UNIVERSITY OF Southampton

Semantic Access to Sensor Observations through Web APIs

Kevin Page, Alex Frazer, Bart Nagel,
David De Roure, Kirk Martinez

Web and Internet Science, University of Southampton, UK

UNIVERSITY OF Southampton

Overview of presentation

- Semantic Sensor Networks and Observations
- Building an API
  - REST and Linked Data
  - Domain expertise
- The High-level API for Observations (HLAPIO) service

UNIVERSITY OF Southampton

Sensors and the Semantic Web

1. Applying Semantic Web techniques and technologies to Sensor Networks
   - Using RDF, ontologies, ... to improve the management of sensor networks
2. Putting Sensor Network data on the Semantic Web
   - Making sensor data a useful component of the larger web of data

UNIVERSITY OF Southampton

Sensors and the Semantic Web

1. Applying Semantic Web techniques and technologies to Sensor Networks
   - Broadly aligned with the *producer-centric* view in OGC SWE (Open Geospatial Consortium)
2. Putting Sensor Network data on the Semantic Web
   - Broadly aligned with the *consumer-centric* view in OGC SWE

UNIVERSITY OF Southampton

Focus on Observations

- How to make observed data semantically useful for developers?
- How to support cross-domain (“unintended”) *re-use?*
- How can observations be linked to other data; to enable mashups?
- We take a domain-driven approach using REST and Linked Data

UNIVERSITY OF Southampton

Boscombe surf status

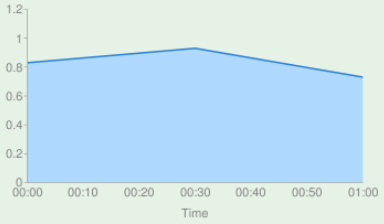
Sensor data

Sensor
An RDF representation of the sensor 'SSG4Env_Boscombe' URI
Location
Co-ordinates
50.71076, -1.83901
District
The Borough of Bournemouth

Sensor location map

Wave height data

Showing wave height data for today (2011-02-15) in metres



Nearby car parks

Overstrand	1.116km
East Overcliff	1.271km
Southbourne Car Park	2.271km
Berry Court	2.535km
Milburn Road Car Park	4.655km
Car Park	4.795km

Road accidents

Road accident statistics for this region (South West) compared to the national average

Food and drink

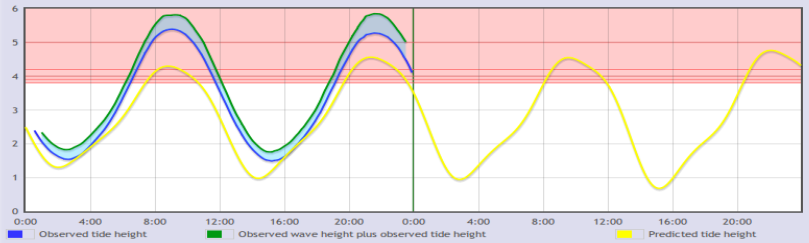
Places to get food and drink within 3km

- **10 pubs/bars**
- **9 cafés**
  - The Clock Café *(1.53km)*
  - Rosie's *(1.65km)*
  - Boscanova *(1.83km)*
  - Café Riva *(1.94km)*
  - Curzon Diner *(2.39km)*
  - Norwegian Wood *(2.70km)*
  - Coffee Republic *(2.87km)*
  - Caffe Nero *(2.88km)*
  - Costa *(2.89km)*
- **7 restaurants/fast food/barbecues /bakeries**
- **13 food/drink shops**

Flood gates

Current tide height

Last measured 4 minutes ago, the tide height is 4.108m.



Based on current observations, tide level is **falling**

The BBC predicts the tide level will **fall** to a level of **0.944m in 3 hours**

All gates

- Gate 0: High Street
- Gate 2: Circular Road
- Gate 1: Queen Street
- Gate 4: Wharf Road
- Gate 3: Mile End Road
- Gate 5: Twyford Avenue

Summary

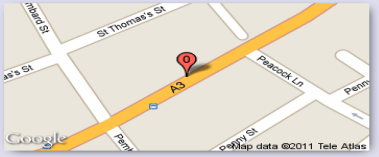
Currently 3 gates should be **closed**:

- Gate 0: High Street (threshold: 3.8m)
- Gate 2: Circular Road (threshold: 3.9m)
- Gate 1: Queen Street (threshold: 4m)

