Griffith Research Station LoRaWAN demonstration

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Introduction

Numerous technology options are available to assist growers with implementing vineyard environmental monitoring systems. Many growers are asking for information on how to set up a sensor network and the reliability of this equipment. This article outlines the installation of a long-range wide area network (LoRaWAN) vineyard monitoring system at the Griffith Research Station, key considerations and where to find further information. Interested growers are welcome to visit the Griffith Research Station and discuss LoRaWAN technology with NSW DPI Development Officer Adrian Englefield.

What is LoRaWAN?

Since 2016, the NSW Department of Primary Industries (DPI) has been trialling the Internet of Things (IoT) as a sensor network for on-farm data capture and processing. The FarmDecisionTECH™ trial (a collaboration between NSW DPI and Bralca Pty Ltd, a commercial farming operation based at Molong) was developed to demonstrate viable options capable of resolving barriers to digital technology adoption on NSW farms.

The most common reason limiting the uptake of digital agriculture was poor internet connection, followed by limited access to new technology and lack of support (Cotton Australia Limited 2018). Lamb (2017) reviewed on-farm connectivity options and found that lack of internet coverage was a significant barrier to adoption affecting new AgTech enterprises. There was a distinction made between connectivity to the farm and across the farm. Most farms have some internet connection to the homestead, but away from this central location it is typically non-existent or requires expensive (in both cost and power) mobile networks.

An alternative approach to a ubiquitous internet-connected sensor network is to use a low power, long-range network to provide data transmission across the farm with a single connection point to relay that to the internet. LoRa is a leading low power wide area network (LPWAN) for Internet of Things deployments. LoRa offers long-range data transmission for devices that do not need high speed or high bandwidth data rates and typically have low power consumption.

LoRaWAN is an open network protocol that operates on top of LoRa, defines the communications and network architecture, and provides inter-operability (the ability of computer systems or software to exchange and make use of information) between devices and manufacturers (LoRa 2015). LoRaWAN devices are typically associated with very small data packets, low-speed transmission, low power consumption and often only a small number of data packets per day. Adelantado et al. (2017) reported small LoRaWAN networks can deliver proper service to applications such as agriculture. A typical device on a farm would be a soil moisture sensor that sends a couple of bytes every hour and could therefore last up to 10 years in the field.

Data transmitted by a LoRaWAN device can be received by multiple gateways if available, each forwarding the data packet to the network server which can be in the cloud or a local network node. The network server then performs all redundancy and security checks before pushing the data to an application, such as a data storage, visualisation and analytics package (LoRa 2015).

FarmDecisionTECH™

An extension project to the FarmDecisionTECH™ trial was launched in 2018 to test the LoRaWAN across eight NSW DPI research stations for use in agricultural research. The project is nearing completion and will cover a number of key industries to NSW DPI research, including horticulture, viticulture, livestock and aquaculture.

A key outcome to date is that some of the issues raised by Cotton Australia Limited (2018) are still preventing technology uptake. Even though there is an increasing variety of commercial providers and open source, community-based networks, access to network equipment specialists in regional Australia is still limited. Similarly, access to sensors and the knowledge to install and interpret data is still hampering the greater adoption of IoT on farms.

Griffith Research Station LoRaWAN installation

As an initiative of the Wine Australia 2017–22 Riverina Regional Program, NSW DPI partnered with Edaphic Scientific to design and install a LoRaWAN vineyard environmental monitoring system at the Griffith Research Station. This system will demonstrate the benefits of LoRaWAN and IoT technologies and allow further viticulture environmental monitoring of projects and Riverina Regional Program activities at the Griffith Research Station.

Node installation (Figure 19) at seven Griffith Research Station sites (Figure 20) allows wireless sensor data communication up to 10 km from a gateway. A gateway (1) receives the data and sends it to a secure cloud-based server via a modem or ethernet connection. Node 3 transmits weather station data from an ATMOS 41 weather station (Figure 21), while the remaining six nodes are connected to sensors measuring:

- leaf-wetness (Figure 22)
- temperature/humidity using an ATMOS 14 digital sensor (Figure 23)
- soil moisture and electrical conductivity (EC) using a Sentek Drill and Drop probe (Figure 24).

