Exposing Real World Information for the Web Of Things

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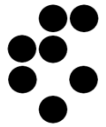
sensorlab.ijs.si  ailab.ijs.si 

Introduction

- *Try to imagine a "world littered with trillions" of wireless sensors. Now try to imagine the problems getting even a few thousand of them to work together in any kind of intelligible way…* [1]

- *We want a way of doing sensing that can make the data available to any application that needs that specific data* [1]

[1]John Cox, Turning the world into a sensor network, NetworkWorld, August 11, 2010.

Introduction

- Internet of Things – world-wide network of heterogeneous smart objects
  - sensors, actuators, RFIDs, MEMS
  - based on standard communication protocols
  - focused on establishing connectivity
- Web of Things – integrating smart objects into the Web
  - a.k.a Sensor Web, Physical Web
  - based on standards like HTML, XML, RSS
  - focused on application layer
- The “Things”
  - a set of sensor nodes and/or embedded device + physical things which are abstracted as one “thing” (large water tank + set of sensor nodes monitoring water level, temperature and purity)
- Wireless Sensor Network - WSN:
  - wireless network of spatially distributed nodes, which jointly observe certain phenomena
  - Traditionally: low complexity, low power, small size/weight, long life, autonomous, short range, low cost

Introduction

- Web Of Things use cases
  - Motivated by an increased interest in automatic management of large systems
  - Commercial use cases (non-exhaustive list):
    - Power grids
    - Transport systems
    - Water distribution
    - Logistics
    - Industrial automation
    - Agriculture
  - Academic
    - Distributed sensing infrastructure
      - Microclimate monitoring
      - Volcano monitoring
      - Psychology of masses

Outline

- Exposing Real World Data
- SemSense Architecture
  - Data Collection
  - Storage
  - Semantic Enrichment
  - Data Publishing
- Conclusions

Exposing Real World Data

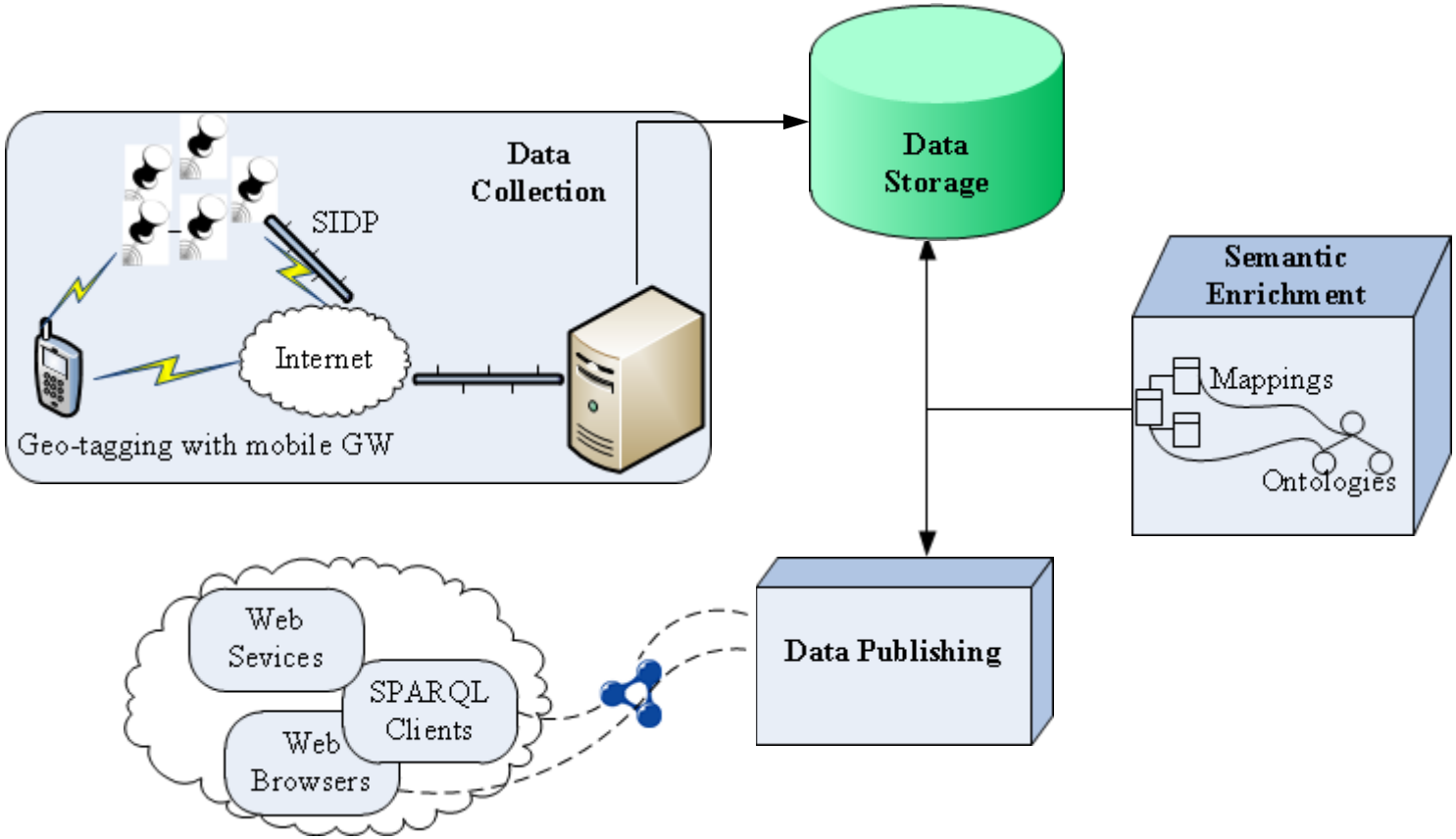
- Web 1.0
  - Static data
  - Read-Only
- Web 2.0
  - User generated data
    - blogs, socializing sites
  - Read-Write
- Web 3.0
  - Semantic Web, web of data
  - RDF, OWL, RDFa for describing things instead of documents