If the tide rises as far as 4.2m (not predicted) the next gates to be closed are:

- Gate: 4: Wharf Road
- Gate: 3: Mile End Road

Gate 0: High Street



- Coordinates: 50.7908, -1.1026
- Threshold: 3.8m
- Must be closed
- Notifiable amenities: nothing within 0.5km

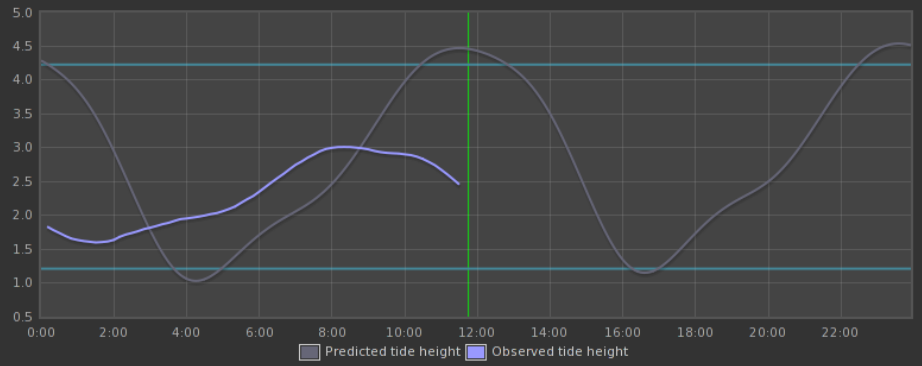
Gate 2: Circular Road

- Coordinates: 50.8078, -1.0918
- Threshold: 3.9m
- Must be closed
- Notifiable amenities: nothing within 0.5km

