



Real World Internet, Smart City and Linked Data

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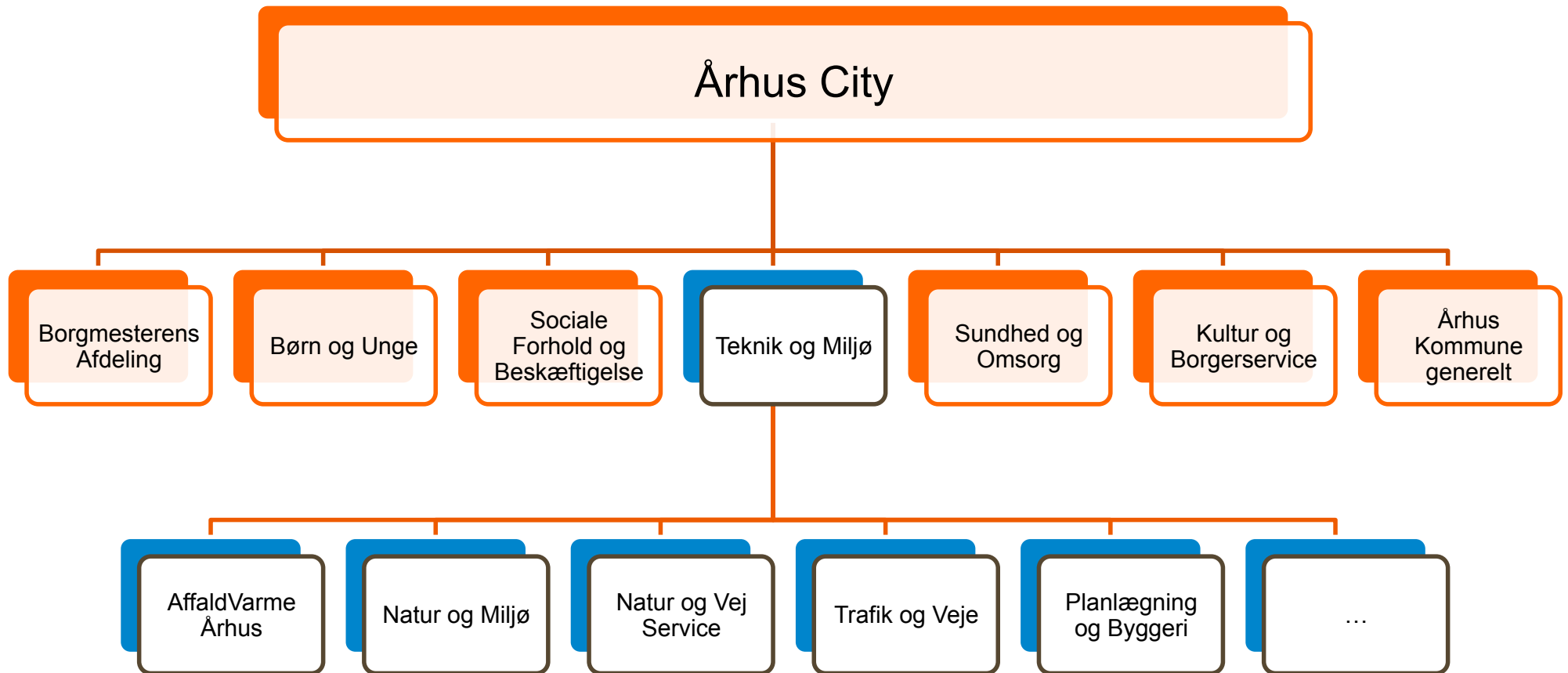
Smart City – why

A few dimensions...

