

- Web service encapsulation
- Focus: Implementation
- Which components can and should be exposed as services?
- WS*
- ...

- Implementation of components
- Programming languages
- ...

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Telecommunications Solution Map

<table>
<thead>
<tr>
<th>Industry Value Chain</th>
<th>Design &amp; Build Infrastructure</th>
<th>Operate Infrastructure</th>
<th>Develop &amp; Promote Products &amp; Services</th>
<th>Sell &amp; Fulfill</th>
<th>Bill &amp; Collect</th>
<th>Assist Customers</th>
<th>Customers &amp; Channels</th>
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<tbody>
<tr>
<td>Suppliers &amp; Partners</td>
<td>Network Life-Cycle Management</td>
<td>Demand and Supply Planning</td>
<td>Investment Management</td>
<td>Network Design and Build</td>
<td>Operations and Maintenance</td>
<td>Marketing Analytics &amp; Product Management</td>
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<td>Content Distribution &amp; Billing</td>
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Content on Demand

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Digital Rights Management & Content Procurement

Digital Rights Management & Content Procurement clusters activities related to the acquisition of licences of copyright material as well as the actual content itself. Licence providers and content providers are usually not identical.

- Content Provider
- Service Provider
- License Provider

1. Request Content from Provider
2. Request Licence for Content
3. Deliver Licence
4. Bundle Content & Licence
5. Deliver Content to Customer
6. Deliver Content
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Digital Rights Management & Content Procurement
Modelling Stack

- Making sense of a domain / problem
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- Which components can and should be exposed as services?

- WS*
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- Implementation of components

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Business Process Notations
Modelling Stack

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Programming Model

Programming in the Large

Workflow System

Orchestration/Process

Web Services/Functions

Application Server

Programming in the Small

Application
Deploying Applications
Business Protocols

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Business Protocols

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Modelling Stack

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- Which components can and should be exposed as services ?

- Solution maps
- Mind maps
- Ad-hoc modelling techniques
- ...
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
The SUPER Trinity
SUPER Methodology

Strategic Semantic Business Process Management

Semantic Business Process Analysis

Semantic Business Process Modelling

Semantic Business Process Execution

Semantic Business Process Configuration

Ontological Foundation

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SUPER Architecture

SUPER Execution
- Semantic BPEL Execution Engine
- Semantic Execution Environment

SUPER Tooling
- Modelling Tool
- Monitoring & Management Tool
- Analysis Tool

Semantic Service Bus

SUPER Platform Services
- SBP Composition
- SBP Process Mediation
- SBP Discovery
- Data Mediation
- SBP Reasoner
- Transformation

SUPER Repositories
- Business Process Library
- Semantic Web Services Repository
- Execution History

Deployment
Event Sink
Protocol Binder

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SUPER Ontology Stack

- SUPER ontologies
- Domain ontologies
- Pre-existing ontologies
- Imports
- Maps to
- Translates to

**Upper-Level Process Ontology (UPO)**

**Business Process Modelling Ontology (BPMO)**

**Business Domain Ontologies**

**Behavioural Reasoning Ontology (BRO)**

**WSMO Ontology**

**sBPEL Ontology**

**Events Ontology (EVO)**

**Process Mining Ontology (PMO)**

**sEPC Ontology**

**sBPMN Ontology**
Super Demo Context
Prototype Scenario

Digital Asset Management

Digital Content Downloading

Content Purchase
Digital Asset Management BPMN

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Digital Asset Management BPMN
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Service/Process Catalogue

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Super Demo Video
Semantic Web Services and eLearning
LUISA Project

- 30 Month 4.2M Euro project
  - Duration: 30 Months
  - Start: March 2006
LUISA Consortium

• 7 Partners:
  – Atos Origin (ATOS) - Spain
  – KMi, the Open University (OU) - UK
  – University of Alcalá de Henares (UAH) - Spain
  – University of Uppsala (ULL) - Sweden
  – Giunti Interactive Labs (GIUNTI) - Italy
  – University Henri Pointcaré (UHP) - France
  – EADS Corporate Research Centre (EADS) - France
LUISA Goal (1/2)

- LUISA addresses one essential problem: the location of (the appropriate) **learning resources** for some **given needs** (of learners, instructors or groups).
- Two main approaches are available as of today:
  - General Purpose Search Engine *(Google!)*
  - Specialized “learning object repositories” (LOR) that provide search based on “specialized” metadata.
- But:
  - The first one does not exploit information specific to learning/instruction.
  - The second one does (to some extent), but without exploiting domain/commonsense/specialized knowledge.
LUISA Goal (2/2)

