Geospatial ontologies and semantic annotation
– experiences from the SWING project

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W3C – TelCon, July 21st, 2009
Introduction

How do we see the Geospatial Web?
Introduction

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How do we see the Geospatial Web?
How are Semantics brought in?

Data Providing Service

Geospatial Data represents

Real World
How are Semantics brought in?

Exposed Data Model

Data Providing Service

Geospatial Data

represents

Ontology

Real World

Introduction
How are Semantics brought in?

Exposed Data Model

Data Providing Service

Geospatial Data

Here!

Annotation

Ontology

represents

Real World

/Introduction

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Introduction

How are Semantics brought in?

Following Guarino:
An ontology is a logical theory accounting for the intended meaning of a community’s vocabulary.
Problem Definition

- Geospatial decision-support calls for service combination
  - Syntactic interoperability through standards
    - Discovery and integration: keyword search and manual work

- Semantic Web Service technology is promising! But...
  - Domain ontologies do not exist or are not shared
  - Requires that services are annotated by specialists
  - Has a high and steep learning curve
SWING Components

WP1 Geospatial dec.-making use cases
WP2 Service Execution Engine
WP3 Ontologies
WP4 Service Annotation Engine
WP5 Services and catalogues
WP6 Development environment
Objectives for the use of ontologies

- Development of ontology infrastructure to support:
  - **Semantic annotation** of service capabilities and service contents
  - Support the user in **formulating goals**
  - **Discovery** of geographic information and geoprocessing services
  - **Specify workflows** for service execution
**GOALS**

Objectives that a client wants to achieve by using Web Services

**ONTLOGIES**

Formal specification of [terminology](#) used by all other components

**WEB SERVICES**

Semantic description of Web Services:
- Capability (functional)
- Interfaces (usage)

**MEDIATORES**

Connectors between components with mediation facilities for handling heterogeneities
Geographic Information Services...

... provide standardized operations for data access
Semantic annotation needed for data content (domain specific)

OGC and ISO Ontologies (WSMO)

Domain Ontologies (WSMO)

Real World

WFS

represents

*
Ontology Formalization in SWING

⇒ Semantic annotation needed for data content (domain specific)
Semantic annotation needed for data content (domain specific)

- OGC and ISO Ontologies (WSMO)
- Feature Type Ontology (FTO)
- Domain Ontologies (WSMO)

\(\text{subConceptOf} \rightarrow \text{annotate}\)

Specific WFS Web Service (WSMO)

WFS represents * Real World

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 Ontology Formalization in SWING

⇒ Semantic annotation needed for data content (domain specific)

OGC and ISO Ontologies (WSMO)

Feature Type Ontology (FTO)

Domain Ontologies (WSMO)

Specific WFS Web Service (WSMO)

Real World

WFS

represents

subConceptOf

annotate

Real World

OGC and ISO Ontologies (WSMO)

OGC Filter Encoding Implementation Specification

OGC GML Implementation Specification

OGC WFS Implementation Specification

Service implementation rules

Filter encoding (optional)

Geodata encoding rules

/Details/Annotation

Ontology Formalization in SWING

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OGC and ISO Ontologies (WSMO)

Feature Type Ontology (FTO)

Domain Ontologies (WSMO)

Specific WFS Web Service (WSMO)

Real World

WFS

represents

subConceptOf

annotate

Real World
Concept-based Annotation: Challenge

Domain Ontology

- QuarrySite
- hasName
- Name
- _string
- Name
- exploitation
- punctual
- production

FTO
Concept-based Annotation: Challenge

Domain Ontology

- QuarrySite
  - hasName
  - Name
    - _string
      - Name
      - exploitation
      - punctual
      - production

FTO
Concept-based Annotation: Challenge

Domain Ontology

swin#annotate

_name
Owner

exploitation
punctual
production

FTO
Concept-based Annotation: Challenge

Domain Ontology

- QuarrySite
- Name
  - hasName
  - hasOwner
    - Owner
      - hasName

swing#annotate

_exploitation_punctual_production

FTO
Concept-based Annotation: Challenge

Domain Ontology

- QuarrySite
  - hasName
  - hasOwner
  - Owner

- Name
  - hasName
  - hasOwner

- _string

- _string

FTO
Instance-based Annotation: Introduction

Domain Ontology

```
 Quarriesite
  
  memberOf

  ?realQuarry

  memberOf

  exploitationpunctualproduction

  memberOf

  ?nameAtt

  ?feature
```

FTO
Instance-based Annotation: Introduction

Domain Ontology

- **NamedObject** hasName **Name**
  - memberOf **?realQuarry**
  - memberOf **?name1**

- **_string** Name
  - exploitationpunctualproduction
    - memberOf **?nameAtt**
    - memberOf **?feature**