Exposing Real World Data

- Philosophy behind Web 3.0
  - Provide machine understandable representation of data
  - Link these data for discovery and reasoning

- Linked Data
  - method of exposing, sharing, and connecting data via dereferenceable URIs on the Web.
    - URI for the real-world object itself.
    - URI for a related information resource that describes the real-world object and has an HTML representation.
    - URI for a related information resource that describes the real-world object and has an RDF/XML representation.

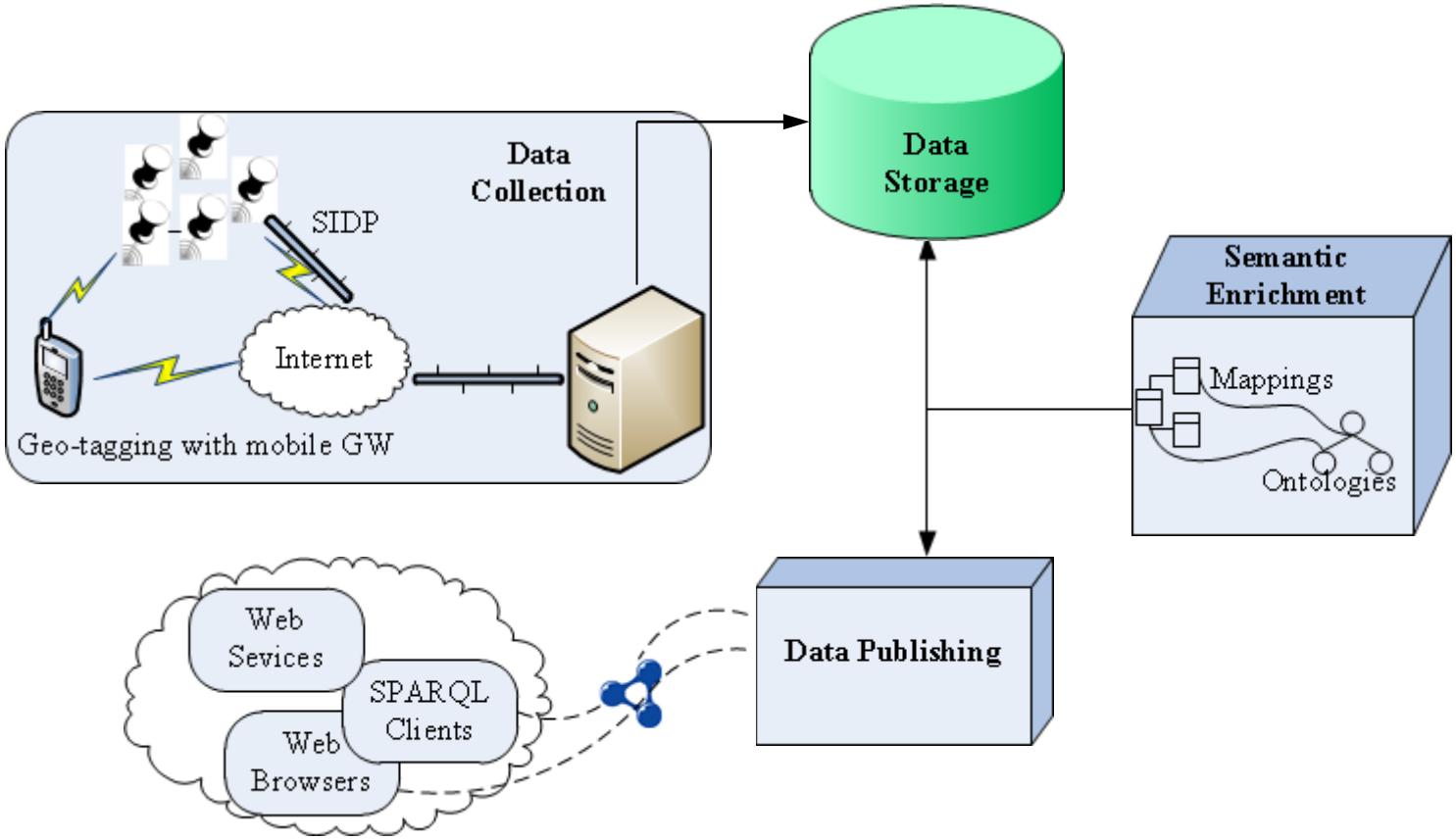
SemSense Architecture



SemSense Architecture Implementation Scenario

- Data Collection
  - Versatile Sensor Nodes deployed in an outdoor testbed
  - observed properties: temperature, humidity, light and pressure
  - Two protocols for meta-data and measurements collection
- Storage component
  - Database schema for separation of data
  - Running on MySQL server
- Semantic Enrichment
  - Semantic Sensor Network (SSN) ontology – W3C standardization
  - Mapping rules between the database and vocabulary
- Publishing Component
  - D2R Server exposes enriched data
  - According to LOD principles