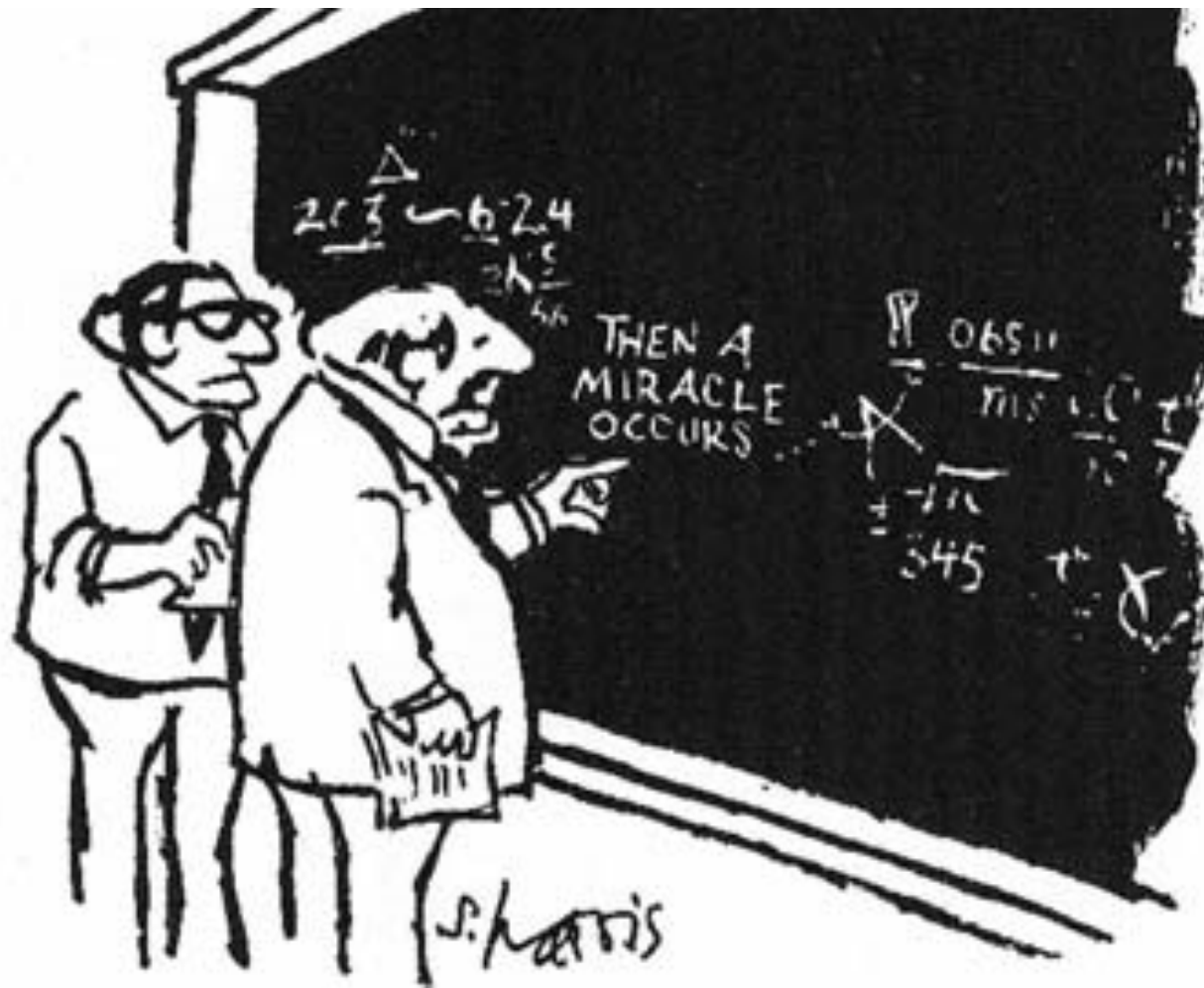
- **urbanisation:** recently we have reached the threshold of more than 50% of the population living in urban areas and the trend is continuing
- **demographics:** the population is aging and living longer
- **climate change:** green house gas emission (GHG) targets have been set, but it is apparent that reaching these targets will be a major challenge for growing cities
- **competitiveness:** cities are in competition, culture, tourism as well as attracting businesses are major factors for cities' success criteria, e.g. creation of jobs.

