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IoT-driven connectivity will revolutionise real-time temperature monitoring of horticulture supply chains

Temperature is recognised as the most important environmental factor in maintaining shelf life and reducing food waste of fruit and vegetables[1]. The addition of wireless connectivity to data logging platforms has greatly increased the convenience and value of temperature monitoring within fresh produce supply chains.

In the past, temperature loggers have been used in horticulture supply chains primarily as a regulatory requirement of disinfestation protocols or as an insurance policy against loss of produce quality due to poor temperature management throughout the supply chain.

In the event of poor quality at the destination market, a grower or exporter who included loggers in their consignments could use the temperature and time data to estimate at which stage of the chain poor temperature management had occurred. In some cases, they may be able to make a claim against a carrier or insurer for loss of income or at least take measures to avoid a repeat of the same situation.

The downside of non-networked loggers, from which data has to be downloaded manually, is that they end up at the shipment destination, while it is the sender who is generally most interested in the data. This is particularly problematic during export, when the reverse logistics of getting the logger back can be expensive, the loggers remain at the destination market, and the data is never seen. This leads to a perceived lack of return on investment in monitoring and has discouraged its routine adoption.

Networked loggers can automatically upload data to the web via a cellular connection or through radio transmission to a networked hub at key locations throughout the chain. The data is immediately available, providing timely access to key players in the supply chain, increasing transparency and informing actions to reduce the financial impact of poor handling.

The wireless communication protocols used in loggers fall into four main categories:

- Satellite:

  Offers the potential for real time monitoring of shipments while at sea or outside cellular network range, but is rarely used in individual consignment monitoring due to the cost of the base infrastructure and connectivity.

- Cellular: GSM (2G), UMTS (3G), LTE (4G), and soon 5G.

  While cellular networks are reliable and nearly ubiquitous, they are a poor fit for battery-powered loggers that regularly transmit tiny packages of data, are regularly on the move and often in areas of poor cellular coverage.

  Unfortunately, for logging requirements, with the development of each generation of cellular standard, the focus has been on maximising the quality and volume of data transfer at the expense of power consumption and device transmission range.

  Nonetheless, cell connected loggers currently offer the easiest entry point into wireless monitoring with no investment into infrastructure and generally good connectivity worldwide. They are best suited to logging short duration shipments, but versions are available with up to 50 days battery life.

- Local or meshed: Bluetooth, BLE (Bluetooth Low Energy), ZigBee, NFC (near field communication), RFID (radio frequency identification).

  Data is transmitted from the logger to a communication hub via e.g. RFID or Bluetooth. The hub then uploads the data to cloud storage which can then be accessed through a web interface. The limited transmission range translates to reduced logger

power consumption, enabling long-term battery operation. However, the limited range requires careful attention to communication hub location to ensure reliable data upload.

NFC systems typically rely on a smartphone with the required app placed close enough to the logger to allow data download.

These systems require good supply chain relationships that allow communication hub installation at the destination or staff on hand with smartphones to download the data.

- LPWAN: NB-IoT, LoRaWan, SigFox, LTE CAT-M1

  Low Power Wide-Area Networks have been developed to bridge the gap between the above modes of communication. They are low power, long-range radio transmission methods that are perfectly suited to infrequent transmissions of small packages of data.

  Sigfox and Lora were the forerunners of NB-IoT (Narrow-Band IoT). They both operate within unlicensed spectrum which limits their commercial use.

  Public networks have developed in many countries, with Sigfox installing their own antennas on existing cellular towers. In contrast, LoRaWAN relies on the user base investing in the transmission infrastructure, which is relatively cheap and growing in coverage thanks to a supportive community.

  NB-IoT and CAT-M1 are competing licensed spectrums that 'piggy-back' on existing cellular infrastructure for their connectivity. One or a combination of both are likely to dominate the IoT networking market.

  LPWAN communication has opened up the potential for sensors and loggers that can operate for years on battery power with very low operating costs.

While each connectivity option has its benefits in the current operating environment, it is almost certain that the majority of future IoT deployment will be on LPWAN networks and communication providers have invested heavily in preparing cellular networks to provide the required connectivity.[2]

The move to LPWAN connectivity should greatly improve the reliability of wireless loggers while reducing the total cost of implementing monitoring of fresh produce shipments. It brings together the best of both worlds with access to mobile cellular networks worldwide, while keeping the power consumption and data costs to a minimum.

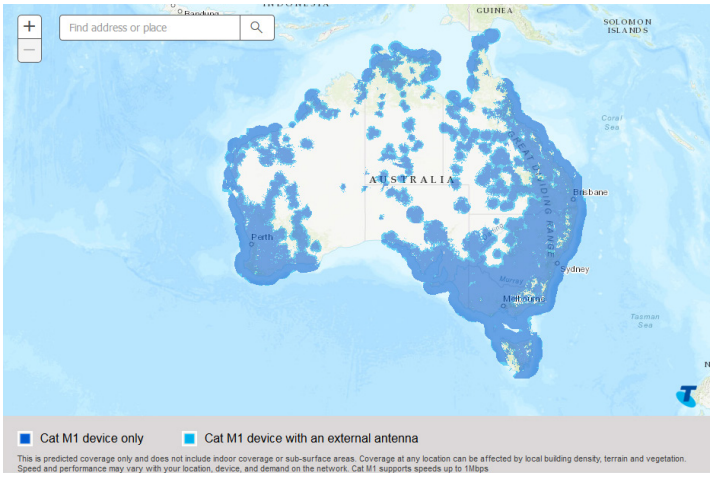

Figure 1. Map of Cat M1 reception areas in Australia

Different use-cases will favour one or more of the wireless communication options available but it is clear that wireless connectivity offers many benefits over the use of non-networked loggers in terms of improved access to reliable data in a timely and cost effective manner, which improves our ability to respond to issues in the supply chain.

The Supply Chain team at the Queensland Department of Agriculture and Fisheries is evaluating new logging and communications technologies as they emerge and assisting the fresh produce industry in the adoption of monitoring technology and strategies to make best use of the data.

Bibliography

1. Kader, A., & Rolle, R. (2004). The role of post-harvest management in assuring the quality and safety of horticultural produce. Rome: FAO.
2. https://www.telstra.com.au/business-enterprise/solutions/internet-of-things/iot-coverage

Metcalfe's law: "The value of a telecommunications network is proportional to the square of the number of connected users in the system (n^2)."

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