UNIVERSITY OF Southampton

Birdwatching mashup

Tide height



Birds

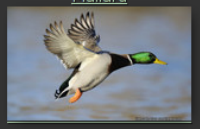
- Birds common in current conditions

These birds are resident in the mid-tide conditions currently found in the area

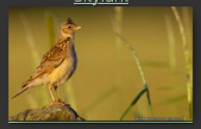
Lapwing

Little ringed plover

Mallard



Skylark



Bearded tit

Reed warbler

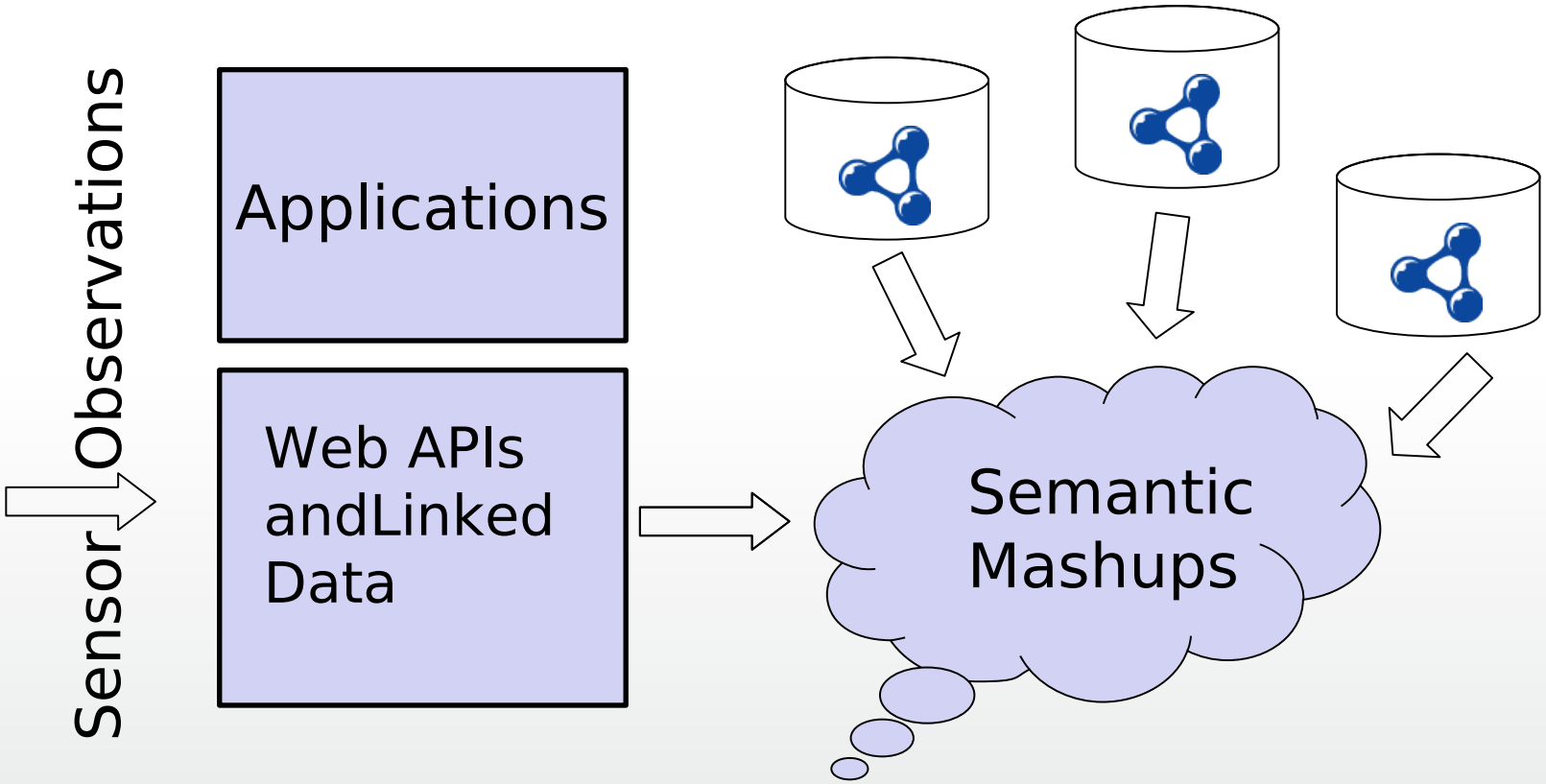
Sedge warbler

Osprey

- Birds you may additionally see if the tide gets higher
- Birds you may additionally see if the tide gets lower

Nearby amenities

- 5 pubs/bars
  - The Mayflower (2.1km) URI
  - The Fishermans (2.5km) URI
  - The Chequers (2.5km) URI


Sensor Observations
Applications
Web APIs andLinked Data
Semantic Mashups

UNIVERSITY OF Southampton

REST

- everything is a resource which is addressable
- resources have multiple representations
- relationships between resources are expressed through hyperlinks
- all resources share a common interface with a limited set of operations
- client server communication is stateless

UNIVERSITY OF Southampton

REST

REST tries to capture the features of the Web which have enabled it to scale so successfully

UNIVERSITY OF Southampton

Linked Data principles

1. Use URIs as names for things
2. Use HTTP URIs so that people can look up those names
3. When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL)
4. Include links to other URIs, so that they can discover more things

UNIVERSITY OF Southampton

Commonalities

- The Primacy of Resources
  - *Identification of resources is the key abstraction in REST and RDF where it is also the means to express relationships*
- Linking is not optional
  - *Links to other URIs to discover more things (Linked Data); and as the engine of application state (REST)*
- Segregation of Semantics
  - *Semantics have their place (and it's not in the resource addressing/URIs)*

UNIVERSITY OF Southampton

Adaptability

Both approaches can evolve over time…

- REST: state transitions can be changed by modifying the links returned by representations

- Linked Data: assertions about the same resource can be made at different times, in different places, using different ontologies

UNIVERSITY OF Southampton

Adaptability

Both approaches can evolve over time…

- REST: state transitions can be changed by modifying the links returned by representations
  - *modifying the hyperstructure*

- Linked Data: assertions about the same resource can be made at different times, in different places, using different ontologies
  - *modifying the hyperstructure*

UNIVERSITY OF Southampton

Model or API

What purpose are the commonalities put to?

Resources and their relationships are used to:

- REST: identify data and transition to other resources; the means to develop an application; an API
- Semantic Web: encapsulate the underlying data model; link to more related data using the model