Tackling these dimensions with increasingly severe budget cuts and more demanding citizens will not be possible if the focus stays on only improving the cities' hard-infrastructures silos (transport networks, buildings, electricity networks, etc).

.....City – today



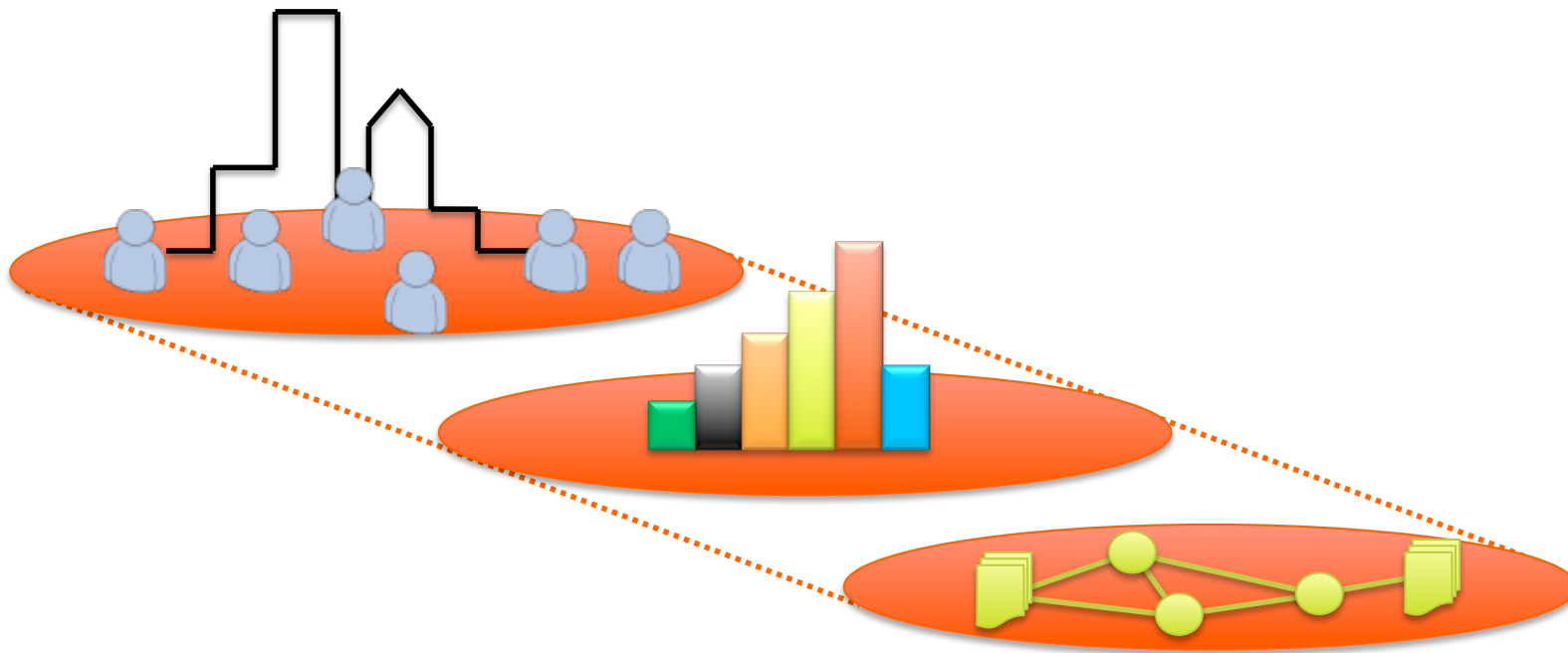
Everything is connected



"I think you should be more explicit here in step two."