- **QuarrySite**
  - memberOf **?realQuarry**

FTO
Instance-based Annotation: Introduction

Domain Ontology

NamedObject hasName Name

memberOf ?realQuarry

memberOf ?name1

_Name string

_Name Name

string annotate

memberOf ?realQuarry

memberOf ?feature

memberOf ?nameAtt
Instance-based Annotation: Introduction

Domain Ontology

```
NamedObject hasName Name
_memberOf ?realQuarry

_name string Name

exploitationpunctualproduction

_memberOf ?nameAtt

?feature [Name hasValue ?nameAtt] memberOf fto#exploitationpunctualproduction and
?realQuarry memberOf domain#Quarry and
generic#hasName(?realQuarry, ?name1) and
swing#annotate(?nameAtt, ?name1).
```

FTO
Instance-based Annotation: Introduction

Domain Ontology

NamedObject hasName Name

memberOf

?realQuarry

memberOf

QuarrySite

?name1

memberOf

_name

Name

exploitationpunctualproduction

memberOf

?nameAtt

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?feature

memberOf

fto#exploitationpunctualproduction and

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FTO
Instance-based Annotation: Introduction

Domain Ontology

NamedObject hasName Name

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_string Name

exploitationpunctualproduction

memberOf

memberOf

?realQuarry

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 shortcut

?feature [Name hasValue ?nameAtt] memberOf fto#exploitationpunctualproduction and

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Instance-based Annotation: Introduction

Domain Ontology

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?feature [Name hasValue ?nameAtt] memberOf fto#exploitationpunctualproduction and
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swing#annotate(?nameAtt, ?name1).

FTO
```
Instance-based Annotation: Introduction

Domain Ontology

NamedObject hasName Name

memberOf

realQuarry

memberOf

name1

String

Name

exploitationpunctualproduction

memberOf

Feature

memberOf

realQuarry

memberOf

domain#Quarry

generic#hasName(realQuarry, name1)

swing#annotate(nameAtt, name1).

fto#exploitationpunctualproduction and

Feature

memberOf

realQuarry

memberOf

domain#Quarry

generic#hasName(realQuarry, name1) and

swing#annotate(nameAtt, name1).

FTO
Instance-based Annotation: Introduction

Domain Ontology

NamedObject

hasName

Name

memberOf

?realQuarry

memberOf

?nameAtt

_ownerAtt

exploitation

punctual

production

_nameAtt

memberOf

_Name

Owner

memberOf

?realQuarry

hasOwner

Owner

memberOf

?realOwner

_string

_nameAtt

memberOf

?nameAtt

_Name

Owner

memberOf

?realQuarry

hasOwner

Owner

memberOf

?realOwner

_string

_Name

Owner

memberOf

?realQuarry

hasOwner

Owner

memberOf

?realOwner

_string

_Name

Owner

memberOf

?realQuarry

hasOwner

Owner

memberOf

?realOwner

_string

_Name

Owner

memberOf

?realQuarry

hasOwner

Owner

memberOf

?realOwner
Instance-based Annotation: Introduction

Domain Ontology
Instance-based Annotation: Introduction

Domain Ontology

```
NamedObject hasName Name

?realOwner

memberOf

_name_

Name Owner _string_

exploitationpunctualproduction

?nameAtt

memberOf

?feature

memberOf

?ownerAtt

memberOf

?realQuarry

memberOf

QuarrySite hasOwner Owner

 membrane

swin#annotate

?realOwner

memberOf

IST FP6-26514

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```
Instance-based Annotation: Introduction

Domain Ontology

```
?feature[Owner hasValue ?ownerAtt] memberOf fto#exploitationpunctualproduction and
?realOwner memberOf domain#Owner and
generic#hasName(?realOwner, ?name2) and
swing#annotate(?ownerAtt, ?name2).
```
Instance-based Annotation: Introduction

Domain Ontology

NamedObject \(\text{hasName}\) Name

memberOf

?realOwner

_name

\_string

Name

Owner

_string

memberOf

memberOf

memberOf

_exploitationpunctualproduction

?feature[Owner hasValue ?ownerAtt] memberOf fto#exploitationpunctualproduction and
?realOwner memberOf domain#Owner and
generic#hasName(?realOwner, ?name2) and
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Instance-based Annotation: Introduction

Domain Ontology

```prolog
?-feature[Owner hasValue ?ownerAtt] memberOf fto#exploitationpunctualproduction and ?realOwner memberOf domain#Owner and generic#hasName(?realOwner, ?name2) and swing#annotate(?ownerAtt, ?name2).
```
Instance-based Annotation: Introduction

Domain Ontology

NamedObject $\overset{\text{hasName}}{\rightarrow}$ Name

memberOf

?realOwner

_name

Naming

memberOf

Owner

memberOf

?realQuarry

 Mitglied

hasOwner $\rightarrow$ Owner

memberOf

?realOwner

exploitationpunctualproduction

memberOf

?nameAtt

memberOf

?feature

Cost

memberOf

domain#Owner

generic#hasName(?realOwner, ?name2) and

swing#annotate(?ownerAtt, ?name2).
Instance-based Annotation: Benefit

⇒ More **flexible domain ontologies** can be developed

- **Global relations** allow for more flexibility
- Subsumptions can be defined in **axioms**
- Using axioms in **attribute definitions** on domain level
- Using axioms that **restrict attribute values** on domain level
  - E.g. located in “France”
Annotation and GI Standards

⇒ Presentations at ISO/TC211 TC meeting
⇒ Presentations at OGC TC meetings
⇒ An OGC Discussion Paper

[Diagram showing data flow from OGC Web Service to Domain Ontology with labels such as Quarry, Tons, and Application Ontology]

http://portal.opengeospatial.org/files/?artifact_id=34916
Thank you!