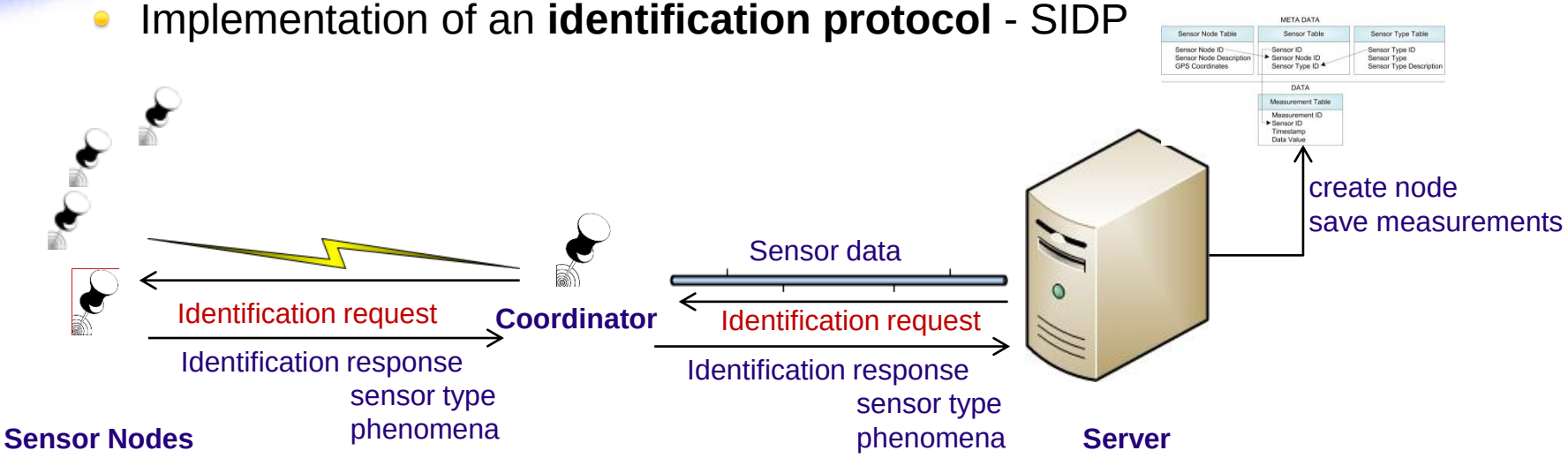
SemSense Architecture



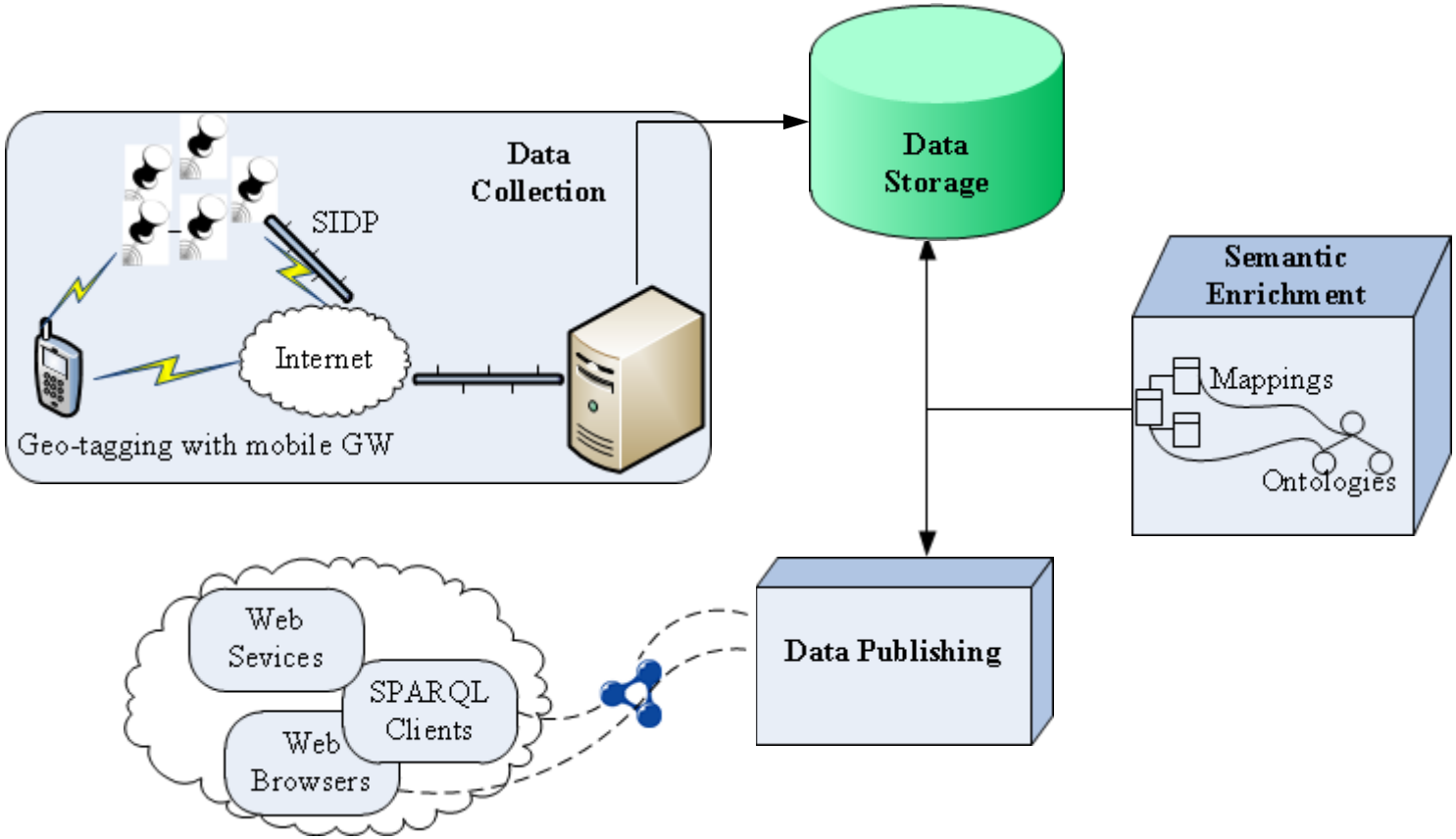
SemSense Architecture Information Collection

