Demonstration: Semantic Web Enabled Smart Farm with GSN

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Abstract. GSN is an open source middleware designed for managing data produced by sensors deployed in a sensor network. We have extended the GSN to enable (i) semantically aware preparation, exchange and processing of the data (ii) user specified event processing for alerts, and (iii) associate sensor data to *things*. Here, we demonstrate our smart farm as a use case of a semantically aware sensor network for better integration of sensor data.

1 Introduction

Sensing devices are used in agriculture to measure and control farming activities. Smarter use of these measurements requires integration with other information. For example, soil condition measurements such as temperature and volumetric water content together with historical and weather forecast data can help make decisions about the time to sow a particular crop. Similarly, the cattle location data together with the current weather data can help monitor the cattle welfare. Since such data are often distributed across different organisations, the semantic web can be used as an integration mechanism for making better decisions.

Sensors produce data streams continuously or at short intervals generating large volumes of data. Therefore, data management is a prominent issue with sensor networks. Global Sensor Network (GSN) [1], an open source middleware, provides some foundation for the management of the streaming sensor data. In order to enable integration of this data across the web, it is necessary to employ ontologies like SSN [2] and techniques like Linked Data [3] that are widely accepted in the semantic web community. The disparity between existing tools like GSN and the need for providing open access for an effective integration of sensor network data exists as a barrier.

Our Kirby Smart Farm is a prototypical 269 hectare livestock property located in Armidale, NSW. In this paper, we use our smart farm to illustrate how GSN can be extended to enable integration of sensor network data with external data, define situation monitoring conditions to produce alerts, and extend the sensor measurements to implement *web of things* in a farm. Specifically, in Section 2, we describe the architecture of smart farm system. Section 3 highlights

our extensions of GSN and semantic web aspects, followed by the conclusion in Section 4. Furthermore, the semantic network aspect of our work in a farming environment is described in [4] while the business aspect is explained in [5]. This system can be accessed from our website `http://smartfarm-ict.it.csiro.au`.

2 Architecture

Our farm contains a mixture of environmental and livestock tracking sensor nodes: 100 soil sensors, 2 weather stations and 65 cattle tags. A soil sensor node contains sensors measuring ground temperature, soil temperature, volumetric water content (VWC) and electric conductivity (EC). A weather station node contains sensors measuring air temperature, photo-synthetically active radiation (PAR), pressure, wind, rain and hail measurements. These nodes also contain sensors to measure temperature, battery status, solar voltage and current of the platform in which the sensors are embedded. Finally, the cattle have active tags attached to their ears, which send radio signals to base stations. Based on the time lapsed to receive the signal at three base stations, the locations of cattle are determined[3].
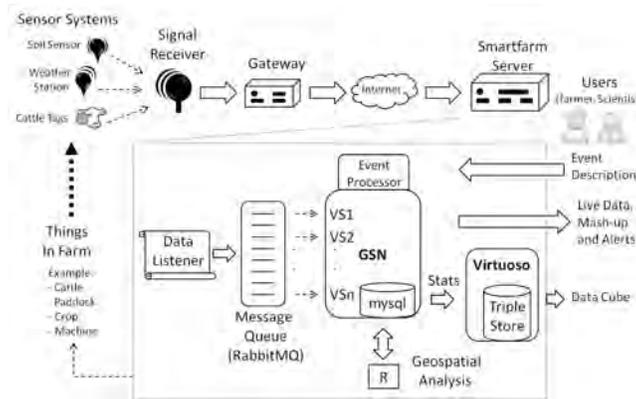

Fig. 1: The Smart Farm System Architecture

The architecture design of the smart farm is shown in Fig 1. Here, the signal received from all the sensors are collected by a gateway located on the farm and sent to smartfarm servers through a high speed broadband network. The smartfarm server contains four software components: data listener (a python script library), RabbitMQ[4] (a message queue system), GSN (a sensor network middleware) and Virtuoso[5] (a triple store enabled DBMS). The data listener

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[3] http://www.taggle.com.au/livestock.php

[4] http://www.rabbitmq.com

[5] http://virtuoso.openlinksw.com/

directly receives data from the farm, transforms them to text messages and then publishes the messages to the message queue. The GSN is configured with virtual sensors which subscribe to these messages.
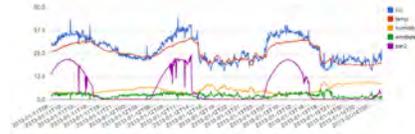

Fig 2. CCI SPARQL query

Fig 3. CCI as a composite variable of temp, humidity, wind speed and PAR

Our sensor network requires management of both static and dynamic data. We have used a hybrid approach to manage them using GSN and Virutoso [4]. Live linked data in RDF format are provided through GSN, while Virtuoso is used to provide archived data in data cube [6] format and visualised using VisualBox[6] (see Fig 2,3).

3   Semantically Enabled GSN

GSN is particularly useful in micro-management of live sensor data. However, GSN in its original form has a few limitations: it requires upgrades of dependent libraries; it lacks some important concepts (e.g. it is not possible to specify the units of measurements); it supports limited situation monitoring queries; and it does not provide data in a format expected by the semantic web community. We have modified GSN to overcome these limitations. In addition, we have extended
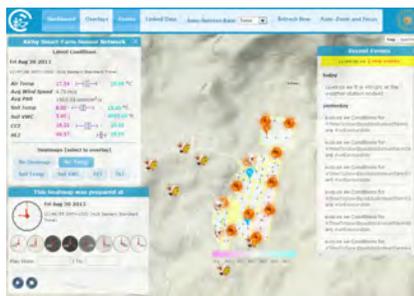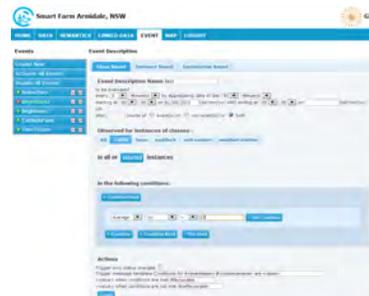

Fig 4. The smart farm map interface

Fig 5. The interface for user defined events

GSN to provide additional features. Firstly, a combination of Java/R algorithms

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[6] http://visualbox.org

is implemented for geo-spatial data processing to produce spatially aggregated cross-sectional data, generate heatmaps and infer relevant measurements corresponding to the cattle location (see Fig 4). Secondly, complex event processing system has been created based on semantic event descriptions [7], which is also embedded in GSN. We have identified and implemented a number of alert conditions, such as 'sowing time' for a crop, 'cattle not in farm', 'frost', and 'soil compaction' which are particularly useful to farmers. At the same time, users can specify their own alerts (see Fig 5), enabling them to embed their knowledge into the system. Thirdly, composite variables as cattle welfare indicators comprehensive climate index (CCI) [8] and heat load index (HLI) [9] have been implemented. Finally, GSN is extended to produce RDF data in linked data formats for both live and archived data.

4 Conclusion

In this paper, we presented Kirby 'Smart' Farm as a prototype farm installed with various sensors and connected with a broadband network. We demonstrated that by enabling a farm with the semantic web and providing query capability on both the static (i.e. archived) and the dynamic (i.e. live) linked data, we can fulfil the needs of the farmers and help them make better decisions.

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