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The road to real-time remote on-farm monitoring

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Key messages

- Solutions are available for creating connectivity and data transport networks across farms.
- Experiences with installation depended on the complexity of the connectivity solution, the level of support and services contracted and the skill level of participants.
- Installation of IoT sensing and monitoring systems created greater awareness of conditions and variability across farms, provided confidence in decision making and changed work practices.

Aims

To accelerate farm businesses to overcome challenges in on-farm connectivity and the use of real-time on-farm digital IoT sensing systems.

To increase awareness and confidence in the potential of this technology for farm businesses through improved operation in a connected digital environment.

Introduction

The Agricultural industry has real potential to be the next $100 billion sector for the Australian economy by 2030. To realise this potential we will need to look towards transformative technologies such as digital and information technologies as the next mega trends capable of influencing Australian agriculture.

Connectivity presents significant constraints to the potential utilisation of digital technology on farm, and the realisation of an estimated extra $24.6 billion to national gross domestic product (GDP) from the unconstrained adoption of digital agriculture in Australia. (Lamb, 2018). The connectivity constraint is also significant to agriculture as it is the least digitised industry globally (Blackburn et al 2017).

Digital agriculture provides the opportunity for sensing systems and associated analytics to lower the cost of knowing what is going on and more accurately predict the future (Robertson et. al., 2018). Enabled as Internet of Things (IoT) devices these sensors are able to collect data and communicate information through networks, which is then processed and analysed either in the cloud or by ‘edge computing’ (data processing closer to the devices). The software can then action this without user intervention through, for example alert messaging or by turning on water pump equipment.

IoT sensors present opportunities to farm businesses to improve the efficiency and profitability of both production and business processes. IoT systems can facilitate the use of real-time information to enable more timely and efficient use of inputs, equipment and labour which is likely to underpin many future farming capabilities.

However, starting on the digital agriculture journey and finding the most appropriate technologies is daunting. There has been limited agricultural industry knowledge in Western Australia on the telecommunication options available to create on-farm connectivity and the value of adopting new digital technologies. The value proposition of IoT devices in broadacre agriculture and more broadly agriculture is not clear. The ability of devices to communicate and share information has been dominated in the market by closed proprietary-based technologies making the ease of curating and integrating farm data difficult. This has also impacted the development of one-stop visualisation dashboards and limited industry capability to provide IoT data analytic platforms suited to agriculture and farm businesses.

The Department of Primary Industries and Regional Development through its eConnected Grainbelt program has invested into this technology disruption space by funding grower groups and agricultural schools to establish demonstration sites. The demonstration sites from this program will be a step towards increasing awareness and confidence in the potential of IoT technologies for farm businesses.

Method

In 2018, Grower Groups and Agricultural schools and colleges across the WA grainbelt were invited to apply for funding to trial and host remote on-farm monitoring technology solutions for Internet of Thing (IoT) sensors and devices.

The program was launched in May 2019 with the aim of increasing farm productivity and profitability through improved decision making from data-driven insights.

Fifteen project recipients investigated available technologies to match their business requirements. Technology solutions were installed on host farms to support monitoring using three IoT sensors, connectivity technology and an IoT data analytics platform using open source techology. The projects were funded with up to $50,000 of matched funds to investigate solutions.

The experiences of the participants were monitored through the installation and operation phases of the project and case studies were developed to capture their learning journeys.

Results

On-farm connectivity solutions

A wide range of connectivity solutions were tested from low and high bandwidth connectivity technologies. Three low bandwidth Low Power Wide Area Network (LPWAN) technologies were tested in the program: LoRaWAN, SigFox and CatM1. As a low bandwidth technology LPWAN can provide coverage over very large distances (up to 50km) and is optimised for low power consumption, but the trade-off is that it can only transport small quantities of data at a time (<5kbps).

Grower groups and agricultural colleges that used low bandwidth LoRaWAN and SigFox connectivity technologies were able to create data networks transferring near real-time low-byte data across large properties with no or limited access to the main power grid. For example, the Mingenew Irwin Group (MIG) host property size was 15-20km wide (east to west) and 20-25km long (north to south).

The higher bandwidth technologies tested included wireless WiFi mesh and the 3G/4G network. While the higher bandwidth solutions have higher data capacity and support IoT sensors and devices, their trade-off is their range and power consumption, which impacts on battery longevity of the IoT devices. However, higher bandwidth solutions provide voice and image capability, which LPWAN networks do not, and for some farm businesses this is a greater pain point in their business. Higher bandwidth technologies also enable remote diagnostics and firmware updates. Both WiFi and LoRaWAN connectivity equipment were installed across hillside terrain.

