

Research Topics in Semantic Sensor Networks

Preface to the Proceedings of the 2nd International Semantic Sensor Network Workshop 2009

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Welcome to the second international workshop: *Semantic Sensor Networks 2009*, held in conjunction with the 8th International Semantic Web Conference, at the Westfields Center, near Washington DC, USA, 25–29 October 2009.

Semantic technologies are often proposed as important components of complex, cross-jurisdictional, heterogeneous, dynamic information systems. The needs and opportunities arising from the rapidly growing capabilities of networked sensing devices are a challenging case.

It is estimated that today there are 4 billion mobile devices that can act as sensors, including active and passive RFID tags. This is complemented by an even larger number of fixed sensors recording observations of a wide variety of modalities. Geographically distributed sensor nodes are capable of forming ad hoc networking topologies, with nodes expected to be dynamically inserted and removed from a network. The sensors are increasingly being connected with Web infrastructure, and the Sensor Web Enablement (SWE) standard developed by the Open Geospatial Consortium is being widely adopted in industry, government and academia alike. While such frameworks provide some interoperability, semantics is increasingly seen as a key enabler for integration of sensor data and broader Web information systems. Analytical and reasoning capabilities afforded by semantic web standards and technologies are considered important for developing advanced applications that go from capturing observations to recognition of events and ultimately developing comprehensive situation awareness. Defence, transportation, global enterprise, natural resource management and climate change industries are leading the rapid emergence of applications in commercial, civic, and scientific operations that involve sensors, web, services and semantics.

The goal of the Semantic Sensor Networks workshop is to develop an understanding of the ways semantic web technologies, including ontologies, agent architectures and semantic web services, can contribute to the growth, application and deployment of large-scale sensor networks and their applications. The workshop provides an inter-disciplinary forum to explore and promote these concepts.

The workshop sought paper submissions on topics including:

- Semantic support for Sensor Web Enablement
- Spatio-temporal reasoning in sensor networks

- Semantic integration in large-scale heterogeneous sensor networks
- Reasoning with incomplete or uncertain information in sensor networks
- Semantic web services architectures for sensor networks
- Semantic middleware for active and passive sensor networks
- Semantic algorithms for data fusion and situation awareness
- Experience in sensor network applications of semantic technologies
- Rule-based sensor systems
- Ontologies for sensor and RFID networks
- Semantic policy management in shared networks
- Semantic feedback and control
- Semantic discovery of sensors, sensor data and services
- Emergent semantics and ambient intelligence in sensor systems
- Semantic approaches to status monitoring and configuration of sensor systems
- Scalability, security, trust and privacy in semantic sensor networks
- Semantic reasoning for network topology management
- Semantic web in sensor data mashups
- Semantic sensor context management and data provenance
- Citizen sensors, participatory sensing and social sensing

The First International Semantic Sensor Network Workshop was held with ISWC in 2006, three years ago. Since that time there has been a considerable growth in interest in the use of modern semantic technologies to address long-standing issues that seem to inhibit the widespread deployment and application of sensor technologies. In particular, the Open Geospatial Consortium has begun to consider the contribution of semantic technologies to the SWE standards. In 2009, a new activity of the W3C, the Semantic Sensor Networks incubator group (SSN-XG) is addressing the development of both semantic annotation for SWE services and an ontology to describe sensor networks and to provide terms for the annotation.

We were excited by the quality and diversity of the 11 submissions we received for the workshop. The papers were each carefully reviewed by 2 or 3 members of our international program committee. We decided to accept all the papers, despite the range in maturity and technical contribution of the works, as all the papers contribute novel ideas to this rapidly developing field. We hope that this decision both promotes development of the field and creates a vibrant and robust workshop on the day. We have 6 full papers and 5 short and position papers in the proceedings.

The survey paper by Compton *et al* , “A Survey of the Semantic Specification of Sensors” , shows just how much the field has developed since the first workshop in 2006. This paper arose from the work of the W3C SSN-XG, and studies 11 separate ontologies for sensor networks and their applications and reasoning support. The authors find wide variation in their coverage of sensor devices, physical characteristics, observations and the domain to which the ontologies are applied. Bell *et al*’s “Sensory Semantic User Interfaces (SenSUI): Position Paper” , also briefly surveys 12 ontologies for sensors (with some overlap), and

suggests a research agenda for ontology-enabled context-aware adaptive user interfaces. In an alternative approach to ontology design, Sequeda *et al* propose a method to derive ontologies for sensor data stream from raw stream schemas, queries over the streams, and external ontology mining, in “Generating Data Wrapping Ontologies from Sensor Networks: A Case Study (Short Paper) ”.

Several papers discuss how rich ontologies of sensor services can be used for better sensor applications, especially when the sensor data needs to be combined with other contextual information for application. Cameron *et al* in “Semantic Solutions for Integration of Federated Ocean Observations” describe a system employing expressive ontologies and mappings to mediate the sensor observation services conforming to the OGC SWE standard. Compton *et al* , in “Reasoning about Sensors and Compositions”, propose that description logic and other reasoning technologies can be used to assist sensor selection and composition to meet application requirements. Moon *et al* suggest that environmental sensor data together with contextual knowledge represented as an ontology and a reinforcement learning algorithm might deliver a high level situation awareness, in the short paper “Situation-Awareness Model for Higher Order Network Knowledge Management Platform”.

A common theme over several papers is how to address the linking open data challenges as they apply to observations derived from sensor networks, mostly in a SWE context. Le Phuoc and Hauswirth in “Linked open data in sensor data mashups” develop a visual explorer relying on RDFa metadata coupled with SPARQL and an underlying data stream management system to enable the composition of sensor streams. Page *et al* in “Linked Sensor Data: RESTfully serving RDF and GML” propose a scheme relating URIs for sensor observations to multiple alternative representations of the corresponding observation data. Sequeda and Corcho, in “Linked Stream Data: A Position Paper”, propose a convention for sensor URIs and also for observation URIs that would directly encode metadata referring to an observation data stream. By contrast, Rodriguez *et al* in “Semantic Management of Streaming Data”, assume a triple-store storage architecture and develop an RDF model for representing time-series data arising from sensors, coupled with an expressive query language extended from SPARQL.

And finally, we have one very different outward-looking paper—Sabou *et al* in “Position Paper on Realizing Smart Products:Challenges for Semantic Web Technologies” identify the trend towards autonomous, sensing and context-aware appliances and draw the correspondences with the challenges for semantic sensor networks.

We hope that you enjoy the workshop, and learn from the papers here. We appreciate your feedback on the workshop this year and hope that you can find a way to contribute to the workshop in 2010.

Workshop website: <http://ict.csiro.au/conferences/ssn/ssn09>

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The chairs would like to thank our advisors and program committee and also our external reviewers: Anni-Yasmin Turhan, Yangfen Shu, and Jemma Wu. We also thank Geoff Squire of CSIRO for help with the paper submission system and Kevin Page of University of Southampton for publicity.