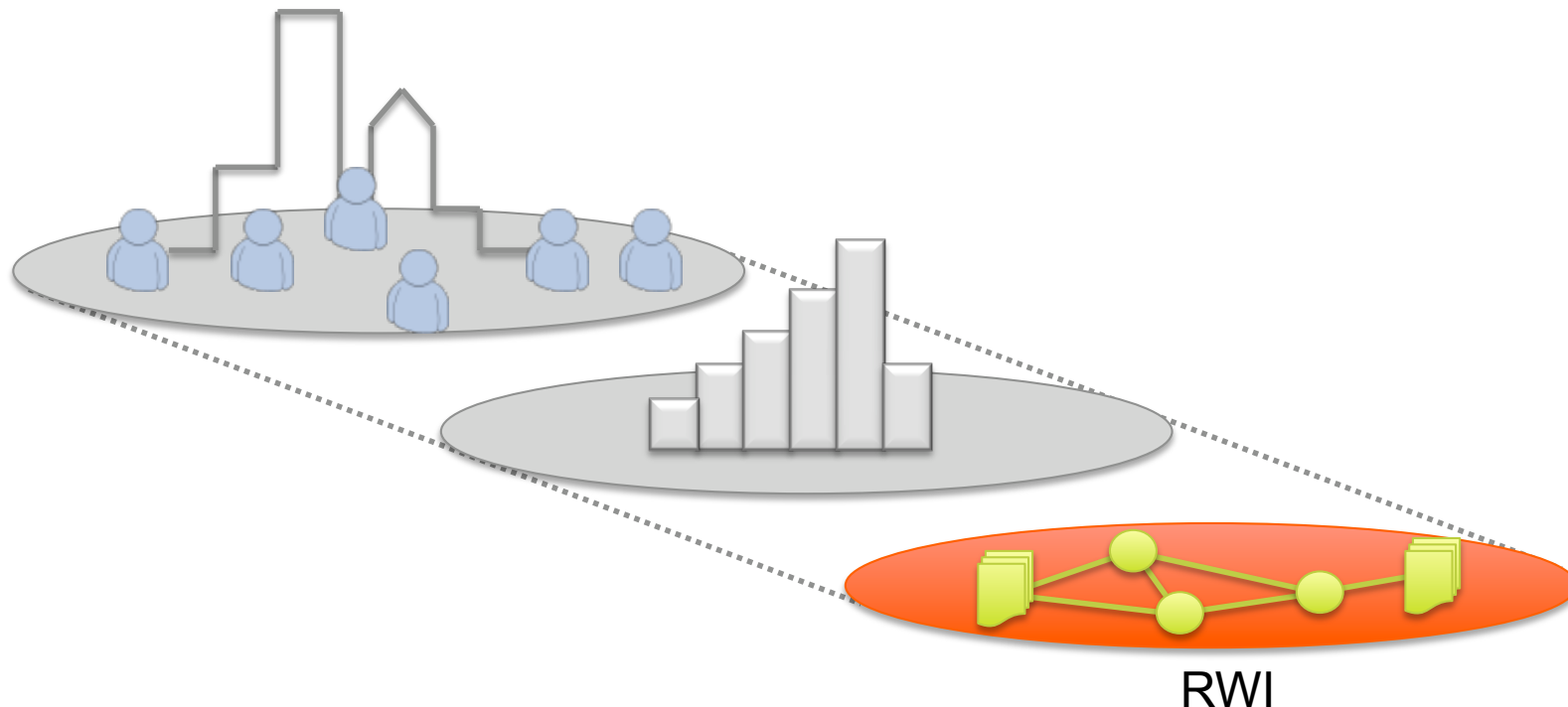
Smart City – concept

- Three levels:
 1. Urban Information Architecture – changing the city
 2. Urban Informatics – making bits tangible
 3. Instrumenting the physical Environment and Data Emancipation



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The Real World Internet (RWI)

- “*The Internet is extending its reach to the real world through innovations collectively termed the Internet of Things (IoT)*”.
- The Real World Internet is a realisation and integration of the *Physical World* into the *Digital World*.
- Enabling technologies :
 - Radio Frequency Identification (RFID) or wireless sensor and actuator networks (WSAN) – or in general Networked Embedded Devices (NED’s),
 - and software and service technologies that enable high-level access and utilisation of the real world data and resources.