- Crowdsourcing
  - depends on participants willingness for providing accurate and complete descriptions
  - large amount of data (Pachube >9000 sources)

- Automatic collection
  - Implementation of an **identification protocol** - SIDP



SemSense Architecture

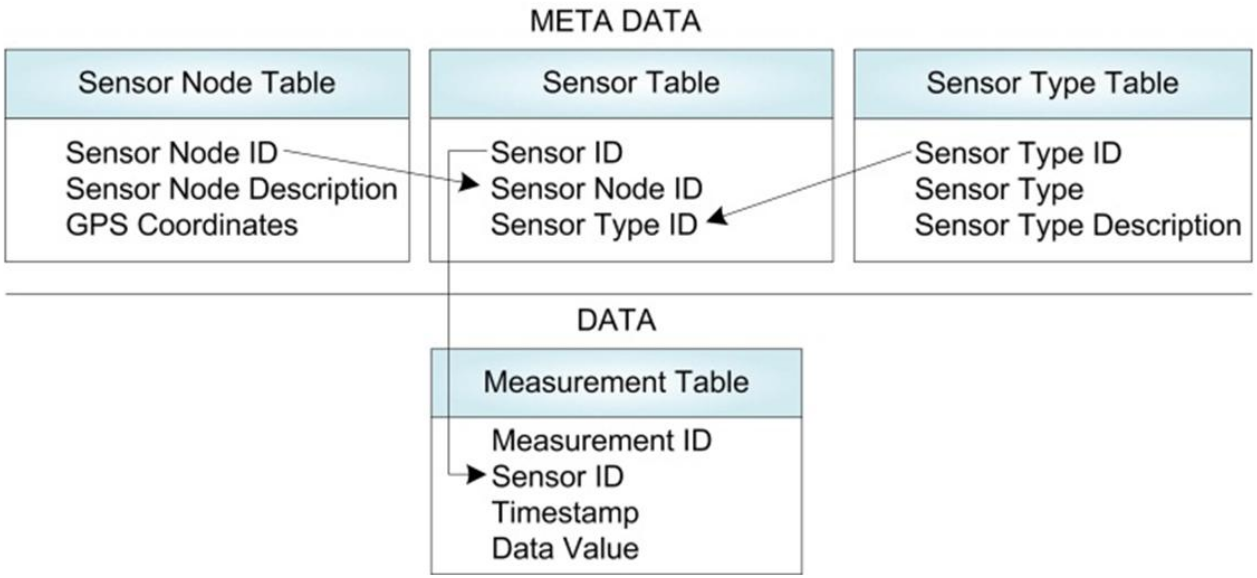


SemSense Architecture
Data Storage

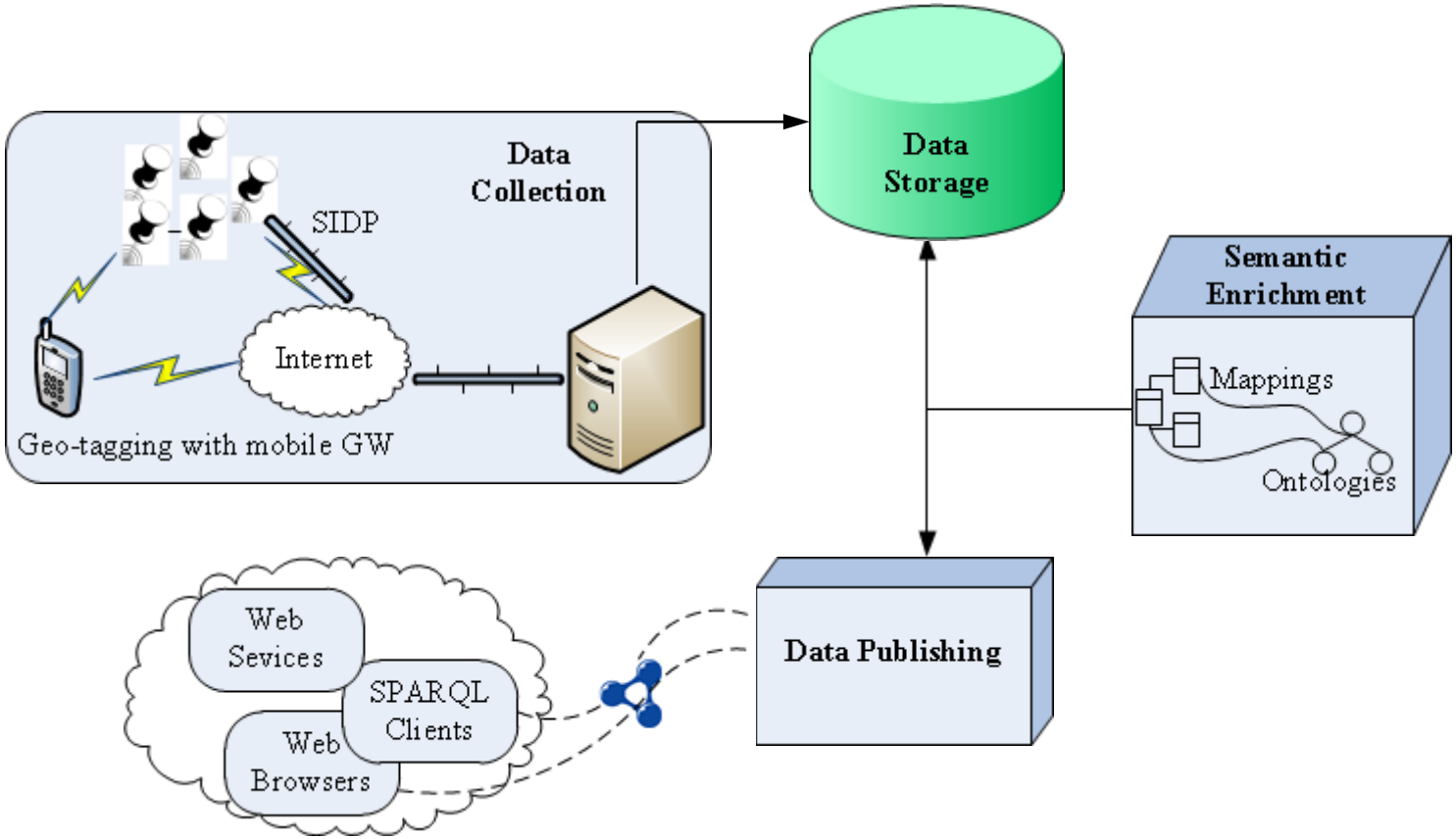
- Database Management Systems
  - Abstraction levels
  - Analysis and querying
  - Large amounts of data
- Distributed storage on the sensor network level (i.e TinyDB)
  - data retrieved directly from the sensor
- Centralized storage on the middle level (MySQL)
  - Storage of both meta-data and measurements
  - Automatic data insertion by data collection server
  - Database design closely related to hardware design, where a sensor node features a set of sensors

SemSense Architecture Data Storage

- Database schema
  - Meta-data: physical devices and phenomena observed
  - Measurements: timestamp, value, sensor id
  - Separation between meta-data and measurements.
- A sensor node can have several sensors attached to it
  - Our testbed: each node has six sensors
  - Same type of sensors on a sensor node