• Proposes a **framework for developing specialized systems or brokers for other systems**.
  – It does not replace but extends existing investment.
• And provides several key innovations:
  1. Enables the expression of queries in terms of **ontologies**.
  2. Locates the **best sources/providers for given queries** (learning needs).
  3. Suggests tentative **compositions** based on learning needs.
  4. Is able of getting **back to the user** for more relevant info (negotiation).
  5. Enables **different query resolution/composition strategies**, including educational knowledge.
LUISA Objectives

- (O1) Developing a Semantic Web Service-based Infrastructure for Learning Object Discovery, Selection, Negotiation and Composition
- (O2) Developing Semantic Learning Object Annotation Techniques
- (O3) Annotation Tool development
- (O4) Integration of the architecture into existing LCMS
- (O5) Case study reports
  - Academic Learning (UHP)
  - Industrial Training (EADS)
SWS-based Infrastructure
Currently, supporting learning objectives means:

- Providing learners with manually created composite learning contents: Learning Objects (LO)
  
  - Ideally based on metadata standards (e.g. IEEE LOM, ADL SCORM, IMS Learning Design)
- Accessing to Learning Object Metadata Repositories (LOMR)
- Using learning (content) management systems (LMS-LCMS) (e.g. Moodle)
E-Learning Technologies: **State of the Art**

- Specific requirements and preferences:
  - Skill Level (learning prerequisites)
  - Language
  - Platform
  - Cost
  - …

Neil (learner)

---

Learning Process Metadata

Learning Data

John (teacher)
E-Learning Technologies: Issues

Alessio (learner)  Stefan (learner)

Content Package

Manifest File (imsmanifest.xml)

Learning Process Metadata

Learning Data

Manifest
- Meta-data
- Organizations
- Resources
- (sub)Manifest(s)

Physical Files
(The actual Content, Media, Assessment, and other file)
E-Learning Technologies: Issues

Issues:

- Limited reusability across different context (learner needs) and metadata standards.
- Limited appropriateness and dynamic adaptability to actual process contexts.
- Limited use of available sources (repositories)
- High development costs

• Main Reasons:
  - Learning support is mainly based on content delivery
  - Content is stored within the learning package
  - Learning package is composed at design-time when the actual learning context cannot be considered
  - Learning package is manually created based on the subjective decision of individual learning designers
Vision: Dynamic Adaptation at Runtime

• Move
  – from a manual design-time composition of learning contents
  – to an automatic run-time adaptation to learning contexts

• By introducing a paradigm-shift
  – from the current data and metadata-centric approach
  – to a dynamic functional-oriented approach based on Semantic Web Services technology
Approach: Dynamic use of Learning (Meta) Data?

(e.g. IMS LD, ADL SCORM, ...)

(multiple repositories. e.g. LUISA LOMR, Open Learn, ...)

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Approach: **Services (dynamic) instead of Data (static)**

1st Step - Abstracting from learning resources …

- Providing functionalities (Web services) supporting learning, instead of static data
- Enables dynamic adaptation to specific learning context, based on dynamic delivery of appropriate data
- Enables dynamic integration of several content sources
- Describing Web services is more efficient than describing data
Approach: **SWS (dynamic²) instead of Data (static)**

... 2nd Step - Abstracting from services ...

- Adopting **Semantic Web Service** technology (**WSMO**)
- Enables **dynamic selection and invocation of functionalities** (Web services) appropriate to achieve a specific **learning goal (objective)**
- Enables dynamic adaptation to different learning contexts based on **dynamic delivery of appropriate functionalities**
Approach: Learning Processes

... 3rd Step - Abstracting from specific learning process metadata standards ...

- Semantic models of learning processes independent from any specific standard
- Describing learning processes in terms of learning goals
- Mapping to and between several metadata standards as well as WSMO goals
Approach: **Generic Processes**

… 4th Step - Abstract from learning process domain.

