SensorWeb 2.0: Service-Oriented Middleware for Heterogeneous Sensor Networks

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Introduction

The identification of common data operations and transformations on sensor data has fuelled the birth of the Sensor Web paradigm. Sensor Web combines sensors and sensor networks with a Service Orientated Architecture (SOA). A SOA allows us to discover, describe and invoke services from a heterogeneous software platform using XML and SOAP standards. When interlinked, geographically distributed services form what is called a Sensor Grid; this is a key step in the integration of sensor networks and the distributed computing platforms of SOA and Grid Computing. Services are defined for common operations including data query, retrieval and aggregation, resource scheduling, allocation and discovery. Sensor networks can be discovered, accessed and controlled over the World Wide Web.

Open Sensor Web Architecture and Middleware Capabilities

The Open Sensor Web Architecture Middleware is built upon a uniform set of operations and standard sensor data representations as defined by the Open Geospatial Consortium (OGC). The OGC is a geospatial standards authority that has defined a Sensor Web Enablement (SWE) method which includes specifications of interfaces, protocols and encodings that enable discovering, accessing, and obtaining sensor data as well as sensor-processing services. The following are the five core specifications of the SWE which are implemented in our SensorWeb middleware as core services:

1. Sensor Model Language (SensorML) [3] – Information model and XML encodings that describe either a single sensor or sensor platform in regards to discovery, query and control of sensors.

2. Observation and Measurement (O&M) [4] – Information model and XML encodings for observations and measurement.

3. Sensor Collection Service (SCS) [15] – Service to fetch observations, which conform to the O&M information model, from a single sensor or a collection of sensors. It is also used to describe the sensors and sensor platforms by utilizing SensorML.

4. Sensor Planning Service (SPS) [5] – Service to help users build a feasible sensor collection plan and to schedule requests for sensors and sensor platforms.

5. Web Notification Service (WNS) [6] – Service to manage client sessions and notify the client about the outcome of the requested service using various communication protocols.

One of the key challenges of our SensorWeb project is how to support ongoing sensor queries which persist over time to heterogeneous sensor networks. This challenge is

addressed with the following features; (i) all services are implemented as stateful Web Services (WSRF), (ii) the SCS works with many different types of sensors, from TinyOS running on Mica2, MicaZ, Imote2 and TinyDB to an in-house sensor running Linux called NICTOR developed by NICTA, (iii) services are capable of handling concurrent requests from multiple users, (iv) a repository service has been added to store historic observation results produced by the SCS.

Software Release and Publications

The SensorWeb 1.0 was developed and released in 2005 (under GPL licence, libraries in LGPL) by the Grid Computing and Distributed Systems (GRIDS) Laboratory at the University of Melbourne. This work was further extended, during 2006-2007, as a NICTA (National ICT Australia) project to support heterogeneous sensors and state-oriented Web services. The new version, SensorWeb 2.0, is available for download under LGPL licence and the software and associated documentation can be downloaded from: http://www.gridbus.org/sensorweb

The key contributors to the SensorWeb 2.0 middleware include:

- Rajkumar Buyya
- Chris Leckie
- Tom Kobialka
- Rao Kotagiri

The two key publications related to this middleware effort are:

- Xingchen Chu, Tom Kobialka, Bohdan Durnota, and Rajkumar Buyya, Open Sensor Web Architecture: Core Services., Proceedings of the 4th International Conference on Intel ligent Sensing and Information Processing, Dec. 15-18, 2006, Bangalore, India.
- Tom Kobialka, Rajkumar Buyya, Christopher Leckie, and Rao Kotagiri, A SensorWeb Middleware with Stateful Services for Heterogeneous Sensor Networks, Proceedings of the 3rd International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP 2007), Dec. 3-6, 2007, Melbourne, Australia.

Future Work Roadmap

The SensorWeb project will now be nurtured and continued actively within GRIDS Lab (its original birth place!) funded through a International Science Linkage Programme (Project: UtilityGrid) of the Australian Department of Innovation, Industry, Research and Science (DIISR) along with support the University of Melbourne and ARC Research Network on ARC Research Network on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP).

For the next version (SensorWeb 3.0) we are working towards making the following innovations:

- Seamless integration of SensorWeb and Grid Computing capabilities developed as part of the Gridbus Project

- Sensor Planning Service with ability to operate across sensor networks from multiple enterprise deployments/domains.
- Power-efficient overlay network for provisioning sensor collection services by creating and deploying application-specific operators
- Novel caching methods for efficient serving of commonly queried sensor observations
- Sensor data driven workflows and management engine
- Eclipse / Visual Studio-based IDE/Plugins for Rapid Development of Applications

The current team members working for SensorWeb 3.0 include: Rajkumar Buyya (Director of GRIDS Lab), M. Palaniswani (Head of ISSNIP Group) and Tom Kobialka (Research Fellow, GRIDS Lab).

For further details on the project and to download our SensorWeb 2.0 middleware, please visit: http://www.gridbus.org/sensorweb/

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