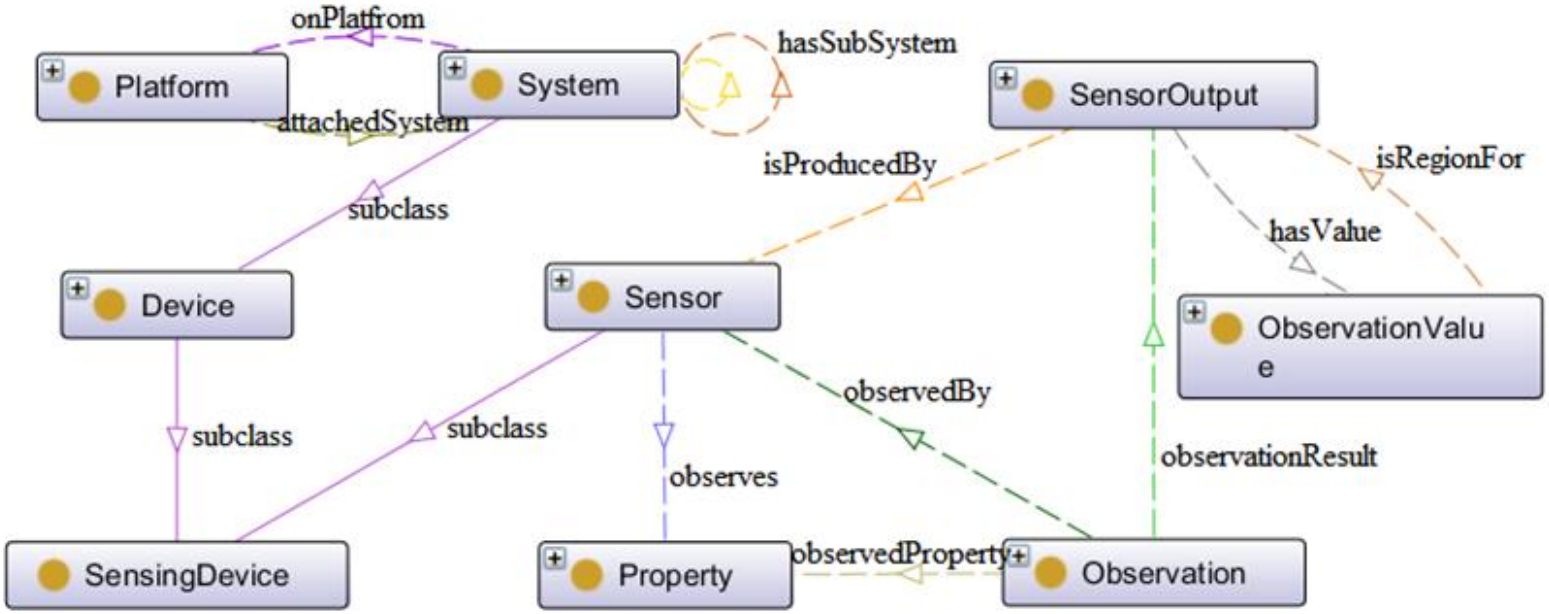


SemSense Architecture



SemSense Architecture Semantic Enrichment

- Semantic Vocabulary
  - SSN ontology
    - Result of W3C Semantic Sensor Network Incubator Group
    - Aligned to DOLCE Ultra Lite
  - Subset of concepts and relationships



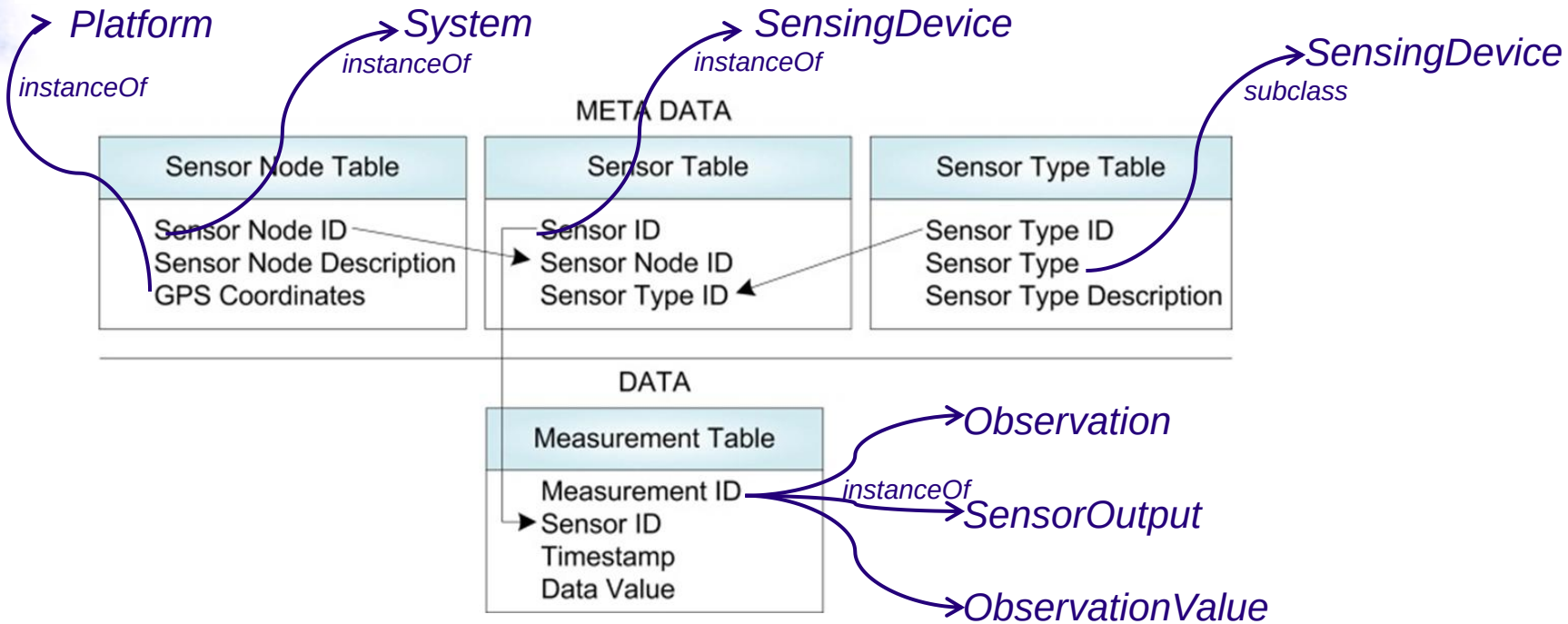
SemSense Architecture
Semantic Enrichment

- Semantic Vocabulary
  - Basic GeoWGS84 vocabulary
    - Geographical location of platforms
    - namespace for representing the coordinates
  - GeoNames
    - Geographical region names
    - findNearbyPlaceName web services
  - *based_near* predicate from FOAF