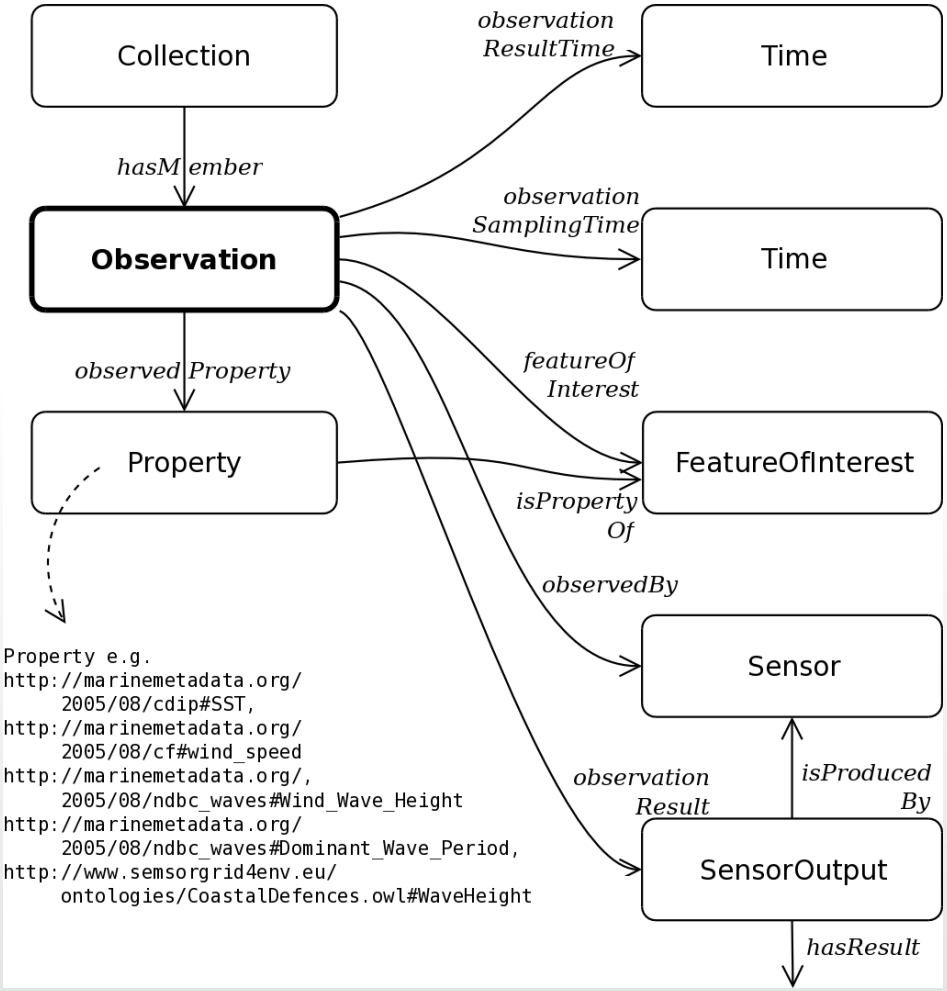
UNIVERSITY OF Southampton

Domain Driven Design

- Both the information model and API design are driven by the domain requirements
- This focuses differentiation and complexity where it should be: *around the issues and meaning specific to the domain*
- A common model can be shared between the data and the API

An Observation model...

- Based upon the work of the W3C SSN-XG
- Incorporated in the SemSorGrid4Env ontology suite
  - with UPM Madrid



UNIVERSITY OF Southampton

...at the core of an Observations API

- The backbone of the API, stored as an RDF model
- A resource for every Observation
- Linked to domain concepts
  - Feature of interest
  - Observed property
  - The sensors

