CAPTURING, DEMONSTRATING AND DELIVERING VALUE FROM INTEGRATING REAL-TIME ON-FARM SENSING WITH EXTERNAL INFORMATION FLOWS

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ABSTRACT

The need for significant productivity gains in the Australian agricultural sector is undeniable - sustainable industries must be capable of consistently producing a margin above the base costs of production. Viable and resilient farm businesses will need to make sense of what they know as they come to know it, and then make fine-grain, accurate and timely decisions. Timely, accurate and objective measurement of resources across the farm business, coupled with sound interpretation and understanding, will enable more accurate, timely and efficient management outcomes.

On an extensive beef grazing farm in the tropical region of northern Australia, a 'Digital Homestead' was established implementing sensor and related technologies to provide information to simple and usable cloud-based decision support systems for farmers and agriculture advisers. A sensor network collects data streams from a range of sensors such as weather stations and walk-over-weighing platforms to collect individual animal liveweight data. The data are uploaded to a central server and can be viewed in real time via a dynamic web interface, or 'dashboard'.

The design and functionality of the dashboard was shaped by ongoing engagement with industry stakeholders. Information flowed in real-time from both the on-farm sensors and off-farm sources such as market information and climate forecasts. Information was presented as a series of 'widgets' to allow customizing to individual preferences, and interrogation of information from a simple overview to detailed data.

For the future viability and resilience of farm businesses the use of these technologies offers a significant opportunity to drive outcomes in profit, productivity and sustainability if data can be linked and translated into insight These new technologies may also form the backbone of emerging agri-environmental services businesses.

Keywords: Precision livestock management, dashboard, sensors, sensor network

INTRODUCTION

In Australia, the requirement for significant productivity gains in the agricultural sector is undeniable. Sustainable, viable industries must be capable of consistently producing a margin above the base costs of production, a more challenging prospect in an increasingly dynamic and challenging environment.

The competitive advantage of Australian extensive livestock farmers in global food production has been largely based on low cost of production and utilisation of home grown pastures and forages. Feed costs have always been a high proportion of the variable and total costs on farms, and farm profitability is often positively correlated with home grown feed consumption. Unfortunately this competitive advantage has been eroded by increased climate variability, and for irrigated regions, low water availability. Between 2001 and 2008 Martin *et al* (2013) observed that cost of production in the northern Australian beef industry increased by 70%.

In addition, there is an increasing need for the agricultural industries to demonstrate improved efficiency to the wider community with respect to certain biophysical aspects of farming including water and nutrient use and environmental impacts such as greenhouse gas emissions. Community scrutiny of animal welfare in animal production systems is also an issue in relation to the industry's future right to farm.

Farmers are also facing more volatile movements in markets, production opportunities, input costs and farm profitability. This has seen a fall in productivity and has raised questions about the viability and resilience of some traditional farm business systems to adjust. Industry's ability to develop and maintain the capability to deal with an increasingly complex business environment is critical for future success. It has been reported that approximately half of the beef producers in Northern Australia spent more than they earned in six of the seven years between 2002 and 2008 (McCosker *et al*, 2010) putting into question the profitability and sustainability of the northern beef industry. Further, Martin *et al* (2013) reported that farm business profit for beef cattle producing farms in northern Australia was an average of $45,100 per farm in 2011–12, and was projected to decline to just $2,000 per farm in 2012–13.

To remain profitable, farmers will need to drive further productivity gains, a challenge that will involve greater flexibility in their strategic (longer term), tactical (within season) and operational (day to day) decisions. Decisions will need to be taken with an understanding of risk, and how they impact across the whole farm business system. Staying the same is simply not a sound economic option for most farm businesses as the cost/price squeeze means reduced profit if productivity gains are not made. To adjust to changes in the operating environment and to remain profitable, farm managers endeavour to move the farm system over time onto new production functions.

The rationale here is that viable and resilient farm businesses in the future will make sense of what they know as they come to know it, and then make very fine-grain, accurate and timely decisions.

The objective of the work described in this paper was to explore how electronic services enabled by connectivity to the National Broadband Network could support greater productivity for farming enterprises, as well as providing related support and social services to rural residents. A simple and usable cloud-based decision support system for farmers and agriculture advisers was implemented using sensor and related technologies to test the hypothesis that more accurate, timely and efficient management (operational, tactical and strategic) across the farm business would be enabled by the timely, accurate and objective measurement of resources (from soil and water to feed, animals and product quality and quantity) coupled with sound interpretation and understanding.

METHODS

Location

CSIRO's Lansdown Research Station at Woodstock QLD (Lat -19º 34' 59" S, Long 146º 49' 59" E) is a 638 ha property located in the tropical region south-east of Townsville, Queensland. The property provides state-of-the-art facilities for field research and demonstration aimed at delivering practical on-farm solutions to improve the productivity, profitability and sustainability of the northern Australian cattle industry. The property is typical of the region, receiving approximately 850mm rainfall annually, mostly in the wet season (December to March). It supports a pasture yield of more than 3 tonnes dry matter per hectare.