RWI Challenges

- Numbers of devices and different users and interactions required.
 - Challenge: Scalability
- Heterogeneity of enabling devices and platforms
 - Challenge: Interoperability
- Huge volume of data emerging from the physical world, security and privacy
 - Challenge: Processing and mining the data, Providing secure access and preserving and controlling privacy.
- Annotations and meta-data
 - Challenge: Unified enriched and interoperable data description models
- Timeliness of the data
 - Challenge: Freshness of the data and supporting temporal requirements in accessing the data
- Ubiquity/Mobility
 - Challenge: addressing mobility, ad-hoc access and service continuity
- Global access and discovery
 - Challenge: Naming, Resolution and discovery of the real world resources

Using semantically enriched data

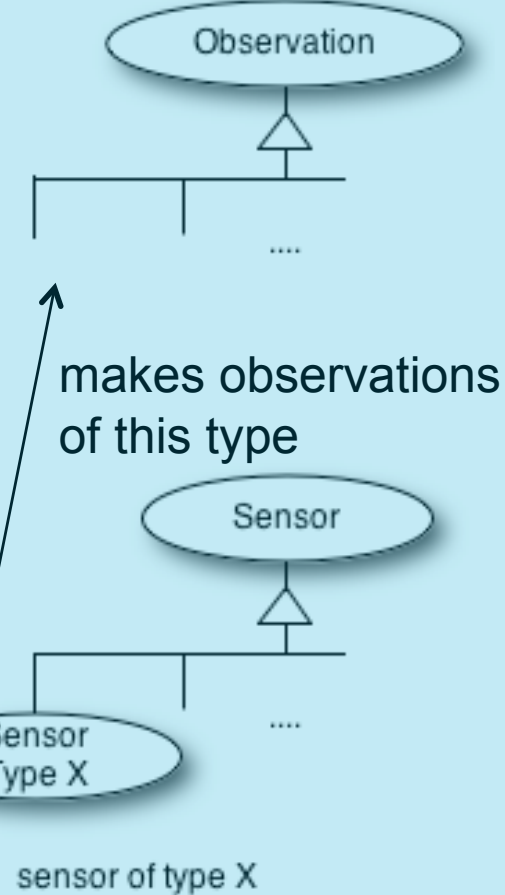
- The core technological building blocks are now in place and (widely) available: ontology languages, flexible storage and querying facilities, reasoning engines, etc.
- There are existing standards such as those provided by OGC and W3C's SSN Ontology.
- However, often there is no direct association to the domain knowledge
 - What a sensor measures, where it is, etc.
 - Association of an observation and/or measurement data to a feature of interest.

W3C SSN-XG ontology

SSN-XG annotations

```
<om:Observation>  
  <om:samplintTime><gml:TimeInstant>...</gml:TimeInstant>  
  <om:procedure xlink:role="http://www.w3.org/2009/Incubator/SSN/ontology/2008/09/proc" xlink:href="http://www.w3.org/2009/Incubator/SSN/ontology/2008/09/proc" />  
  <om:observedProperty xlink:href="http://www.w3.org/2009/Incubator/SSN/ontology/2008/09/observedProperty" />  
  <featureOfInterest xlink:href="http://sws.geonames.org/1295668" />  
  <om:result uom="http://www.w3.org/2009/Incubator/SSN/ontology/2008/09/uom" />  
</om:Observation>
```