Figure 19. Node installation at the Griffith Research Station vineyard.

Figure 20. The location of the gateway (1) and the seven Griffith Research Station nodes.

The gateway is located in the farm manager's office and receives node signals through an aerial approximately 10 m in elevation. Design considerations include:

- the spreading factor: there is a trade-off between this and the communication range, where transmission is slower with a higher spreading factor. Communication range should be as small as possible to limit both the time on air and the subsequent off-period. In other words, the gateway must be close enough to the end devices.
- the number of channels must be carefully designed and accommodate the:
  - number of end-devices or sensors
  - maximum duty cycle: defined as the maximum percentage of time during which an end device can occupy a channel. The selection of the channel must implement pseudo-random channel hopping at each transmission and be compliant with the maximum duty cycle.

Figure 21. An ATMOS 41 weather station.

Figure 22. A leaf wetness sensor.

Figure 23. A temperature/humidity sensor.

Figure 24. A soil moisture probe ready to be installed.

Class B nodes were installed where data transmission from each node occurs at synchronised times to avoid all nodes communicating with the gateway at the same time. The LoRaWAN application is not applicable to industrial automation and critical infrastructure monitoring requiring real-time operation (industrial control loops may require response times around 1–100 m/s) (Adelantado et al. 2017).

Under ideal conditions, a node can communicate with a gateway up to 10 km away. However, growers must consider grapevine canopy density, topography, buildings or other factors affecting line-of-site. The node aerial at the Griffith site (Figure 19) is 2.1 m above the ground to accommodate an over-row fungicide spray cart. Signal strength was measured on 7 January 2019, with full canopy growth at different heights to demonstrate how fully grown grapevine canopies affect line-of-sight and signal strength (Table 4).

Table 4. LoRaWAN signal strength at seven Griffith Research Station nodes.

Node	Aerial height above ground level (m)	Signal strength (dBM)	Distance from gateway (m)
1 Gateway	10.0	N/A	N/A
2 Disease-resistant varieties (white)	2.1 1.2 0.3	-92 -95 -99	284
3 ATMOS 41 weather station	2.1	-72	77
4 Chardonnay_1	2.1 1.2 0.3	-90 -96 -107	203
5 Chardonnay_2	2.1 1.2 0.3	-73 -99 -93	128
6 Shiraz	2.1 1.2 0.3	-97 -95 -108	307
7 Chardonnay_3	2.1 1.2 0.3	-102 -103 -104	375
8 Durif	2.1 1.2 0.3	-104 -103 -102	484

dBM = decibel-milliwatts.

Typical signal strength values should range from between -50 to -120 dBm (Forster 2019). LoRaWAN nodes will usually operate at signal strengths down to -120 dBm. Once the signal strength reaches approximately -120 dBm, data transmission can be intermittent and unreliable. However, even a signal strength of -119 dBm is adequate to transmit the small data packets from a LoRa node. The highest observable signal strength is approximately -60 dBm.

Signal strength testing also occurred across the Griffth district (Table 5) using a mobile LoRa node where the aerial was located at approximately head-height (1.8 m above ground). The mobile LoRa node was moved to various locations and distances from the NSW DPI research station within the Griffith region. Depending on location, the LoRa node attempted transmission of data under non-ideal conditions and there was signal attenuation by numerous objects such as buildings, vegetation and hills. Regardless, the mobile LoRa node was still able to send a signal to the gateway from various locations around Griffith.

Table 5. Signal strength (dBm) at various Griffith region locations.

Location	Signal strength (dBm)	Distance from gateway
1 Griffith Research Station	-54	20.0 m
1 Yoogali Public School	-118	2.39 km
2 Cnr Murray and Hanwood Rds	-114	2.99 km
3 Hanwood Store	-121	3.72 km
4 Jack McWilliams Road	-117	4.30 km
5 Riverina Winegrape Growers Office	No signal	5.00 km
6 Hermit Hill lookout (Figure 25)	-114	5.44 km
7 Ted Scobie sports oval	-119	5.51 km
8 Cnr Rosetto and Gorman Rds	-120	6.8 km
9 De Bortoli Road	-121	7.87 km
10 Lake Wyangan Public School	No signal	9.27 km
11 Yenda	-121	15.72 km
12 MIA Vine Improvement Society	No signal	16.52 km
13 Nericon	No signal	19.70 km

Recommendations

Growers considering installing a LoRaWAN vineyard environmental monitoring system need to consult with specialists to design a sensor network for their individual requirements.

