TECHNOLOGICAL PRACTICE CASE STUDY | JANUARY 2009

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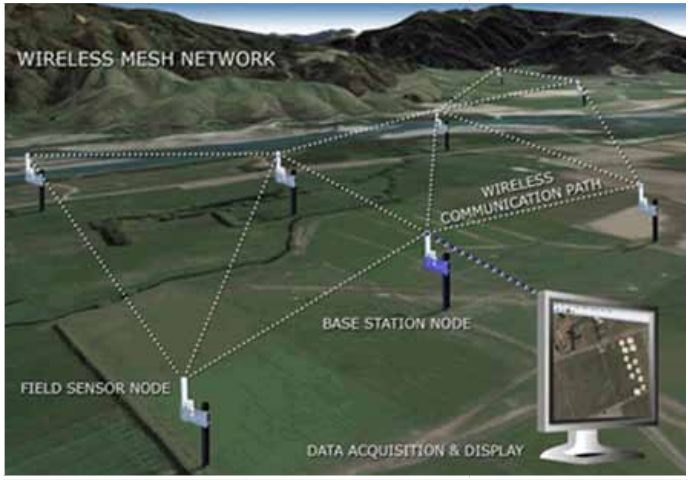


MESH PROTECTION

Electrical engineer Dr Dave Rankin has developed an innovative system to monitor horticultural crops using a wireless mesh network that delivers climatic information to growers using a robust and simple technology. Early accurate information is vital for effective intervention, in, for example, watering management and frost-damage limitation. This case study looks at the development of the system and its trialling at three vineyards and a kiwifruit orchard.

FOCUS POINTS INCLUDE:

Technological Systems

- Set of interconnected parts
- Exists as a result of human design and functions without further human input
- Transformation, storage, transport and control of materials, energy and/or information

ADDITIONAL SUPPORT MATERIAL

- Indigo Systems www.indigosystems.net.nz
- Frost monitoring the smart way TVNZ Business News 13 May 2009

MESH PROTECTION

More than 30,000 hectares now produce grapes for wine production in New Zealand. The increase has seen growers resort to using land not previously thought to be able to sustain such a harvest because of potentially devastating frosts in spring and autumn. Claire Le Couteur talks to an innovative engineering firm helping to take the risk out of the wine industry.

With the increasing popularity of our wines at home and overseas, it is important to protect these valuable crops as efficiently and fully as possible. Dave Rankin, an electrical engineer, has developed an innovative system to monitor horticultural crops using a wireless mesh network that delivers climatic information to growers using a robust and simple technology. "After a fair bit of development of hardware and software, I came up with a product that collects information in real time for vineyards," says Dr Rankin.

Based in Christchurch at the Canterbury Innovation Incubator (Cii), Dr Rankin's company, Indigo Systems, arose from earlier wireless mesh communications work he completed after finishing his PhD at the University of Canterbury in 2001. While designing home automation systems he saw a possible use for the technology in the agricultural and horticultural area, especially using advanced power saving algorithms to prolong battery life and radio waves to carry information across much longer distances.

BEGINNINGS OF AN INNOVATION

Through a series of fortuitous incidents he was introduced to staff at Cii who conducted market research, sorted out trials, and helped with other things he had not have much experience with at the time.

Dr Rankin employs two part-time staff and Christchurch-based Assembly Specialists to manufacture the wireless Indigo units. He is also about to employ a new engineering graduate to work in the company.

The product comprises a radio unit and microprocessor in a robust IP67 tube about 30 centimetres long, powered by a next-generation nickel-metal-hydride battery, or by a solar panel. The low self-discharging batteries will last up to a year in the field before needing to be recharged.

Dr Dave Rankin, founder of Indigo Systems and inventor of the Indigo mesh network environmental monitoring system.

Alongside each radio unit in the field are a number of sensors for measuring climatic variables – temperature, humidity, atmospheric pressure or wind speed for example. Other information such as the pressure of an irrigation pump can be relayed and controlled if necessary. The grower decides on the number and placement of sensors according to the particular size and geography of the vineyard. Typically, vineyards can have different areas of soil compaction and water retention that complicate the problem for growers. Variable limits are set by the grower and entered into the system for the radio units to activate alarms if they are breached. The grower can choose to control the system manually or automatically.

The radio units "nodes" are arranged in a mesh network, generally with one unit and its accompanying sensors every 2-3 hectares. The number varies according to the terrain and Dr Rankin has sites where he has installed more than one sensor per hectare and others with one every 10 hectares. He sees this versatility as one of the major advantages of his system. It is very scalable and easily configured to match any situation.

In a mesh network all the nodes talk just to their nearest neighbours and route information to an end destination. Should a node fail for some reason, the other nodes know how to bypass it and get the information through. The system automatically configures itself and this "self-healing" feature adds to the robustness of the overall network.

