Semantic Web Enabled Smart Farm

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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.

Kirby Smart Farm, Armidale

Kirby Smart Farm is a prototypical 269 hectare livestock property located in Armidale, NSW, Australia. This farm contains a mixture of environmental and livestock tracking sensor nodes [1]:

- 100 soil sensors measuring ground temperature, soil temperature, volumetric water content (VWC) and electric conductivity (EC),

- 2 weather stations measuring air temperature, photo-synthetically active radiation (PAR), pressure, wind, rain and hail and

- many livestock tracking devices attached to cattle ears, which send radio signals that are triangulated to determine their locations.

Extended GSN

Signals from the sensor nodes are relayed to the base stations. The gateway in the farm collects the data and sends to the smart farm servers. The server employs a message queue system in a publish/subscribe model to make the data available to GSN [2]. The GSN has been modified to provide additional features: geo-spatial analysis, event processing and semantic web enablement.

Geo-Spatial Analysis

The characteristics of *'things'* (e.g. cattle, paddock) in a farm are more meaningful to a farmer than the individual sensor measurements. Therefore, linking sensor data back to the *'things'* is important. We combined Java and R algorithms to perform Kriging to estimate the distribution of measurements from the sensors to the entire farm. Spatial aggregation is performed on paddocks and the sensor measurements were imputed for the location of cattle at that time. This approach helps reduce noise in the sensor measurements. In addition, we integrate the same sensor data to produce composite variables: comprehensive climate index (CCI) [3] and heat load index (HLI) [4] by creating custom wrappers in GSN.
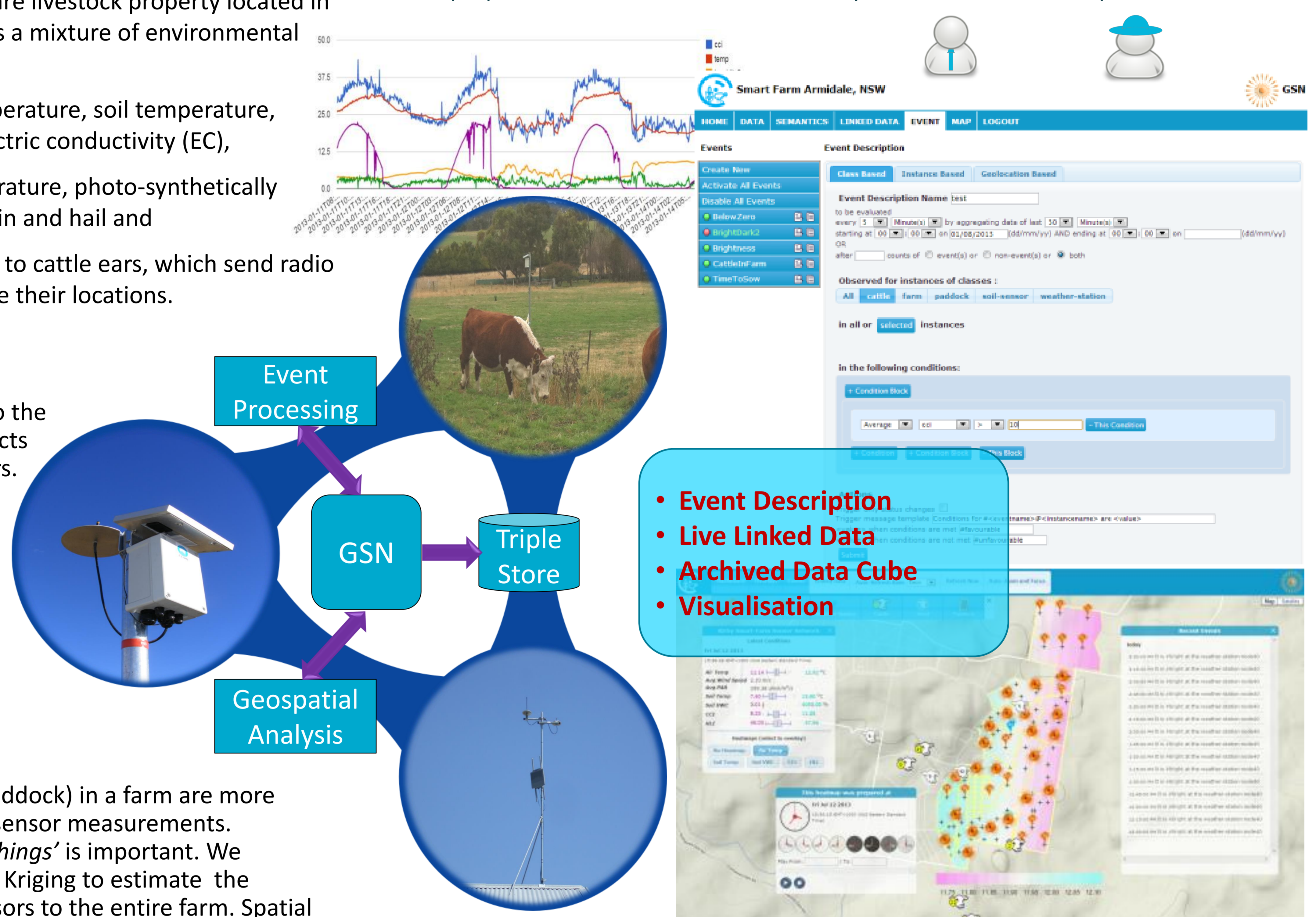
Semantic Event Processing

Event processing is an important aspect in semantic web enablement. We have extended GSN to enable event processing based on our event processing model [5] such that users can specify events using a web interface. Semantic descriptions of events are stored and evaluated within GSN.
   We considered two types of events in farming environments: synchronous events and asynchronous events to generate alerts. 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, enabling them to embed their knowledge into the system

Semantic Web Enablement

We have considered two requirements of semantic web enablement: (i) the static data such as the spatio-temporal summaries of data as data cubes over a fixed interval, and (ii) dynamic sensor data such as the sensor data streams and their aggregation using sliding windows. GSN is modified to prepare static data for Virtuoso, and dynamic data based on specific URIs.

- **Event Description**
- **Live Linked Data**
- **Archived Data Cube**
- **Visualisation**

Table 1: Important URLs and URI patters

Latest Data in RDF	http://smartfarm-ict.it.csiro.au/latest
Sensor Ontology based Description	http://smartfarm-ict.it.csiro.au/semantics.jsp
Access to Linked Data	http://smartfarm-ict.it.csiro.au/linkeddata.html
Events	http://smartfarm-ict.it.csiro.au/event.html
URI Patterns	
ROOT	http://smartfarm-ict.it.csiro.au/dataset/sensornets/kirby-farm/
Latest Data	ROOT/latest
Specific Data	ROOT/category/id/year/year/month/month/day/day/time/time[Z]
Aggregated Archived	ROOT/[category/id]/year/year[/month/month[/day/day]]
Aggregated Live	ROOT/[category/id]/last/[hour/hour[/min/min[/sec/sec]]]

Conclusion

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. Our extension of GSN is particularly interesting to achieve socially enabled farms using customised and linkable alerts. The data generated from our smart farm opens new semantic machine learning opportunities. In this way, farming in Australia can step up from informed farms to connected farms, an important step towards an integrated smart farm.

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