A demonstration site was established to monitor growing steers in an extensive grazing environment covering 150ha. Three groups of thirty steers each graze one of three paddocks in rotation. The paddocks are 15 ha and have one permanent water point per group of three paddocks that is fenced off and has two spear gates, one for entry and one for exit. At the entry of each pen is a walk over weigh station which is connected to wireless sensor network as described below.

Wireless sensor network & data delivery

A static sensor network and gateways were designed, developed and deployed with a total of 80 nodes across the Lansdown property. Six of the nodes were weather stations and three were Walk-over-Weighing stations to capture individual cattle weights. On the 150ha used for the project, there are 40 nodes approximately 200m apart (Figure 1).

The static network nodes have been designed for environment sensing connectivity. Each sensor hub node is mounted inside an enclosure with a 3.6V @

16Ah Li-ion battery and external 5V @ 600mA solar panel. The enclosure is mounted to a metal pole with radio antenna and solar panel.

A large number of different environmental sensors can be connected to the wireless static sensor hub node including soil and leaf moisture sensors, photosynthetically active radiation (PAR) sensors, weather stations, walk over weighing stations. They can also relay data acquired by new livestock monitoring devices that record animal location and activity (behaviour) continuously.

Data is relayed through the network to a Global Sensor Network (GSN) backend. The GSN backend is an open source middleware designed for managing data produced by sensors deployed in a sensor network (see Gaire *et al* 2013). It was specifically chosen because it is open-source software that is scalable, flexible and easy to tailor for the capture, integration and management of sensor network data as well as external data streams from a range of disparate sources.

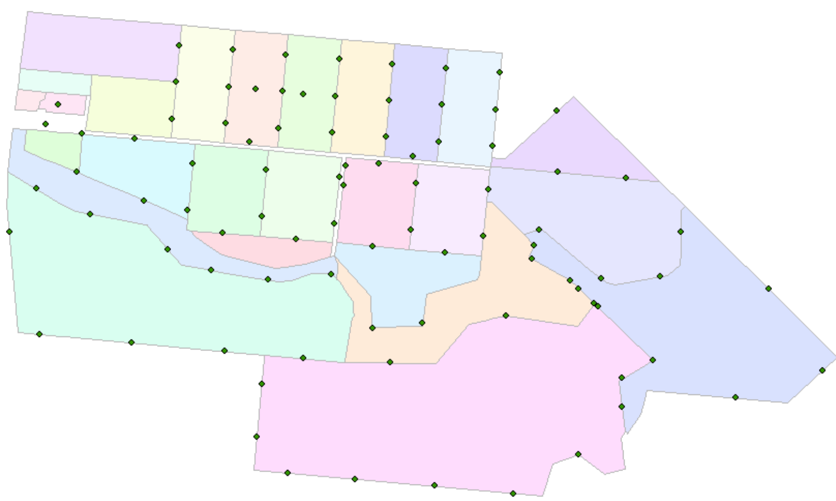

Fig. 1. Location of sensor network nodes at the Lansdown Research Station

Data sources & dashboard presentation

A cattle industry reference group consisting of graziers and service providers was engaged to shape the design and functionality of a dynamic web interface, or "dashboard". The over-arching objective of the dashboard was to capture, integrate and present in real-time all the data streams from both within the farm and from external sources, relevant to any given farm business and its environment.

The dashboard was based on JavaScript libraries including jQuery and jQueryUI. The backend was implemented as WSGI python modules hosted on an Apache server storing interface data via SQLAlchemy in a PostgreSQL database. Sensor data was pulled via RESTful Ajax calls directly from GSN, whereas other data like the weather forecast was fetched indirectly from the web via the python backend. The received JSON data was presented on the website with visualising plots generated by the Google charts API.

Data was captured from key sources within the farm including:

1. Individual animal live weights - acquired from three Tru-test walk-over-weighing platforms (model XR3000) deployed in separate paddocks. Animals voluntarily walk over the platforms, lured by the availability of water and/or supplement. A National Livestock Identification Scheme (NLIS) panel reader at each Walk-over-weighing station records individual animal ID, time, and weight. Individual weights are acquired, then algorithms applied that smooth and filter the data to calculate current animal live weight (kg/hd), live weight trends and live weight change (kg/hd/d).
2. Local (on-farm) weather was sourced from 6 Vaisala Weather Transmitters (WXT520) deployed across the property, each recording temperature, rainfall, barometric pressure, humidity, and wind speed and direction.
3. Farm Map (based on Google Maps) showed all current paddock and property boundaries, and the locations of geo-referenced infrastructure (eg walk-over-weighing platforms, weather stations) and other resources. When cattle with monitoring technology are deployed, their location will be shown in real time. The farm map is overlaid with a visual satellite image.