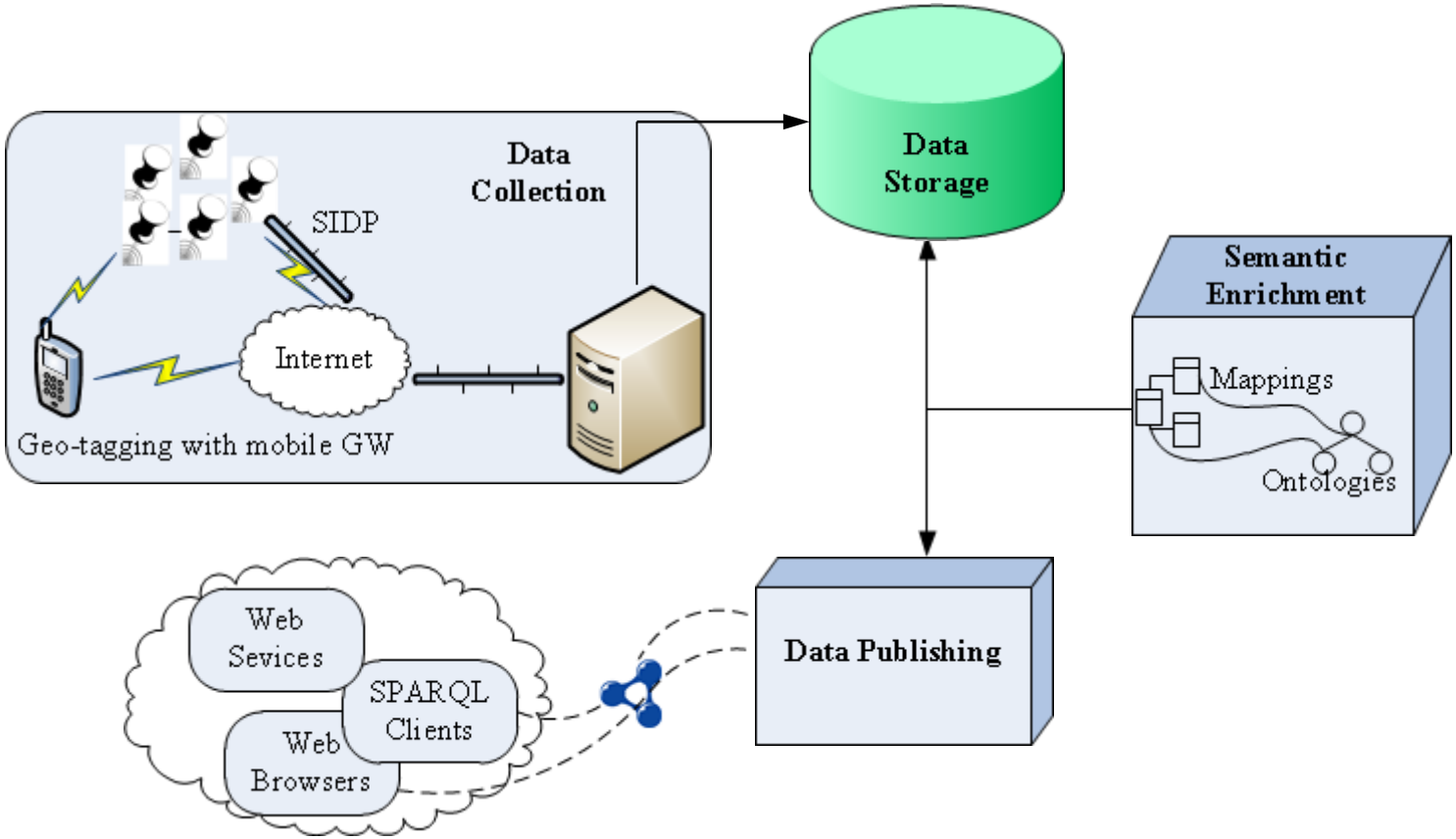
SemSense Architecture Semantic Enrichment

```
map:Platform a d2rq:ClassMap;
d2rq:dataStorage map:database;
d2rq:uriPattern
"platforms/LightPole@@sensor_node_table.gps_latitude@@-
@@sensor_node_table.gps_longitude@@";
d2rq:class vocab:LightPole;
d2rq:classDefinitionLabel "Light Pole";
d2rq:additionalClassDefinitionProperty map: PlatformSubclass;
d2rq:additionalClassDefinitionProperty map: SpatialThingSubclass.
```