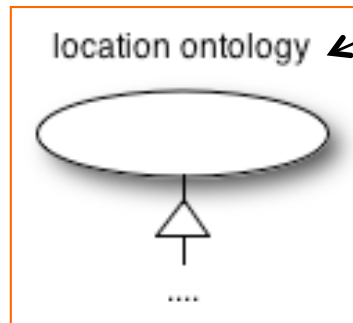
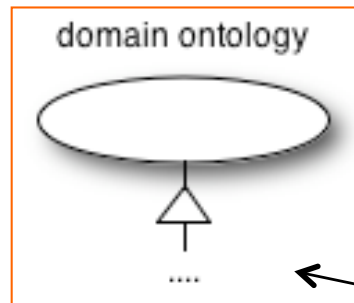
SSN-XG Ontology Scope



what it measures

what are the units

where it is



SSN-XG ontologies

Linked Data principles and RWI

- URI's as names for things;
 - URI's for RWI resources and data;
- HTTP URI's to enable people to look up those names;
 - Web-level access to low level sensor data and real world resource descriptions;
- Provide useful RDF information related to URI's that are looked up by machines or people;
 - Publish enriched resource descriptions, observation and measurement data in the form of linked RDF data;
- RDF statements that link to other URI's to enable discovery of other related things of the web of data;
 - Link and associate real world data to the existing data on the Web of Data;

Example: Using linked data for annotating sensing resources

Sense2Web - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://localhost:8084/Sense2Web1.0/SensorPub.html

Sense2Web

Sense to Web

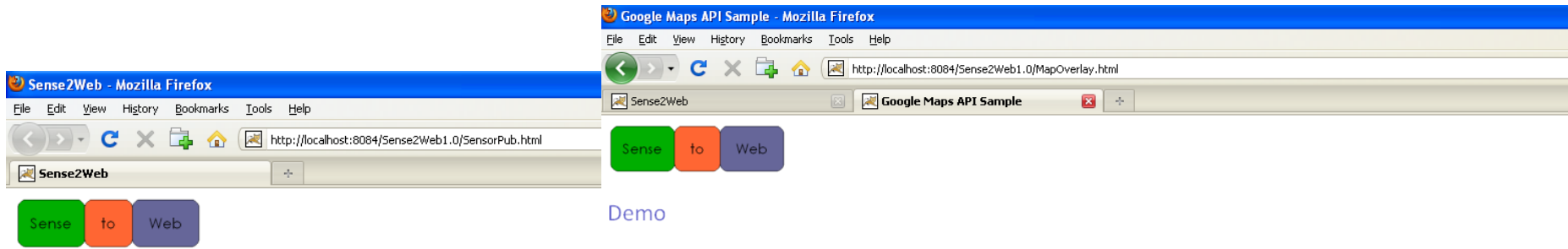
Sensor Registration Page

Sensor Name: TeloSBSensorTS1
Sensor ID: 3223a-86bca-0123-e123
Sensor Type: temperature
Temperature sensor@en | <http://dbpedia.org/resource/Temperature_sensor>
Sensor Location: CCSR
CCSR | <http://www.ee.surrey.ac.uk/ccsr/sensei/LocationOntology.owl#Building_CCSR>
Sensor Location from Linked-data: Guildford Any Place
Guildford@en | <http://dbpedia.org/resource/Guildford>
Tags from Linked-data:
Guildford@en | <http://dbpedia.org/resource/Guildford>
Guildford@de | <http://dbpedia.org/resource/Guildford>
Guildford@es | <http://dbpedia.org/resource/Guildford>
Guildford@fi | <http://dbpedia.org/resource/Guildford>
Guildford@fr | <http://dbpedia.org/resource/Guildford>
Guildford (Surrey) railway station@en | <http://dbpedia.org/resource/Guildford_%28Surrey%29_railway_station>
SOS link:
Guildford@it | <http://dbpedia.org/resource/Guildford>
Compton, Guildford@en | <http://dbpedia.org/resource/Compton%2C_Guildford>
Guildford@nn | <http://dbpedia.org/resource/Guildford>
Old Guildford, New South Wales@en | <http://dbpedia.org/resource/Old_Guildford%2C_New_South_Wales>
Sensor description file (RDF/OWL):
Browse...
Save Clear

