inContext-Sensing: LOD augmented sensor data*

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Abstract. In this demo paper, we present a system that shows how users with no expertise in sensor data can benefit of Linked Data and semantic annotations to make sense of raw sensor data. Our motivations are that (1) these users are becoming the main consumers of sensor data, but sensors conceptualisation do not consider their point of view and (2) so far, no application dynamically creates Linked Data for sensors (as the linked datasets are usually predefined).

Keywords: Sensor, Silk, Pachube, Linked Data, Smartphone, Linked Sensor Data, SSN-XG

1 Introduction

To address the lack of interoperability between sensors, the application of Semantic Web technologies has been proposed[1]. Recent efforts from the Open Geospatial Consortium (OGC) go in the same direction by abstracting from XML-based serializations the Sensor Web Enablement standards i.e. SensorML and Observation-and-Measurement. Such standards have also been mapped into an ontology by the W3C Semantic Sensor Network Incubator Group[1]. Still there are the following problems that we aim to address.

Sensor Context The advantages of applying Linked Data principles[3] on sensors relies on the contextual information added by linking to the Linked Open Data (LOD) cloud. For instance a user can drive faster if he follow the reoutes suggested by his particulat GPS car navigation system whose suggestions are based on crossing the information about the hilly surrounding area (from Geography LOD datasets) and the near both roadworks (from Government LOD datasets) and ongoing social events (from Media LOD datasets).

Current applications providing Linked Sensor Data - e.g. Sensor Discovery On Linked Data - actually link only to a restricted set of LOD datasets that users cannot modify. Our system - *inContext-Sensing* (screencasts at http://spitfire-project.eu/incontextsensing/index.html) - looks for potentially linkable resources from all the SPARQL endpoints available on the LOD, using customisable criteria.

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[1] Final Report:http://www.w3.org/2005/Incubator/ssn/XGR-ssn-20110628

Linked Sensor Data for average users The amount of casual people who regularly use sensors is increasing, thanks to sensors embedded in smartphones and house appliances (e.g. kitchen stoves). At the same time, although semantics could solve interoperability among sensors, users with no expertise are not supported in the sensor semantic annotation process. Especially, sensor ontologies used for annotation do not consider the user perspective, for whom most concepts might be not understandable, *e.g.* `ssn:Deployment`. Others might appear over-detailed, *e.g.* `ssn:ObservationResult` and `ssn:ObservationValue` . We address such issues by automating semantic annotations of sensors and by using accurately improved ontologies.

2 *inContext-Sensing*

inContext-Sensing is a RESTful Web Service developed on top of the Pachube API to let average users benefit of Linked Sensor Data. Pachube[2] is a platform where users who own sensors can publish their (raw) sensor data. Wherever such data are set as public, they can be aggregated into customizable views through the Pachube API. The *inContext-Sensing* architecture in Fig. 1 consists of (1) a Pachube View extractor: collecting data from the Pachube API; (2) a URI builder: assigning proper URIs to predefined resources; (3) a Semantic Annotator (details in Section 2.1); (4) a Link Creator (details in Section 2.2); (5) a REST API for accessing enhanced Linked Sensor Data and (6) a Graphical User Interface (details in Section 2.2).

Fig. 1. inContext-Sensing Architecture

2.1 Average user perspective on sensor ontologies

We rely on our belief that average users are interested in the information that sensors provide only if it relates to real-world situations of interest and it is trustable. This means that these users do not care (and should not have to) about some concepts common in sensor ontologies like brands, manteinance, etc. This is reflected by the Pachube Resource Model[3], that includes three resources focused just on the sensor outcome and the monitored real-world situation:(1) the *Environment* resource (real-world situation); (2) the *DataStream*

[2] `https://pachube.com/`
[3] `http://api.pachube.com/v2/`

resource (stream of sensor data whose multiple aggregation compose an *Environment*); (3) the *DataPoint* resource (single value and time of collection of each sensor data). . We use the SPITFIRE[4] ontology since its goal is precisely to add context to sensor data. It has been extended to conceptualize such resources. Other ontologies used during the semantic annotation, are FOAF (for data publishers), Dublin-Core (for the data aggregation document itself) and SWEET (for natural phenomena).