UNIVERSITY OF Southampton

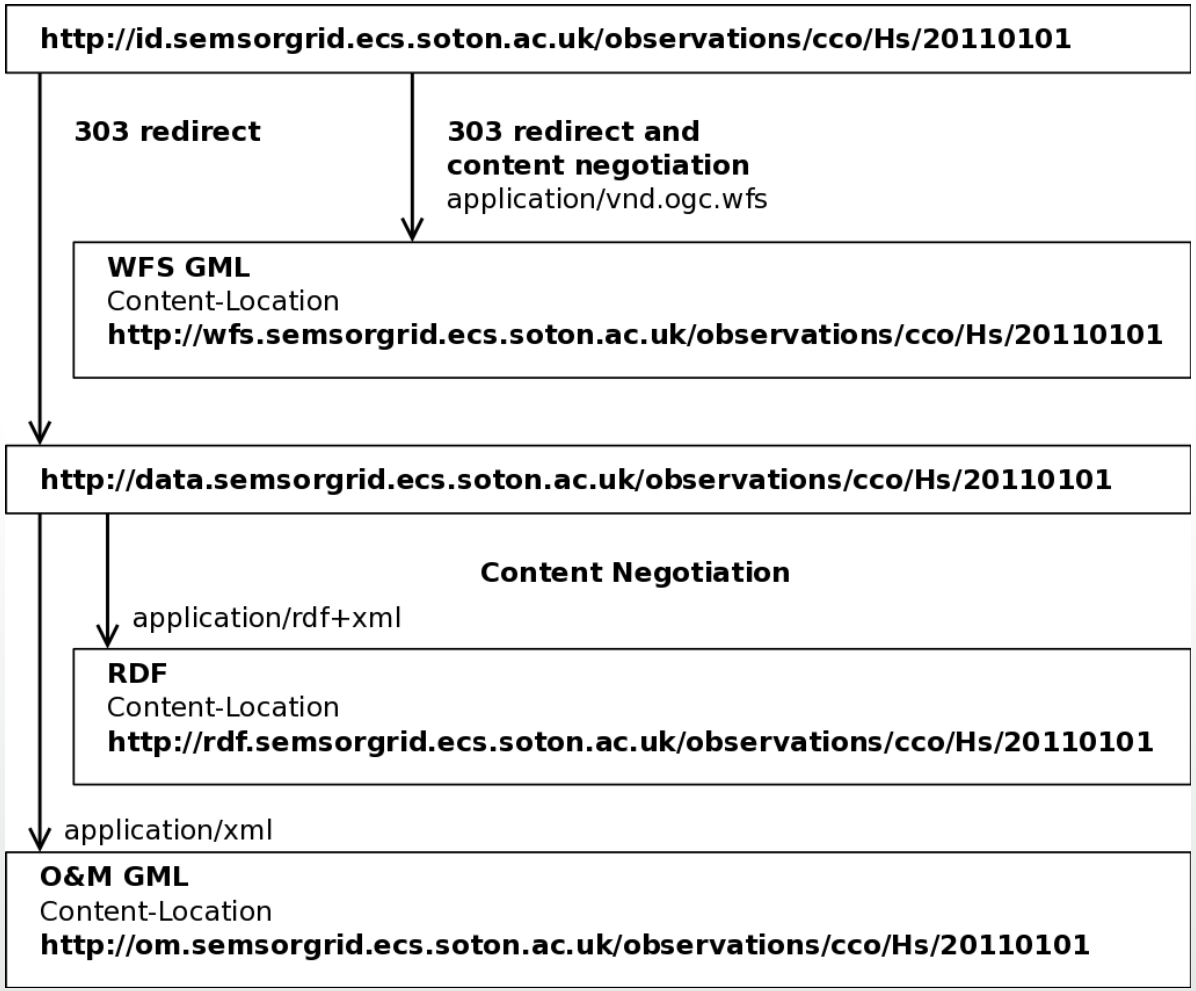
Is Linked Data enough?

- Is data, using a domain model, published as Linked Data, sufficient for a good API?
- It is a solid foundation, but further resources and representations are required to support the needs of developers (and thereby users)
  - Furthermore, we can utilise the semantics in the domain model to automate the delivery of this extended API

UNIVERSITY OF Southampton

Additional representations

- RDF is the primary internal representation
  - Serialised and added to a triplestore for SPARQL query interface
- Observations & Measurements GML
- HTML
- WFS GML
- GeoJSON


http://id.semsorgrid.ecs.soton.ac.uk/observations/cco/Hs/20110101
303 redirect
303 redirect and
content negotiation
application/vnd.ogc.wfs
WFS GML
Content-Location
http://wfs.semsorgrid.ecs.soton.ac.uk/observations/cco/Hs/20110101
http://data.semsorgrid.ecs.soton.ac.uk/observations/cco/Hs/20110101
Content Negotiation
application/rdf+xml
RDF
Content-Location
http://rdf.semsorgrid.ecs.soton.ac.uk/observations/cco/Hs/20110101
application/xml
O&M GML
Content-Location
http://om.semsorgrid.ecs.soton.ac.uk/observations/cco/Hs/20110101

UNIVERSITY OF Southampton

Additional resources

- /latest
- “next” and “previous”
- IsMemberOf / “up”
- /summary
- /sensors

UNIVERSITY OF Southampton

Publishing APIs: the HLAPIO service

- The API is designed to simplify the life of the (mashup) developer, who will be able to “follow his nose”
  - This doesn't make generating the API simple!
- Getting the domain model and data correct requires significant input from a domain expert
  - We can re-use these captured semantics to automatic and simplify deployment of the High-level API for Observations (HLAPIO) service