Internal location ontology (local)

Lined-data location (external)

Example: Using linked data for annotating sensing resources



Sensor Registration Page

Sensor Name:

Sensor ID:

Sensor Type:

Sensor Location:

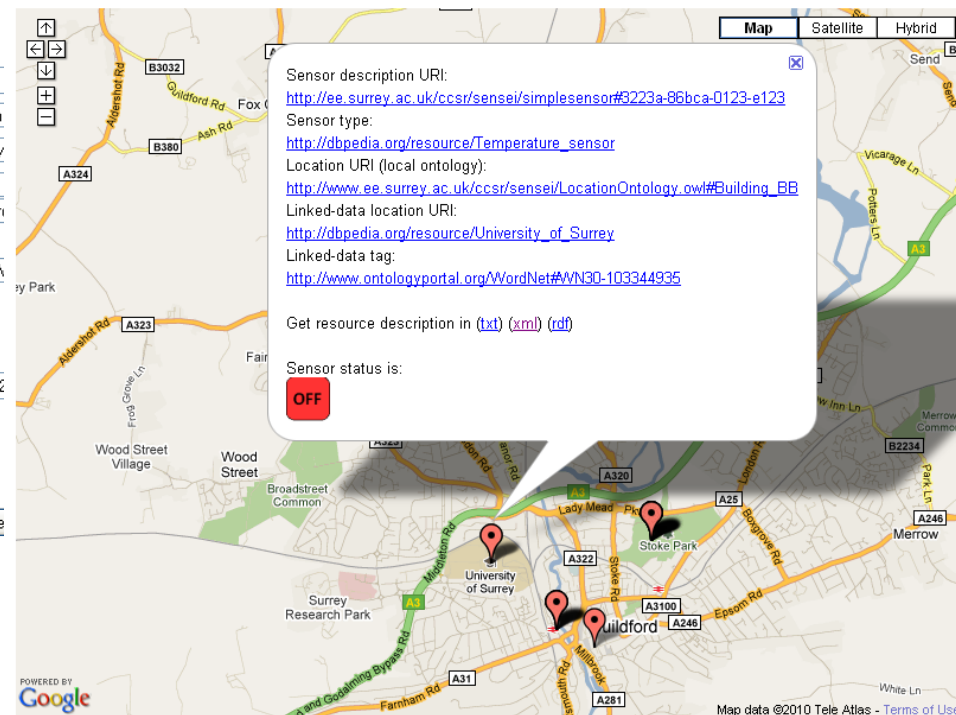
Sensor Location from Linked-data:

Tags from Linked-data:

Limit number of suggestions to:

SOS link:

Sensor description file (RDF/OWL):



- [HumanSensor](#)
- [Sensor#123](#)
- [FX-GD-67](#)
- [PMB-123](#)
- [sdfsdf56765](#)
- [ABC-test-SDB1](#)
- [TeloSBSensorTS1](#)

Linked data and RWI

- We can use existing linked data (Web of data) resources to annotate the Real World resource and data
 - Associating real world data and resources to the domain knowledge
 - e.g. GeoName entities to describe location, DBPedia entities to describe theme
- Publishing the resource descriptions and observation and measurement data as linked-data
 - i.e. Publishing RDF data and making it accessible via HTTP
- Providing standard interfaces to access and query the real world data
 - e.g. SPARQL-end points and reasoning mechanisms