- SWING IST FP6-26514
- FP6 - STREP
- March 2006 – March 2009
- 7 partners
- **http://www.swing-project.org**

- www.sinetef.no/
- www.ijs.si/
- www.ionicsoft.com/
- www.brgm.fr
- www.uni-muenster.de/
- www.nuigalway.ie
- www.uibk.ac.at
Register annotated services

Register (WSML)

Annotate
Discover (WSML)
Scenarios all
/Demo

MiMS@Work - Annotation/Discovery
MiMS@Work - Composition Development

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Wrap-up

Why do we require ontologies?

How do we build the ontologies?
Knowledge Acquisition Strategy

- OGC and ISO standards
  - Knowledge already (semi-) formally available
  - UML via OWL to WSML to generate ontology skeletons
Knowledge Acquisition Strategy - DE

**Question 1: Concept: Quarry Location**

1. Is it in the aggregate domain?
2. Is it an activity?
3. Is it associated with humans?
4. Is it a physical thing?
5. Is it a natural thing? Does it exist in nature?
6. Is it related to geology?
7. Is it on the surface of the earth?
8. Is it a geological entity (a rock a volcano)?
9. Is it solid?
10. Is it determined by three dimensions?
11. Is it commonly available?
12. Does it have a color?
13. Is it a landscape object?
14. Does it have a size that is measurable?
15. Is it close to rivers?
16. Is the presence of rivers a prerequisite?

<table>
<thead>
<tr>
<th>Concept Name</th>
<th>French Name</th>
<th>further Relations (to Data Types)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AggregateResource</td>
<td>ressource en granulat</td>
<td>hasAmount (in tons)</td>
</tr>
<tr>
<td>BindingMaterial</td>
<td>liant, agglomérateur</td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>construction, bâtiment</td>
<td></td>
</tr>
<tr>
<td>Company</td>
<td>compagnie</td>
<td>Address, name</td>
</tr>
<tr>
<td>Concrete</td>
<td>béton</td>
<td></td>
</tr>
<tr>
<td>ConstructionApplication</td>
<td>application à la construction</td>
<td>Amount of consumption</td>
</tr>
<tr>
<td>ConstructionApplicationSite</td>
<td>site d'application à la construction</td>
<td>Location (end point of aggregate transportation)</td>
</tr>
<tr>
<td>ConstructionMaterial</td>
<td>matériaux de construction</td>
<td>hasFunctionalProperties2</td>
</tr>
<tr>
<td>ConsumptionRate</td>
<td>taux de consommation</td>
<td>hasValue</td>
</tr>
<tr>
<td>Extraction</td>
<td>extraction</td>
<td>ofType (Drilling, Blasting, Shoveling, Sawing)</td>
</tr>
<tr>
<td>Geology</td>
<td>géologie</td>
<td></td>
</tr>
<tr>
<td>IndustrialSite</td>
<td>site industriel</td>
<td>hasLocation, Type (Consumers of Quarry Product e.g. Paper Industry)</td>
</tr>
</tbody>
</table>

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SWING application theme

- Quarries and Aggregates

Aggregates = crushed hard rock (limestone, volcanic rock, sandstone, recycled concrete, …), or on- & off-shore sediments (sand & gravel)

Use Cases:

1. Create a consumption-production map of aggregates
2. Create a map of constraints
3. Create a map of quarry best locations

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Ontologies under Development

OGC and ISO Ontologies

- Geodata Encoding
  - General Feature Model Ontology
  - Spatial Schema Ontology
  - Temporal Schema Ontology
  - Geography Mark-up Language Ontology

- OGC Services
  - Web Service Common Ontology
  - Web Mapping Service Ontology
  - Web Feature Service Ontology
  - Web Coverage Service Ontology
  - Filter Encoding Ontology
  - Web Processing Service Ontology

Domain Ontologies

- Ontology on Location
- Ontology on Measurement
- Ontology on Geology
- Ontology on Quarrying
- Ontology on Hydrology
- Ontology on Water Management
- Ontology on Ecology
- Ontology on Environmental Protection
- ...
Ontologies under Development

OGC and ISO Ontologies

- Geodata Encoding
  - General Feature Model Ontology
  - Spatial Schema Ontology
  - ...
- OGC Services
  - Web Service Common Ontology
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Domain Ontologies

- Ontology on Location
- Ontology on Measurement
- Ontology on Geology
- Ontology on Environmental Protection
- ...

http://swing.brgm.fr/repository/ontologies