Two grower groups created catchment-wide data networks with their members using 3G/4G for connectivity. Yuna Farm Improvement Group (YFIG) created a soil moisture probe network in addition to their rainfall gauge network, while Merredin and Districts Farm Improvement Group (MADFIG) created a rainfall gauge network across their member properties. These IoT systems were typified by these farmers having a single IoT device on the property.

The projects that opted to use cameras as part of the IoT system required higher bandwidth technologies and used 3G/4G and WiFi mesh connectivity. The use of high bandwidth WiFi connectivity achieved connectivity to blackspot areas on farms such as sheds where previously phone calls and searching for machinery parts on the internet was not possible.

The projects experiences during the installation of their connectivity solution depended on the complexity of the connectivity solution used (3G/4G vs WiFi), the level and capability of support and services contracted (self-installed vs engagement of an end-to-end provider), and the skill level of participants. Some projects chose to share the costs of connectivity infrastructure across neighbouring and remote properties. Others learnt that obstacles, (i.e. hills, power lines and trees) affected the 'line of sight' and impacted the signal strength. In short, the selection of connectivity requirements for a data transport network across a farm property needed to consider the amount of data the connectivity technology could transport, its range (distance), and the amount of power needed for its operation.

IoT solutions

There were 232 IoT sensors/devices installed across the 15 projects, with 16 different types of IoT sensors tested. These included soil moisture probes, rain gauges, weather stations, wireless cameras, tank level sensors, frost sensors, soil pH, salinity sensors and others.

Soil moisture probes were the most popular IoT devices installed, with 42 installed across the agricultural region. The probes were installed so that decisions could be made on whether to grow higher risk canola and lupin crops in low rainfall areas, or to make nitrogen decisions in-season regarding the amount of finishing soil water available. The experiences with the soil moisture probes were similar to DPIRD's own network of 35 soil moisture probes. The soil moisture readings were not calibrated to the site soil type and instead used the default factory settings. Soil moisture readings were improved when calibrated with results from the characterised soil samples from the sites. The projects also highlighted the importance of correct installation techniques, and that physical inspections are required to check the devices as part of a regular maintenance program.

Some 36 rain gauges and 16 weather stations were installed across the projects. The South East Premium Wheat Growers Association (SEPWA) wanted to demonstrate the benefits of a higher density of rainfall stations across a farm, while MADFIG installed a network of 25 rainfall devices. Stirlings to Coast Farmers (SCF) are aspiring to build a 100-strong weather station network across their member properties and are interested in the next steps needed to produce a hyper local weather forecast and improve weather forecasting for their area. Many participants found their level of awareness on the variability in conditions over short distances increased as a result of their IoT device installations.

An example of the variability found in conditions was a 60mm difference in the rainfall over 15km in Esperance observed during the growing season. The impact of this variation in conditions on farming practices was evident when one of the host farmers admitted they often did not really know what was going on at their property 30km away, and quite often they would arrive there and find the conditions very different to the conditions at home, reporting that time and money was wasted on the 60km round trip. Others reported the live wind data gave confidence for spraying in locations notorious for spray drift and the data gave confidence to staff to make the best spray decisions.

Of all the IoT sensors, the sensor that demonstrated the easiest and quickest return on investment during the nine-month project was the tank level sensor. Tank level sensors were used on water tanks, fuel tanks, FlexiN tanks and livestock lick feeders in the projects. It was the water tank level sensors, using ultrasonic sensors to measure levels in the tank that provided the most immediate savings on farm. An example from SCF showed that with just one water tank level monitoring device installed, labour savings over a 28km round trip could be as much as $9,300 over five years. Moora Miling Pasture Improvement Group (MMPIG) was able to show that 23,000km of mileage and six weeks labour could be saved for their host farm example on the 140km round trip. The experience from all participants with these sensors installed was that they improved water awareness and enabled more timely decisions to improve efficiencies and save costs.

IoT data platforms

The ideal IoT system is one that has a single dashboard that displays all data. This was the reason for the requirement to use open-source technology in this project. Feedback from participants on the dashboards included the need to be simple enough for everyone to understand, not have confusing layouts and optimising the dashboard for access on mobile devices. However, some projects were not able to achieve a single dashboard when using multiple sensor/devices or the data analytics, with Morawa Agricultural College requiring three dashboards for viewing. Some of the projects had custom designed dashboards but there were still some reports of cumbersome design and this was dependant on how involved the project participants were in the customisation, and the ability and willingness of providers to tailor their products.