For adequate signal strength, install aerials as high as possible and with as few line-of-sight obstructions between the node and gateway as possible. For example, in Table 5, the signal at the Riverina Winegrape Grower's office is obscured by buildings and the signal at Lake Wyangan Public School is obscured by Scenic Hill. To improve signal strength at the Griffith Research Station, the LoRaWAN gateway line-of-site could be improved by increasing gateway–aerial height above the current 10 m level.

If nodes are located more than 10 km from a gateway, then additional gateways should be considered. On a larger scale, further gateways might be required depending on line-of-site considerations including topography and buildings.

It is also important to recognise that nodes and gateways are not data logging nor storage devices. The purpose of LoRaWAN is to provide real-time (or near real-time) data for management decisions. If the power supply at a node is disrupted, or if the gateway is inhibited, then most LoRaWAN systems will not record data and no other data can be retrieved. If historical data is critical for your operation, then a data logging system, rather than LoRaWAN, might be more appropriate.

Some online platforms that display data from LoRaWAN devices have data storage capacity, but data storage is usually not a default setting and it is important that your LoRaWAN provider can offer this facility to you.

The Griffith Research Station LoRaWAN system operates on a time scale of one to several hours. It is ideal for hourly weather station or soil moisture probe information updates. However, if you need high-frequency data for critical management decisions, a modified version would be more appropriate.

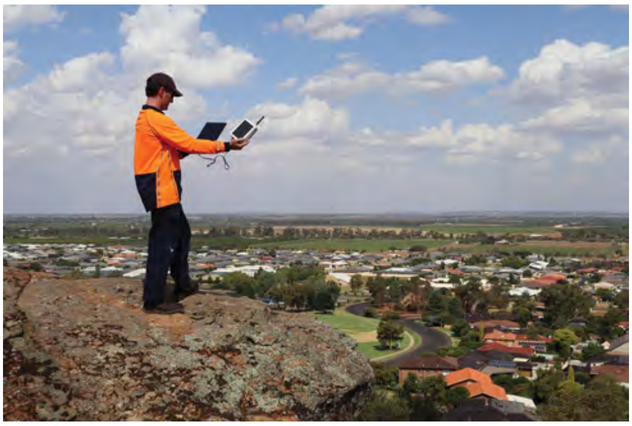

Figure 25. Testing signal strength at Hermit Hill lookout.

If you are interested in visiting or for more information regarding the installation of the Griffith Research Station LoRaWAN network, please contact NSW DPI Development Officer Adrian Englefield:
P: 0428 324 099
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A demonstration website for the Griffith Research Station LoRaWAN network can be found at https://portal.sensori.cloud/public/dashboards/195/token/3sKun

References

Adelantado F, Vilajosana X, Tuset-Peiro P, Martinez B, Melia-Segui J and Watteyne T. 2017. Understanding the Limits of LoRaWAN. *IEEE Communications Magazine*, 55: 9, 34–40.

Cotton Australia Limited. 2018. Regional Telecommunications Review, Submission to Cotton Australia.

Forster M. 2019. Edaphic Scientific Pty Ltd. Personal communication.

Lamb D. 2017. Accelerating precision agriculture to decision agriculture. A review of on-farm telecommunications challenges and opportunities in supporting a big data future for Australian agriculture. University of New England and Cotton Research and Development Corporation, Australia.

LoRa Alliance. 2015. A technical overview of LoRa and LoraWAN, LoRa Alliance, LoRa Alliance Technical Marketing Workgroup: https://lora-alliance.org/resource-hub/what-lorawanr

Acknowledgements

Wine Australia

Riverina WINEGRAPE GROWERS

edaphic scientific
environmental research & monitoring equipment