- Semantic models of processes independent from specific kind of process, e.g. learning process, business process
- Enables mapping between different kind of domain processes
Use of semantics: **Ontology Stack**

The diagram illustrates the use of semantics in an ontology stack. It shows the mapping relationships between different semantic layers and models. The layers include:

1. **semanticLearningProcessModelLayer**
   - ieelomO
   - adlScormO
   - LPMO
   - maps to imslodO

2. **semanticProcessModelLayer**
   - DOLCE:DnS
   - COoP
   - maps to LPMO

3. **semanticWebServiceLayer**
   - WSMO

The mappings flow from the semantic layers to the learning process, which is further divided into roles, processes, situations, and parameters. The goal is at the bottom, with mapping relationships indicating the flow of information from the Web Service (WS) to the medium (Med).
Luisa SWS Infrastructure: Architecture

Annotation Interface → LUISA LMS → eLearning Applications → Authoring Applications → Interface Layer

Negotiation Layer

Results Composer → Query Manager

Transparency Layer

SWS Environment (IRS-III)

Semantic Web Service Layer

Service Layer

Data Layer

Annotation Tool → LUISA LOMR → … → …
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Use Case
Use Case: Scenario

Highly adaptive and standard-compliant learning packages:

- One unique IMS Content Package (IMS LD) reused across different learning contexts

- Different learners supported by achieving his/her different objectives
  (e. g. “Learn German”, “Learn Italian” …)

- Individual learner preferences (e. g. native language) are considered at runtime for the dynamic service selection
  (e. g. french learners get french learning content… )
Use Case: IRS-III

Standard-compliant Packages (Process Designer/Automatic)

WSMO Descriptions (Resource Provider)

LPMO Descriptions

Learning Web Service (Resource Provider)
Use Case: Dynamic Context-Adaptation

- Context-adaptive delivery of …
- … distributed learning resources based on semantic matchmaking

1. User details → User Authentication
2. User objective → Gap Analysis
3. User selects competency → Identify Repository
4. User selects repositories → Retrieve LOs

Update Profile
Use Case: Dynamic Context-Adaptation

- Context-adaptive delivery of …
- … distributed learning resources based on semantic matchmaking

1. User details
   2. User objective
   3. Identify Repository
   4. Retrieve LOs
   5. Update Profile
Prototype Application: User Authentication

Involved Semantic Web Services …
Prototype Application: **User Authentication**

Involved **Semantic Web Services** and 
**semantic concepts:**

```
wsmo:Goal
Get User Profile

wsmo:WgMediator
Get User Profile

wsmo:WebService
Get OU User Profile
wsmo:WebService
Get UHP User Profile
wsmo:WebService
Get EADS User Profile
```

```
lpmo:Name

lpmo:Organization

lpmo:Actor

lpmo:Individual

lpmo:ActorDescription

uhp:Profile

eads:IndividualDescription

eads:OrganisationalUnit
```
Prototype Application: **User Authentication**

Involved **Semantic Web Services** and **semantic concepts**:

```
wsmo:Goal
  Get User Profile

wsmo:WgMediator
  Get User Profile

wsmo:WebService
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wsmo:WebService
  Get UHP User Profile

wsmo:WebService
  Get EADS User Profile
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```
lpmo:Name

lpmo:Organization

lpmo:Actor

lpmo:Individual

lpmo:ActorDescription

uhp:Profile

eads:IndividualDescription

eads:OrganisationalUnit
```
Prototype Application: **User Authentication**

Involved **Semantic Web Services** and **semantic concepts**:

```
wsmo:Goal
Get User Profile
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wsmo:WebService
Get UHP User Profile
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```
wsmo:WebService
Get EADS User Profile
```

```
lpmo:Name
```

```
lpmo:Organization
```

```
lpmo:Actor
```

```
lpmo:Individual
```

```
lpmo:ActorDescription
```

```
uhp:Profile
```

```
eads:IndividualDescription
```

```
eads:OrganisationalUnit
```

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Use Case: Dynamic Context-Adaptation

- Context-adaptive delivery of ...
- ... distributed learning resources based on semantic matchmaking
Prototype Application: **Gap Analysis**

Involved **Semantic Web Services** …

```
wsmo:Goal
Gap Analysis

wsmo:WgMediator
Gap Analysis

wsmo:WebService
Gap Analysis
```
Prototype Application: Gap Analysis

Involved Semantic Web Services and semantic concepts:
Prototype Application: **Gap Analysis**

Involved **Semantic Web Services** and **semantic concepts**:

- **wsmo:Goal**
  - Gap Analysis

- **wsmo:WgMediator**
  - Gap Analysis

- **wsmo:WebService**
  - Gap Analysis

**computed competency gap**

(list of competencies)
Use Case: Dynamic Context-Adaptation

- Context-adaptive delivery of …
- … distributed learning resources based on semantic matchmaking