2.2 Meaningful external linkage

The service identifies semantically annotated links using all the LOD datasets that expose a SPARQL endpoints[5]. Each dataset has been manually labelled[6] with the category it belongs to, which varies among Geography, Life-Science, Publication, Government, User-generated content and Media. Then links are generated by running Silk Single Machine[2]: a framework to discover links with a certain confidence-level. It follows user-defined (through XML configuration file in which the Link Specification Language is used) heuristics to identify which resources should be considered similar and then linked. The default setting which consists in one distinct configuration file per dataset category, is customizable through either GUI or REST API by specifying (1) which categories of datasets should be considered; (2) either Space (location), Time or Thing (feature of interest) as linking criteria and (3) a confidence level threshold.

Fig. 2 shows a screenshot of the GUI displaying the outcome of submitting a Pachube View ID. In this case the user has selected "'Rain"' as observed feature of interest, among all the aggregated ones. Then additional context information is provided splitted in two section, depending on whether it refers to either the Observed Feature or to the Location. In the screenshot part of the interfac is shown, containing about the Observed Feature "'Rain"': (1) from DBpedia and WordNet: definition of the concept rain; what it is hyponym or holonym of; (2) from Musicbrainz: songs about rain; (3) from DBLP: publication about the acid rain on a journal; ; about the Location "'Lichfield Road"':(1) from geonames: Lichfield Road is in the Lichfield Distrinct (a third order administrative division), United Kingdom, Staffordshire; (2) from flickrwrappr: photos of Lichfield Road.

3 Conclusion

From an application perspective, Pachube consumers will be the first users of our application and they already constitute a large user-base. We expect them to be attracted (1) by the advantages of sensor interoperability gained from the semantic annotations that we automatically provide and (2) by the view over sensor data that we offer augmented with context information from the LOD.

[4] SPITFIRE website at `http://spitfire-project.eu` and ontology at `http://spitfire-project.eu/cc/spitfireCC_n3.owl`
[5] `http://labs.mondeca.com/sparqlEndpointsStatus/`
[6] `http://spitfire-project.eu/ds-mapping/categories-map.txt`

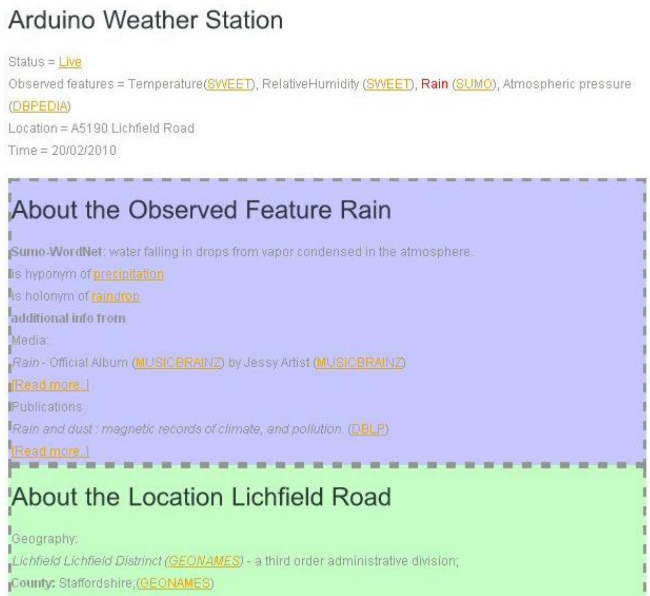

Fig. 2. inContext-Sensing screenshot

In addition, our research contributions in this paper include (1) dynamic and customizable linking (2) support for average users' interests by extending current sensor ontologies (applied to the SPITFIRE ontology). We plan to extend the linkage to the Web of Data and to run experiments aimed at both improving our semi-automatic linkage and collect user feedback. During the Demo exhibition, conference attendees will be able to directly use the application with the pachube data of their choice

References

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2. J. Volz, C. Bizer, M. Gaedke and G. Kobilarov, *Silk A Link Discovery Framework for the Web of Data* . 2nd Workshop about Linked Data on the Web (LDOW2009), 2009.
3. C. Kessler and K. Janowicz, *Linking Sensor Data Why, to What, and How?*, in Proceedings of the 3rd International Workshop on Semantic Sensor Networks (ISWC2010), 2010.