Data sourced from outside the farm include:

1. Market information specific to the business operations is sourced from Meat & Livestock Australia in the form of the "Eastern Young Cattle Index" (EYCI). Local saleyard and abattoir information will be integrated at a later date.
2. Weather forecasts are sourced from the Australian Bureau of Meteorology to provide 7-day forecasts. Users can select their nearest location from a drop-down menu.

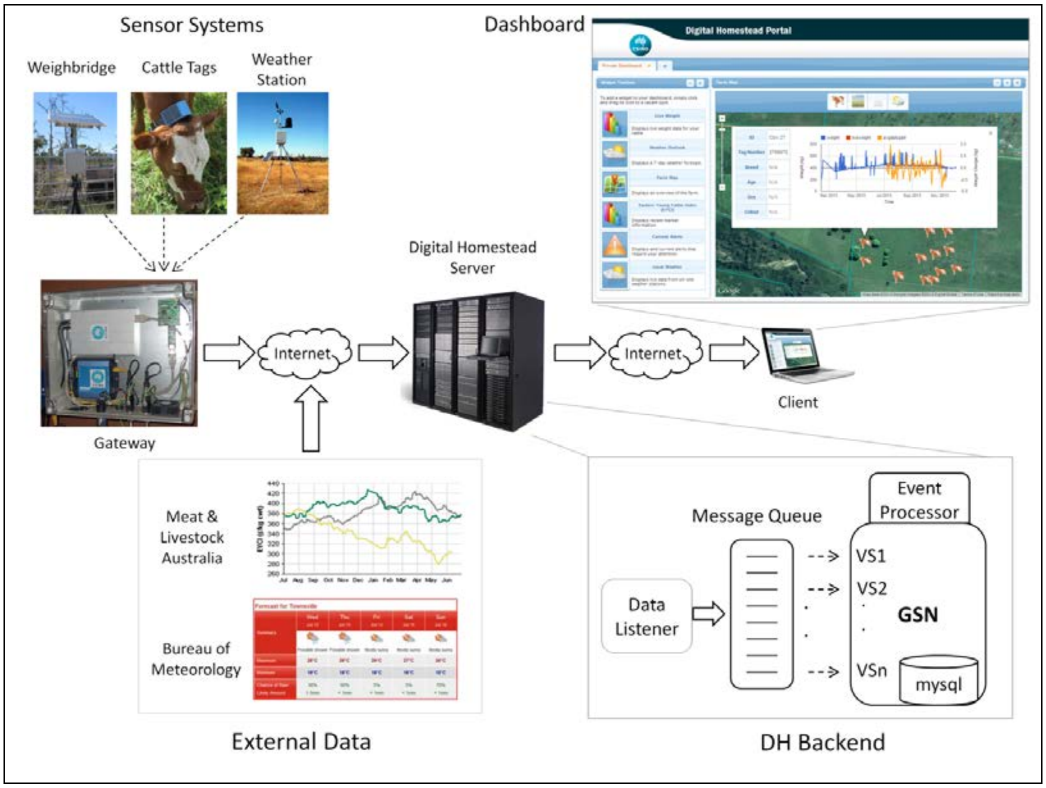

Fig. 2. Schematic showing the flow of data from on- and off-farm sources to the dashboard

RESULTS & DISCUSSION

User requirements

Engagement with industry stakeholders and potential end-users, including both graziers and the service sector through the supply chain, identified a number of key requirements for the dashboard. It was clear that it should be accessible on both a web-based platform and also mobile devices (perhaps in a cut down version), and that it should be designed as a 'one-stop shop' where all the information relevant to a farm business and its environment is integrated and presented.

Presentation of information was seen as key – it needed to be simple so that information could be easily interpreted and understood, and timely to capture 'windows of opportunity' in farm business management. Users stressed a need for it to show the state of the farm business in 'one glance only' that enables an immediate decision to be made: "do I go about my daily business, or do I need to do something?". The subsequent ability to interrogate information at greater detail was important, but not all users at all times believed they would dive into the detail.

Accuracy of data was seen as important, but it was also accepted that in some instances the outcome was more confidence in decision making and very high levels of accuracy were not always required. It was also recognised that some data streams were potentially providing information where no frequent or timely data was otherwise available, so lower levels of accuracy were acceptable.

There was a clear message that timely information was critical, but that true insight would be gained by providing predictive information. To address the diversity of farm systems, geographic regions, management regimes, personal needs and preferences and so on, the ability for any end-user to customise the dashboard was critical.