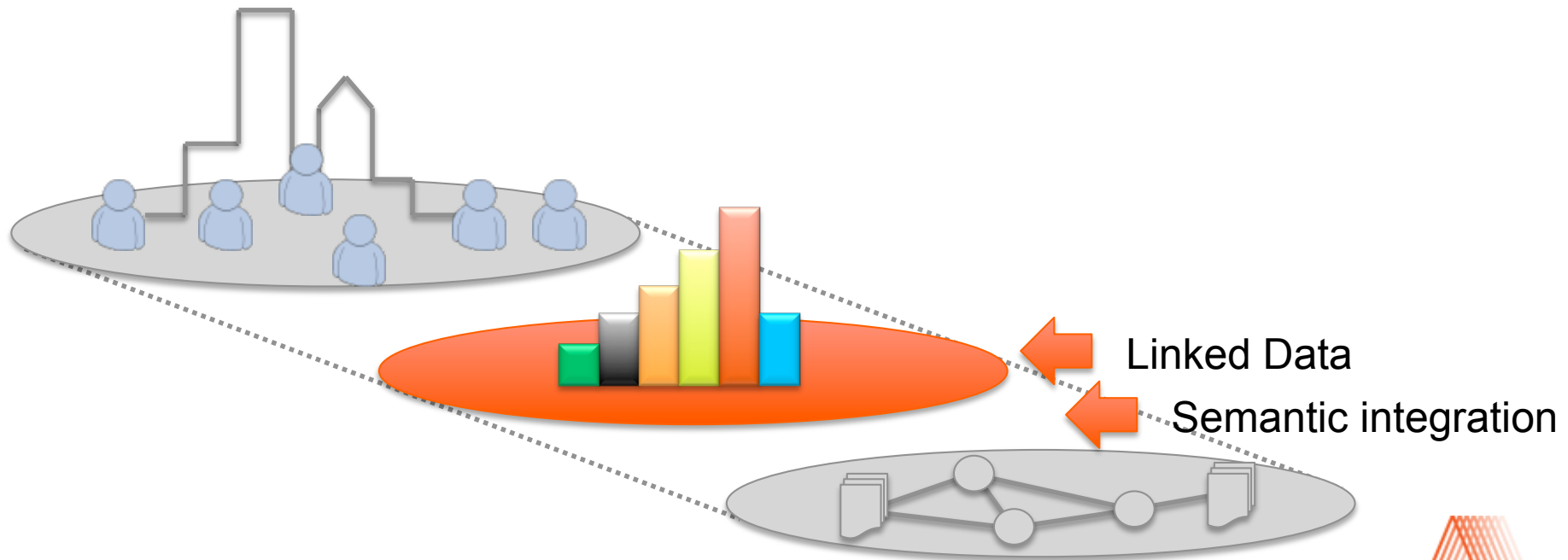
Associating data to other data and entities makes it more visible/exploitable



Image Source: <http://webupon.com>

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Now, EVERYTHING is connected

Gartner: „By 2015, wirelessly networked sensors in everything we own will form a new Web. But it will only be of value if the ‘terabyte torrent’ of data it generates can be collected, analyzed and interpreted.”



What does that mean for **Cities**?

- Cities are becoming like “AMAZON” – showing and reacting in real-time to citizens, events and incidents.
- Planning is performed not on snapshots but on accurate historic data from multiple dynamic resources with measurable effects (KPIs).
- Patterns can be identified and real reasons why and what is happening can be identified, leading to better knowledge.

COST SAVINGS
QUALITY OF LIVE
SUSTAINABLE

SAFETY
NEW BUSINESS
OPPORTUNITIES



What do we need (enablers in the FI)?

- Real time dynamic data streams (many low data rate), transmitted, annotated, accessible and stored:
 - ... lots of them! Capillary Networks to Terabit Pipes.
 - ... not very accurate! Trust.
 - ... not always there! Discovery. Robustness.
 - ... very sensitive! Privacy. Security.
 - ... fragmented and sector specific! Standards.

and

- ... no real incentives! Business Models.



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