The nodes are usually placed on posts in the vineyard amongst the vine canopy but below the level where mechanised trimmers prune the vines. This is a compromise as dense or damp foliage could diminish the signal, but viticulturists do not want tall posts throughout their vineyards. Nodes are also put onto three-metre masts at the periphery of the vineyard and, with their longer range, can provide a "backbone" network between possibly obstructed in-vineyard sensors and radios.

ROBUST AND RELIABLE

There is typically one co-ordinator node connected to a central PC or to Indigo's servers. The client can log onto the website and access to the data. At that point the information is relayed back automatically. On the website, the vineyard's nodes are pictured on an aerial map and by clicking on each icon the grower can access historical data, graphed to show trends in temperature, for example. It is essentially an end-to-end system with controllers and sensors at one end to collect the data through to the visualisation and web display.

"The whole network is robust and reliable. If you can talk to one radio on the network you can essentially talk to all the radios in the network," says Dr Rankin. "It is easy to add more units to the network – they automatically talk to one another."

The system allows growers to manage their resources more effectively and efficiently. Often vineyards use a water-based system to fight frost and this can be expensive or the water can be in short supply. Using the mesh network, wastage is minimised by accurately forecasting frost conditions and only spraying suitable volumes onto the vines, thus saving energy while reducing side effects caused by over-watering.

At certain times of the year, too much water can also damage the vines by encouraging the growth of harmful fungi and other disease-causing organisms. It can also cause water-logging in poorly-drained soils and result in root rot of the vines.

Frosts occur in spring and autumn in New Zealand so the vines and grapes need protection in both seasons. A major contributor to the severity of frosts is hour-to-hour variation in the weather, particularly in cloud cover. Wind direction and strength both have a strong influence on cloud cover. The wind can influence where cold spots occur in vineyards, shifting a known cold spot some distance away from a stationary sensor. Monitoring this variability is very difficult for growers using a manual system.

Dr Rankin's system interfaces with watering systems, wind machines and helicopters in the fight against frost. It is important that pilots know when they should begin flying because of the expense of keeping helicopters in the air. By using his system, growers can see how effective the helicopters are at raising the temperature and can direct them to where they are needed.

"Typical vineyards have only one sensor connected to a cell phone and if this is in the wrong spot that could be a problem," says Dr Rankin. "If you are monitoring in real time over the entire vineyard you don't have this problem. You can get the trend of what is happening and monitor it and see how effective your actions are and maximise effective use of your resource base."

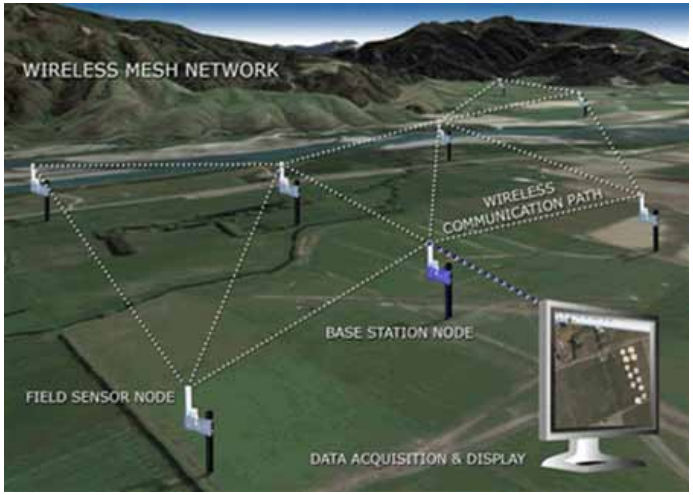
TRIAL MESHES

Indigo Systems has three vineyard trials underway in 2008, as well as one in a kiwifruit orchard in the Bay of Plenty. The largest trial is in a 350-hectare Marlborough vineyard, which is currently expanding to cover 400 hectares. There are 65 air temperature sensors linked to the same number of radio units mounted on posts at the fruiting wire height throughout the vineyard. The vineyard became involved after the owners met Dr Rankin at the Marlborough Wine Research Centre where he was collecting data for a scientific trial to measure the influence of climatic conditions on the variability of grape quality. The vineyard's owners had previously run their frost-monitoring system manually, taking their temperature sensors into the vineyard to look for cold spots. They would then record the temperature by hand and make a decision whether to turn the water sprinklers on or not, taking into consideration the availability of that water in the dry Marlborough climate.

"They would have to be conservative about that," says Dr Rankin. "One of the things they recognised quite early to their credit was that they wanted real-time data to react to. They have a large property and they wanted information across all of it."