1. User authenticates
2. User sets objective
3. User selects competency
4. User retrieves LOs
5. User updates profile

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Prototype Application: **Identify Repositories**

Involved **Semantic Web Services** …

- `wsmo:Goal` Identify Repositories
- `wsmo:WgMediator` Identify Repositories
- `wsmo:WebService` Identify Repositories
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Prototype Application: **Identify Repositories**

Involved **Semantic Web Services** and **semantic concepts**:

```
wsmo:Goal
Identify Repositories

wsmo:WgMediator
Identify Repositories

wsmo:WebService
Identify Repositories
```

Diagram showing relationships between different semantic concepts and resources involved in identifying repositories.
Prototype Application: **Identify Repositories**

Involved **Semantic Web Services** and **semantic concepts**:
Prototype Application: Identify Repositories

Involved Semantic Web Services and semantic concepts:

Matching repositories (list)
Use Case: **Dynamic Context-Adaptation**

- Context-adaptive delivery of …
- … distributed learning resources based on semantic matchmaking
Prototype Application: **Retrieve Objects**

Involved **Semantic Web Services** …

![Diagram showing the flow of Semantic Web Services](image-url)
Prototype Application: Retrieve Objects

Involved Semantic Web Services and semantic concepts:
Prototype Application: Retrieve Objects

Involved Semantic Web Services and semantic concepts:

Filter Parameters
Prototype Application: **Retrieve Objects**

Involved **Semantic Web Services** and **semantic concepts**:

- **Filter Parameters**
  - \texttt{wsmo:Goal}
  - \texttt{wsmo:WgMediator}
  - \texttt{wsmo:WebService}
    - \texttt{Get Query Parameters}
    - \texttt{Query OAI Repository}
    - \texttt{Query Open Learn}
  - \texttt{wsmo:WebService}
    - \texttt{Filter Results}

- **Repository Descriptions**
  - \texttt{lpmo:DomainConcept}
  - \texttt{lpmo:Domain}
  - \texttt{lpmo:CompetencyInDomain}
  - \texttt{lpmo:CompetencyLevel}
  - \texttt{lpmo:Language}
  - \texttt{lpmo:Educational Method}
  - \texttt{lpmo:InteractionType}

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Prototype Application: Retrieve Objects

Involved Semantic Web Services and semantic concepts:

- wsmo:Goal
  - Get Objects
- wsmo:WgMediator
  - Get Objects
- wsmo:WebService
  - Get Objects
  - Query OAI Repository
  - Query Open Learn
  - Filter Results
- wsmo:Domain
- Ipno:DomainConcept
  - partOf
  - targets
  - providedBy
- Ipno:Resource
  - targets
  - providedBy
- Ipno:ActorDescription
- Ipno:CompetencyInDomain
- Ipno:CompetencyLevel
- Ipno:Language
- Ipno:Object
- Ipno:Repository
- Ipno:Service
- oai:Object
- ol:Object
- Ipno:InteractionType
- Ipno:Educational Method

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Prototype Application: **Retrieve Objects**

Involved **Semantic Web Services** and **semantic concepts**:

[Diagram showing relationships between semantic web services and concepts, including `wsmo:Goal`, `wsmo:WgMediator`, `wsmo:WebService`, `ipmo:Domain`, `ipmo:Resource`, `ipmo:ResourceDescription`, `ipmo:Service`, `ipmo:Repository`, `oai:Object`, `ol:Object`, and interactions between these entities.]

Learning Objects
Prototype Application: **Retrieve Objects**

Involved **Semantic Web Services** and **semantic concepts**:

- WSMO: `Goal` Get Objects
- WSMO: `WgMediator` Get Objects
- WSMO: `WebService` Get Query Parameters
- WSMO: `WebService` Query OAI Repository
- WSMO: `WebService` Query Open Learn
- WSMO: `WebService` Filter Results

**Filter Parameters**

**Learning Objects**
Prototype Application: **Retrieve Objects**

Involved **Semantic Web Services** and **semantic concepts**: 

Matching objects (list)
Luisa Demo Video
Summary

• Applying SWS to support emergency planning
  – Integration of IRS-III and Google Maps

• Applying SWS to business process modelling
  – Ontology stack related to BPM notations and BPEL

• Applying SWS to eLearning in the Luisa project
  – Moving from learning objects to learning services
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