Dashboard development

Given the design and functionality requirements described above, a prototype web-based dashboard was developed (Figure 3), with information flowing in real-time from on-farm sensors and off-farm sources. The dashboard was designed with a series of 'widgets' that can be selected (or turned off) according to the preference of individual users by simply grabbing and dragging an icon to a desired location on the screen. When any widget is launched only the most critical information is presented in a very simple way so that at a quick glance a user can establish whether further interrogation is required and/or subsequent management intervention is necessary. Once the dashboard has been set up with the preferred widgets, it will remember those preferences so that if desired, it can operate as an automated static dashboard.

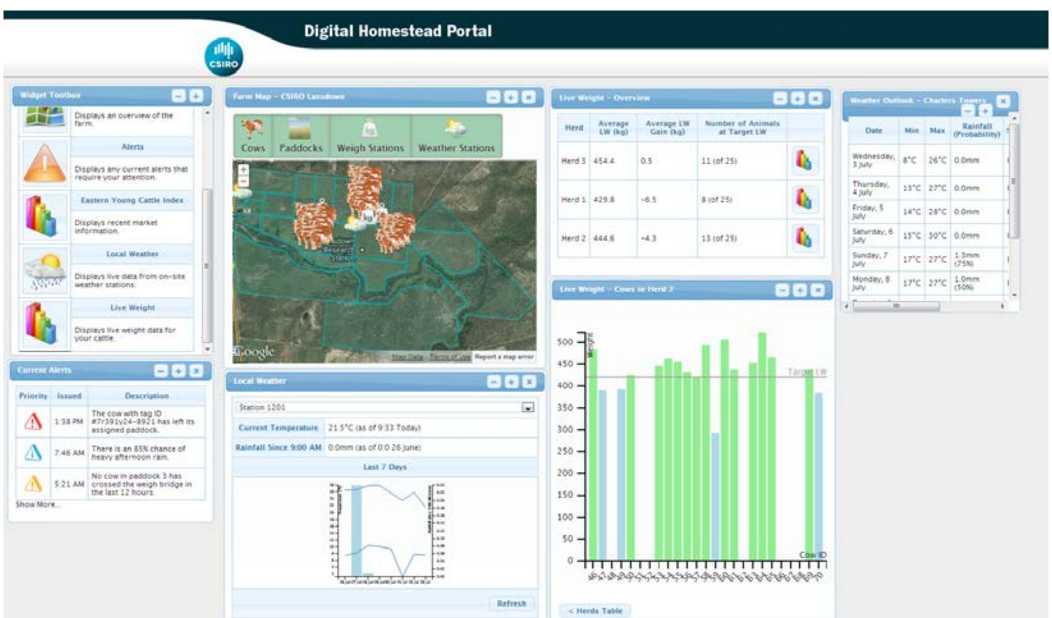

Fig. 3. Snapshot of the Digital Homestead dashboard

As an example of how the individual widgets operate, consider the need for individual and herd level animal liveweights. Livestock grazing enterprises across northern Australia are very large, with some stations larger than one million hectares, and livestock may only be mustered and physically seen twice a year.

Graziers expressed a need for frequent and accurate information on animal liveweight to assist management decisions for improved reproductive efficiency, optimising animals meeting market specifications and early warning on animal health and welfare.

Individual animal live weights were acquired from three walk-over-weighing platforms deployed in separate paddocks, where animals voluntarily walked over the platforms lured by the availability of water and supplementary feed. The introductory widget displayed herd average data – current liveweight (kg/hd), liveweight change (kg/hd/d) and the number of animals in the herd currently reaching a target live weight (that could be set by the user). If desired, secondary widgets could then be launched to interrogate the individual animal data and changes over time. Alerts were also displayed – these could be configured on any of the data streams flowing into the GSN back-end, based on any single or combination of thresholds, and then viewed in a separate widget, or pushed to a mobile device.

Capturing value from real-time data

The over-arching requirement of such a system is that it has to move beyond acquisition and delivery of data, to actually enable improved decision making, whether it be more: timely, accurate, and/or risk-informed decisions. At the farm or enterprise scale, one value proposition is that it must enable the rapid management of animals/feed or other resources at more precise scales than the herd or paddock scale.

Henry *et al* (2013) described how platform technologies and services over the past decade have been centred around the individual (eg a mobile device serves as the core platform to deliver services such music, location-based services, email and social networks) with data typically being stored on a remote cloud server. The opportunity demonstrated here is to evolve this from being centered around the individual to being centered around an agricultural enterprise.

As high-speed broadband networks become the backbone for delivery of new services including high-definition multimedia or other streaming data, new business models will need to evolve which can take advantage of information which is increasingly shared between multiple enterprises while still maintaining a competitive marketplace.

For the future viability and resilience of farm businesses in an increasingly complex operating environment, the use of these technologies offers a significant opportunity to drive outcomes in profit, productivity and sustainability if data can be linked and translated into insight.

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