At this time, their Marlborough property was only 200 hectares and employed seven staff on frost-event duty, which included monitoring the temperature, opening valves and turning on the pumps. Now with the property at 350 hectares and growing to 400 hectares, the owners have only three staff on this duty. They have pretty much doubled their area and halved their staff.

They were able to achieve this because the information is much better and collected in real time from all over the vineyard. This allows them to activate their frost control equipment using remote solenoids and gives them much better control over how much water they use in an area where water is restricted. It also means that they do not apply too much water and adversely affect the plant or fruit.



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VALUE OF DATA

This trial has really opened the eyes of the wine growers as to how things change in real time. One day last autumn they thought they were going to have a frost event. The temperature dropped to a point where they would have turned the system on previously, but because they could see it was rising from borderline critical, they decided not to respond and the frost did not eventuate. They have the confidence to do this with the new system in place.

At another 200-hectare Marlborough vineyard, Indigo Systems installed 15 units to control irrigation, not frost protection. The system monitors the downstream pressure on several irrigation pumps, which are prone to blocking and failing. Nodes automatically check these pumps around the clock, saving the grower time and effort in daily monitoring.

A smaller system is also installed in a Martinborough vineyard where there are 15 units installed for frost protection. This vineyard has a wind-powered system for breaking up the cold air on frosty nights. The current trials have progressed to stand-alone systems with little need for input from Dr Rankin, but he is there for troubleshooting should the need arise.

He aims to export the system, but he would like to gain market control in New Zealand first. He does not have many competitors and sees his advantage lying in cost savings as well as in the flexibility of his system.

The radio units currently cost $250 each and the rechargeable battery units are $100 each. Solar panels, at $350 each, require virtually no maintenance. Growers add the number of sensors that they need and these are available off-the-shelf, or as part of a solution package.

A huge advantage the system has over current systems is that it uses license-free frequencies in the ISM band (Industrial Scientific and Medical). Other systems face great expense by using mobile phone-based communication.

Dr Rankin is spreading the word by advertising in trade magazines, as well as attending conferences. In the complex business of producing wine from vines exposed to so many climatic variables, it makes sense to monitor the growing process as carefully as possible. Using Indigo's cutting-edge technology is one way that growers can achieve consistently good harvests and increase their profits.

Claire Le Couteur is a Christchurch-based freelance writer.

Curriculum Links

Understanding The Nature of Technology Strand: Characteristics of Technological Outcomes

Technological outcomes are defined as fully realised products and systems, created by people for an identified purpose through technological practice. Within this definition, technological outcomes can be categorised into two types – technological products and technological systems. For discussion of this topic, see www.techlink.org.nz/curriculum-support/papers/nature/char-tech-out/page2.htm

FOCUS QUESTIONS

System or Product?

Christchurch-based electrical engineer Dave Rankin, has developed an innovative system to monitor horticultural crops using a wireless mesh network that delivers climatic information to growers using a robust and simple technology. "After a fair bit of development of hardware and software, I came up with a product that collects information in real time for vineyards," says Dr Rankin. Here the outcome produced is described as both a system and a product.

Task: Discuss how the outcome produced could equally well be categorised either as a system or as a product.

Designing a wireless mesh network

Reference: www.indigosystems.net.nz

A wireless mesh network is a series of radio transmitting devices arranged so that each of the nodes can communicate with any other node – rather than just back to the central receiver.

In self-configuring networks, like the Indigo network, nodes look around for their nearest neighbours and automatically establish links with them. This makes the network very reliable because if one node falls out, or is removed, the network searches for alternative routes to keep the communication path alive.

Mesh networks use a lot less power than traditional transmitters – only enough power is required to transmit to the nearest node, rather than to a central receiver. The nodes spend most of the time asleep and wake only to transmit packets of data. These features make for a vastly extended battery life.

These networks can transmit any kind of environmental data – if a physical quantity can be measured with a sensor, then it can be connected to an Indigo node and beamed back to the data collection point.

Nodes can receive as well as transmit so networks can be used to both monitor and control the environment.

Task: Develop a conceptual design showing inputs outputs and transformations for a system to maintain soil moisture levels on a hill country vineyard.

Other references to intelligent sensors and wire mesh networks:

- **Remote sensors and their applications**
  For a long time, environmental scientists have braved extreme conditions – high altitudes, rough seas, steep terrain, isolation, rain, snow and wild animals – to gather the data they need to understand natural phenomena. They may need less bravery in the future: wireless sensor networks (WSNs) are taking some of the adversity out of their jobs and simultaneously sparking rapid advances in environmental science. Read Nova Science in the News article: www.science.org.au/nova/097/097box02.htm.
- **Smart sensors and the environment**
  How do you manage a unique natural resource like the Great Barrier Reef when it's threatened on so many fronts? Read Nova Science in the News article: www.science.org.au/nova/110/110key.htm.