Applying Semantic Web Technologies in Service-Oriented Architectures

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Semantic Web for Air Transportation (SWAT)
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Introduction

• Intro to OGC
  – Cross Community Interoperability (CCI) Threads
  – Aviation Threads

• Testbed 9 (OWS-9): Semantic Mediation

• Testbed 10: Ontology

• Testbed 11: Symbology

• Future Work
OGC’s Approach for Advancing Interoperability

- **Interoperability Program (IP)** - a global, innovative, hands-on rapid prototyping and testing program designed to unite users and industry in accelerating interface development and validation, and the delivery of interoperability to the market.

- **Standards Program** - Consensus standards process similar to other Industry consortia (World Wide Web Consortium, OMA etc.).

- **Compliance Testing and Certification Program** - allows organizations that implement an OGC standard to test their implementations with the mandatory elements of that standard.

- **Communications and Outreach Program** - education and training, encourage take up of OGC specifications, business development, communications programs.
**OGC Testbed Projects**

**OGC Testbeds** provide an environment for collaborative, fast-paced, multi-vendor rapid prototyping efforts to define, design, develop, and test candidate interface and encoding specifications.

- **29 organizations**
- **> 150 individuals**
- **56 components**
- **31 Documents**
- **$1.8 Million**
OGC Testbed Projects

OGC Testbeds provide an environment for collaborative, fast-paced, multi-vendor rapid prototyping efforts to define, design, develop, and test candidate interface and encoding specifications.
• **Challenge**
  - Demonstrate the querying of Aviation data through user terminology from the Pilots’ Glossary (e.g. High Speed Taxiway -> aixm:Taxiway)

• **Semantic Mediation Requirements**
  - Implement user friendly interfaces that are based on understood concepts (glossary)
  - Interface with web services based on OGC standards and offering data modelled on the Aeronautical Information Exchange Model (AIXM)
  - Experimental application of the FAA Air Transportation Information Ontology
Pilots terminology

- Using **Air Transportation Information Ontology**

  - **Includes** Pilot Controller Glossary for the JPAMS project (air traffic control procedures)
AIXM features

GM_Point
(from ISO 19107 Geometry)

<<object>>
Point

horizontalAccuracy : ValDistanceType

<<object>>
 ElevatedPoint

elevation : ValDistanceVerticalType
gs: geoidUndulation : ValDistanceSignedType
verticalDatum : CodeVerticalDatumType
verticalAccuracy : ValDistanceType
## AIXM features

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>locationIndicatorICAO</td>
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<tr>
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</table>
OWS-9 CCI Aviation Architecture

- Pilots
- Web Feature Service
- Web Processing Service
- SPARQL Server
- FAA Air Transportation Information Ontology mappings Glossary and AIXM
- Pilot Controller Glossary
- OGC
- AIXM Data (GML)
WPS SPARQL Server provides mappings

```xml
<wps:Execute service="WPS" version="1.0.0" xmlns:wps="http://www.opengis.net/wps/1.0.0"
xmlns:ows="http://www.opengis.net/ows/1.1" xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:xsi:nil="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/wps/1.0.0
http://schemas.opengis.net/wps/1.0.0/wpsExecute_request.xsd">
  <wps:DataInputs>
    <wps:Input>
      <ows:Identifier>query</ows:Identifier>
      <wps:Data>
        <wps:LiteralData>High Speed Taxiway</wps:LiteralData>
      </wps:Data>
    </wps:Input>
  </wps:DataInputs>
  <wps:ResponseForm>
    <wps:ResponseDocument storeExecuteResponse="false" lineage="false" status="false">
      <wps:Output>
        <ows:Identifier>result</ows:Identifier>
        <ows:Title>result</ows:Title>
        <ows:Abstract>result</ows:Abstract>
      </wps:Output>
    </wps:ResponseDocument>
  </wps:ResponseForm>
</wps:Execute>
```
WPS responds AIXM features from a WFS

```xml
<ns:ProcessOutputs>
  <ns:Output>
    <ns1:Identifier xmlns:ns1="http://www.opengis.net/ows/1.1">result</ns1:Identifier>
    <ns1:Title xmlns:ns1="http://www.opengis.net/ows/1.1">result</ns1:Title>
    <ns:Data>
      <ns:LiteralData dataType="xs:string">
        <![CDATA[
        ]]>"
      </ns:LiteralData>
    </ns:Data>
  </ns:Output>
</ns:ProcessOutputs>
```
Search interface
Search Interface
Testbed 10