UNIVERSITY OF Southampton

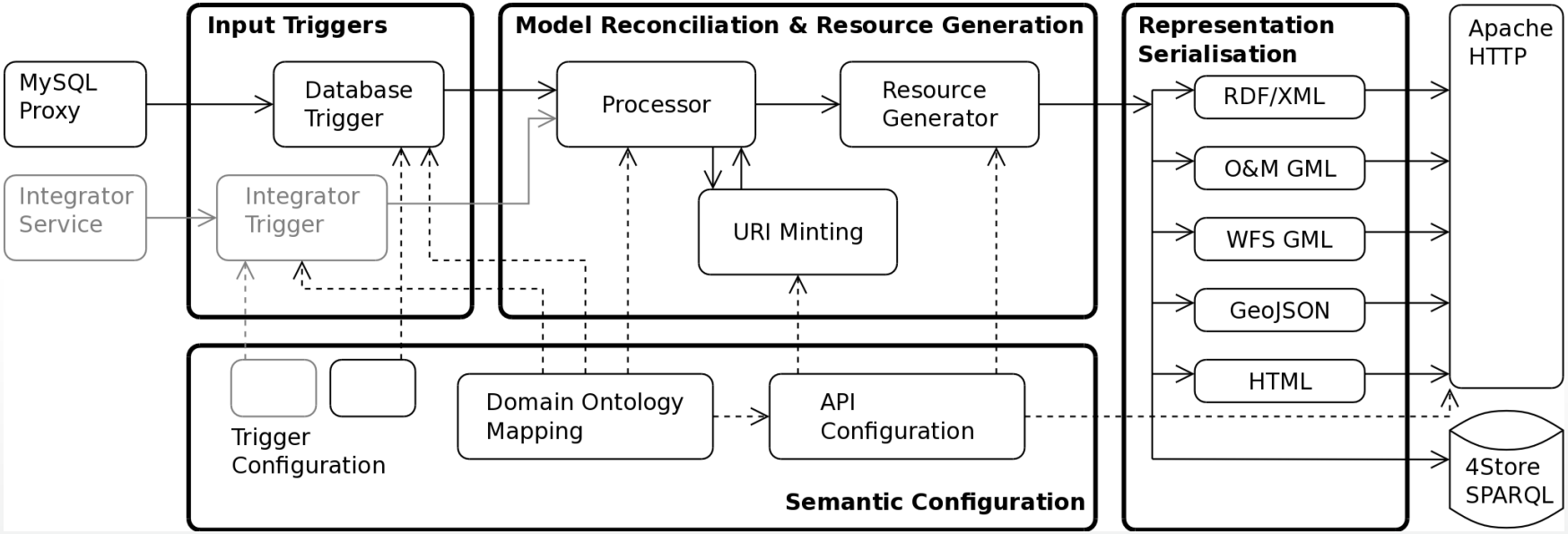
Expertise and configuration

- Building on the core Observation model
- The domain expert
  - Configures domain model
  - Correlated the sensor network measurements to this domain model
  - Links to other domain ontologies
  - Captured using an extension to D2RQ

UNIVERSITY OF Southampton

Automation from configuration

- The service administrator
  - Defines additional resources appropriate to the data source
  - For URIs to be “minted” and observation collections
  - Using terms from the domain model
- Model reconciliation and resource generation are automated from this configuration
- And for each resource, representations generated


Input Triggers
Model Reconciliation & Resource Generation
Representation Serialisation
MySQL Proxy
Database Trigger
Processor
Resource Generator
RDF/XML
Apache HTTP
Integrator Service
Integrator Trigger
URI Minting
O&M GML
WFS GML
GeoJSON
HTML
Trigger Configuration
Domain Ontology Mapping
API Configuration
4Store SPARQL
Semantic Configuration

UNIVERSITY OF Southampton

Summary

- A common semantic structure can be used as the basis for
  - A domain model
  - A Web API for lightweight web app development
- We have developed an example of this approach in the HLAPIO service
- The structure captured for the domain model can be used to assist automated provision of the HLAPIO service

University of Southampton

Thanks and acknowledgements

- Co-authors
  - Alex Frazer, Bart Nagel, David De Roure, Kirk Martinez
- Funding
  - European Commission IST FP7-223913 (SemsorGrid4Env)

- **Any questions?**