The goal of the program was to gain more from the data platforms than just viewing data. The potential power of data analytic platforms lies in their predictive analytics. Hyper-local weather forecasting is an example of this because it integrates large amounts of data from local weather stations, other data and smart algorithms to provide advice on harvest and spray conditions. Only one of the participants in the program achieved the level of understanding regarding the value of open data analytic platforms to the farm business and investigated the solutions. However this participant highlighted the limited capability in the industry to provide open IoT data analytic platforms suited to agriculture and farm businesses. They also found that those available were not very affordable and voiced concerns over third party data use. Open platforms that are flexible and solve for the user needs provide a lot of opportunities for the agriculture sector.

How much does it cost?

The total cost of an IoT system depends on many variables, including how many sensors you want to set up and what type, the size/distance of the property(s) you want to monitor, the environmental terrain it will be covering, and the type of connectivity to be used. The cost will also depend on what you want to get out of the data, the dashboard/data analytics platform being used, and also whether you want to self-install or use an end-end service provider that manages the design and installation for you.

Indicative costs from the project ranged dependant on the funding provided from the smallest $10,000 project to the maximum $50,000 that was matched by the project. The cost of implementing the projects was generally more than budgeted. The basic upfront costs for equipment across connectivity technologies are not as expensive as first thought with an average cost of $1500 per component, for example a sensor device with telemetry. Depending on the device, (i.e. weather station vs soil moisture probe) additional sensors can be added to the device for a smaller cost. The basic ongoing costs include subscription to connectivity providers per device, (i.e. 3G/4G) or per single/twin gateways in the case of WiFi & LPWAN, and dashboard support and access fees.

The next level of costs would depend on the terrain/distance needing to be covered and whether towers need to be installed to receive/repeat signals (i.e. WiFi) or external aerials are required on devices in low signal areas (i.e. 3G/4G). You may also want assistance with solution design and installation, and need to consider the equipment maintenance costs. These systems are not a ‘set and forget’ proposition and a service agreement with established replacement and travel costs to cover the maintenance and service of devices is a good strategy.

On the whole, the IoT systems provided efficiency and time savings to farm businesses by creating better awareness of conditions and situations across the farms.

Discussion and Conclusion

A wide range of IoT enabled sensing systems for monitoring and gathering data on farm conditions were installed by the projects with 63 host farms across the WA grainbelt. These ranged from single IoT devices on 3G/4G connectivity to multiple IoT devices on more complex WiFi connectivity systems. More specialised fit-for-purpose IoT data collection systems were also installed using the LPWAN technologies LoRaWAN, Sigfox and LTE-M/CatM1. This project highlighted the many options available for whole farm connectivity even, as one grower group noted from their learnings, “without mobile phone coverage”.

The remote on-farm monitoring enabled growers to become better informed about the variability in their paddocks and businesses by focusing on what growers did not know about their local landscapes and farming systems. The growers gained a better understanding of the variation across their properties, particularly around rainfall and temperature variation across relatively short distances. Growers could remotely check on key areas of the farm using cameras, which provided peace of mind and security with high bandwidth technology. Data networks across farms were created transferring near-real time low-byte data across large properties with no or limited access to the main power grid using low bandwidth technologies.

The projects also implemented large-scale community data networks focused on collecting and sharing data among members to map rainfall and soil moisture profiles across the local landscape. At a school community level the program, through the IoT devices, was instrumental in motivating student interest in agriculture. At Edmund Rice College students were excited to learn about the new agricultural technologies available and WA College of Agriculture Cunderdin students inspired farming parents with the detail and ease of monitoring the farm from home during the COVID lockdowns.

The journey from implementation to operation was very challenging for many of the participants with a number of providers across different technologies falling short of expectations. Further education, information resources and support in terms of capable and consolidated local service providers will be essential as the IoT sector for the agricultural industry matures. Most importantly the funding demonstrated the breadth of cost-effective technology that is accessible to all sizes of farming businesses.

The IoT and road to real-time on-farm monitoring is still at the beginning of its journey to digitalise agriculture. Continuing to address the 'digital divide' and installing fit for purpose connectivity on farms will help to propel the agricultural industry towards digitisation and continued regional growth.

Case studies on the 15 projects are available at https://www.agric.wa.gov.au/real-time-remote-farm-monitoring-case-studies-wa-iot-decisionag-grant-program

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