- Linking
- Point conflation
- Core Ontology
Gazetteer Linking Concept

NGA Data (UFI) → NGA - GeoNames Link (UFI/GeoNamesID) → GeoNames Data GeoNamesID Attribute/Spatial Information

Dbpedia - GeoNames sameAs → DBpedia

GeoNames - OSM sameAs

- OpenStreetMap Point
  - OSM Node ID

- OpenStreetMap Polygon
  - OSM Relation ID

NGA UFI: -569498
GeoNames ID: [http://sws.geonames.org/6076211/](http://sws.geonames.org/6076211/)
Dbpedia Link: [http://live.dbpedia.org/page/Moncton](http://live.dbpedia.org/page/Moncton)
OSM Point: [http://linkedgeodata.org/triplify/node204466183](http://linkedgeodata.org/triplify/node204466183)
OSM Boundary: [http://linkedgeodata.org/page/triplify/relation1109568](http://linkedgeodata.org/page/triplify/relation1109568)
Point conflation in the Monterey area

Example scenario: Add all (non-duplicate) firestations from TNM to TDS

Attribute mappings (TNM->TDS)

- address -> address
- name -> geoNameCollection.memberGeoName.fullName

Fixed attribute value:
- featureFunction-1->”firefighting”
Testbed 10 - Geospatial Ontology

Temporal
- Temporal Entities
- Temporal Reference Systems
- Temporal Quantity
- Temporal Relations
- Temporal Units

Measure
- Quantity
- Measurement Scale
- Reference Systems
- Measure
- Observable Properties

Mereotopology
- Topological Object
- Topological Primitives
- Topological Relations
- Mereology

Common
- Upper Ontology
- Collections
- Role
- Identifiers
- Relations

Math
- Math Entities
- Math Operations
- Math Relations
- Math Datatypes
Testbed 11

- Linking
- Symbology mediation
- Semantics of Business Vocabulary and Rules
Linking with the National Map

Geographic names refer to hydrographic features

Hydrographic features follow the land elevation

Stream gauges and water sampling refer to hydrographic features
Overview of Components: TNM Hydro & Names

- **GeoSPARQL**
  - Rules to map and link Hydro and non-hydro features
  - (Uses algorithms to convert needed data (e.g. TNM in RDF))

- **WFS-G**
  - GNIS

- **WFS**
  - The National Map
  - NHD + GNIS

- **WPS**
  - Convert RDF data from the TNM

- **Client(s) for Semantics**
  - GIS.FCUs

- **Image Matters**

- **Envitia**
  - RDF Conversion

- **OGC**

Testbed 11 - Symbology Mediation
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Styled Layer Descriptor / Symbology Encoding

Aviation Client

GeoSPARQL Ontology Service

AIXM Web Feature Service

SLD/SE Producer

Data Broker

Feature Portrayal Service (FPS)
Aviation Symbology Demo

Luciad AviationClientX - Dispatch Client

Set type: Rotary wing Set start date: Now Set speed: 60.00 km/h

AIXM Data Loader
FlXM Data Loader
WPS Client
WXXM Data Loader
Map Layers
Portrayal Connector

LUCIAD

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Community models

Application Schemas created extending classes via UML

How can we express (model) and validate this?

ICAO Annex 11: “If a control zone is located within the lateral limits of a control area, it shall extend upwards from the surface of the earth to at least the lower limit of the control area.”
ICAO Annex 11: “If a control zone is located within the lateral limits of a control area, it shall extend upwards from the surface of the earth to at least the lower limit of the control area.”
Solution: SBVR to Schematron

SBVR Text:

NounConcept  VerbConcept  Name  Keyword  Other

Each Airspace.type equal to 'CTR' or 'CTR_P' must have at least one AirspaceGeometryComponent.airspaceVolume.lowerLimit equal to '0' and one AirspaceGeometryComponent.airspaceVolume.lowerLimitReference equal to 'SFC'

Automatic

Schematron

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Linking Data recommendations from Testbed11

• Registry for managing unique identifiers for Linked Data
• Application of URI aliases (owl:sameAs)
• Advertise future NHD Linked Data Products in Semantic Web Search Engines
• Establish a standard for a GeoSPARQL Server
Web Services Architecture Pattern

Client

Web Feature Service

Web X Service

SPARQL Server

NEW
Testbed 12 – ideas for future work

- Standard Server for GeoSPARQL
- Advance use of LinkedData for conflation (trust and provenance)
- Restful architectures and discovery patterns using OGC services and models
- UML semantic modeling (mapping)
Questions?

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