tic vocabulary, based on the



SemSense Architecture

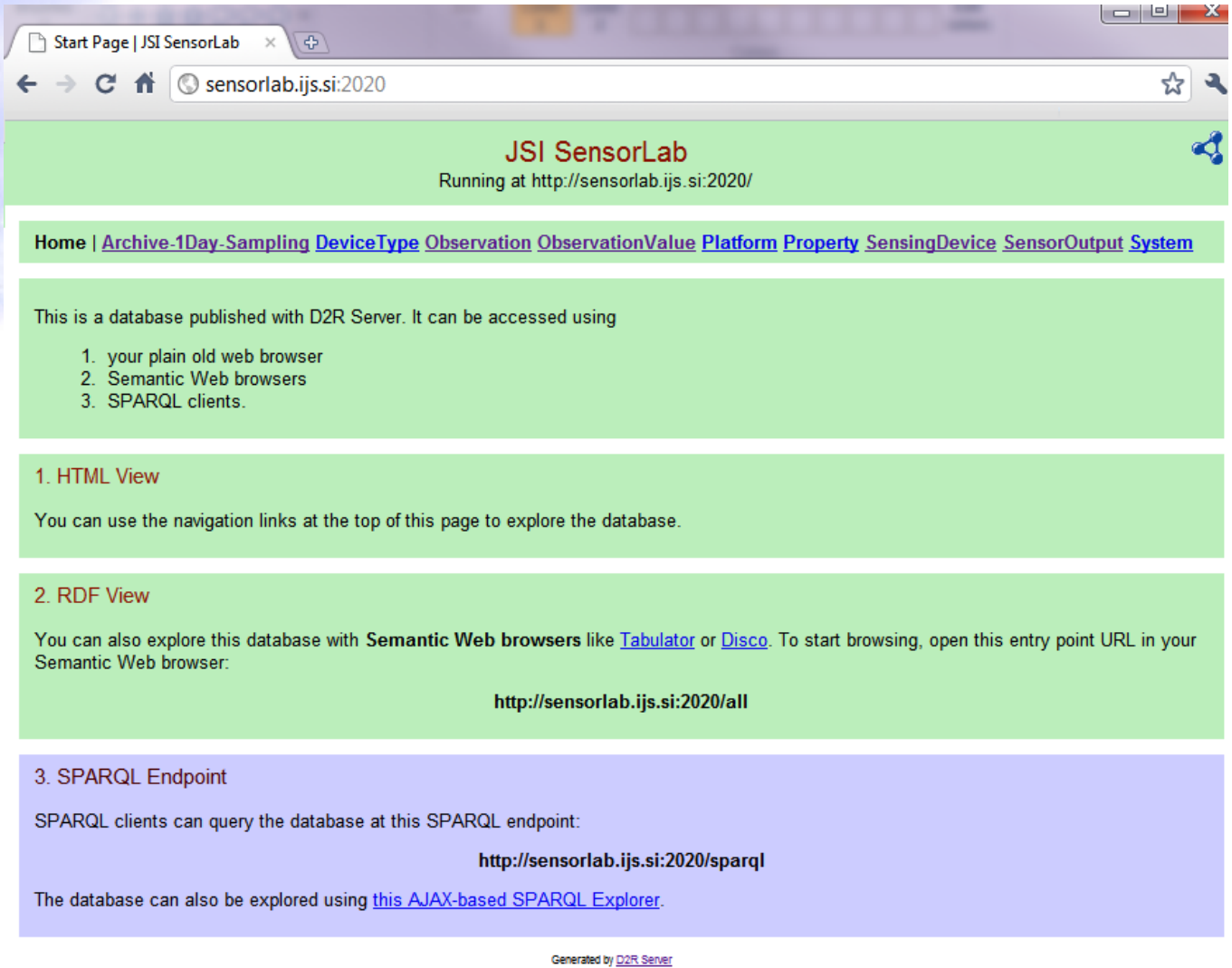


SemSenseArchitecture
Data Publishing

- Publishing methods
  - standardized web services – OGC's SOS
  - application specific: Pachube, Sensorpedia
  - Linked Sensor Data
- Publishing tool used
  - D2R Server – generates RDF and HTML descriptions of database content based on the mapping rules
    - no replication of the database
    - can be accessed by SPARQL clients and browsed using HTML interface

SemSenseArchitecture Data Publishing

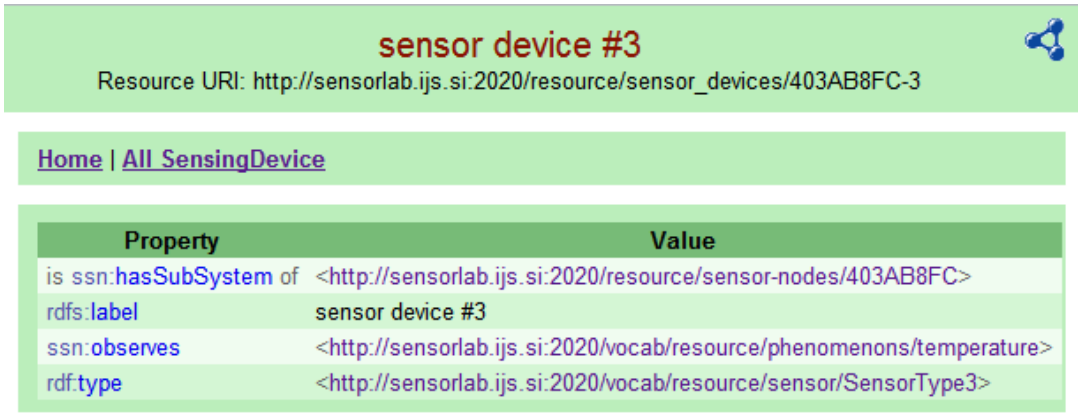
- http://sensorlab.ijs.si:2020/



SemSenseArchitecture Data Publishing

- *Which are the sensors measuring temperature located in the Vič region of the city of Ljubljana?*

```
SELECT DISTINCT ?s WHERE {
?sn ssn:hasSubSystem ?s.
?s ssn:observes
<http://sensorlab.ijs.si:2020/vocab/resource/phenomenons/temperature>.
?sn ssn:onPlatform ?p.
?p foaf:based_near <http://sws.geonames.org/3187818/>.}
```



sensor device #3

Resource URI: http://sensorlab.ijs.si:2020/resource/sensor_devices/403AB8FC-3

Home | All SensingDevice

Property	Value
is ssn:hasSubSystem of	<http://sensorlab.ijs.si:2020/resource/sensor-nodes/403AB8FC>
rdfs:label	sensor device #3
ssn:observes	<http://sensorlab.ijs.si:2020/vocab/resource/phenomenons/temperature>
rdf:type	<http://sensorlab.ijs.si:2020/vocab/resource/sensor/SensorType3>

- http://sensorlab.ijs.si:2020/snorql/

Conclusions

- It is important to make sensor data available
- SemSense architecture for collecting and exposing real world data to the Web
  - Data collection, storage, semantic enrichment, publishing according to LOD principles
- Future Work
  - Extend SemSense for multiple heterogeneous sensor networks
  - Automatically generate mapping rules
  - Comparative analysis with other similar systems


THE END!