Wireless technologies are set to be used increasingly for process supervision and control in the manufacturing environments of the future. Researchers at the Advanced Manufacturing Technology Group in Waterford Institute of Technology describe a low-cost prototype they have developed for remote plant monitoring.

In a centralised remote monitoring facility, specialists can be employed to provide support to a far greater number of plants simultaneously.

Remote plant monitoring using wireless technology

Wireless media has been undergoing a rapid innovation process in search for a reliable, simple and business-viable solution to consumer demands for fast, easy, and inexpensive information access. Over the last five years, a number of wireless protocols have been developed and a variety of application vendors have begun to ship wireless products to the market.

In recent years, the demand for personal mobile communications and 'anytime anywhere' access to data and communication service has become increasingly clear. The digital cellular telephone has seen rapid acceptance and growth in the past 20 years. Likewise, the tremendous impact of the internet has resulted in a growing demand for a new kind of data access.

The development of radio frequency wireless is still in its infancy. However, in the relatively near future, very fast plant transient modules (expert systems) will make it possible to optimise start-up and shut-down of a unit with the help of an advanced transient analysis provided by the centre, based on actual plant data. In the future, wireless network technology is going to increase significantly, and new fields of application will arise.

A significant amount of R&D is being conducted in this area, as companies attempt to exploit the advantages of wireless systems. It is envisaged that such wireless technology will be very suited to deployment in fully flexible manufacturing environments, typically where plant and process equipment will be physically moved throughout a factory for different manufacturing tasks. It also is very suited to materials handling and transfer monitoring – for example in the tracking and control of AGV's through a factory.

Prototype system

At the School of Engineering at Waterford Institute of Technology, we have developed a prototype wireless communication prototype offering significantly lower cost implementation overheads compared with existing technologies.

The essential elements of the system are the use of a SCADA system for monitoring and controlling, the use of a PLC to control a remote plant and the implementation of wireless communication between the two. For the purposes of this project, LabVIEW software and digital I/O hardware were chosen. More generally, in an industrial setting, any SCADA system with simple digital I/O would be sufficient to implement the wireless communications described

Choices had to be made concerning each of the three primary elements to select the most suitable programs, methods and hardware for an effective system:

- SCADA system requirements
- Monitoring of individual system components and display on a GUI (graphic user interface) to determine system status
- Control of remote plant from host monitoring station.
- Capability for system status signals from the remote device to be received at the monitoring and controlling station

External monitoring of remote plant over a network

PLC requirements

- Capability to control the operation of the remote device and relay the system status to a transmitter
- Transmission of system status output at pre-determined intervals, unless requested from the monitoring and controlling station

Communication requirements

- Transceiving of reliable status signals over short distances.
- Relaying of control signals when requested by the user.
- Low cost

Communicating wirelessly

The first step in achieving wireless communication was to establish communication from the SCADA system (LabVIEW) on the PC to a simple remote controlled receiver device. A control switch on the LabVIEW front panel activated a terminal on the receiving device by remote control. The terminals for the four operating channels on the remote controlled device were then each connected to an opto-isolator and in turn to individual input terminals on the PLC.

The next step was to establish communication in the form of an output from the PLC and display this on the LabVIEW front panel. A PLC program was written to give a specified output from the PLC when a specified input was activated.

The third step was to attempt to transmit and receive signals simultaneously. Due to interference, it was not possible to operate transmitters and receivers with the same operating frequency in close proximity. Therefore, both 27MHz and 40MHz transmitters and receivers were used.

A simple system, involving liquid level control in a tank, was chosen as the application for the remote plant.

Low-level serial protocol

Due to the fact that the transmitters and receivers used were limited to four operating channels, serial communication was implemented from the PLC to the SCADA system. This operated over a single channel, which incorporated RTS signals and parity. A simple timing sequence was set up in a PLC program.

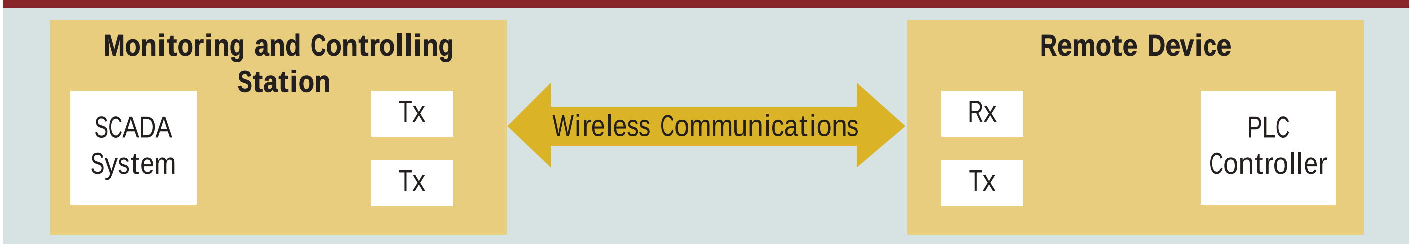
A VI (virtual instrument) was developed to read this sequence. It was programmed to recognise the initial 1.5-second RTS (ready to send) pulse as the start of the transmission and then store the subsequent data sequence as a binary number. An eight-bit sequence allowed 256 different digital numbers to be transmitted by the system. A serial communication protocol was developed specifically for the system. This protocol was implemented to transmit a wireless signal, which corresponded to the status of the remote device. Using a SCADA system, this signal could be interpreted allowing real-time monitoring of any remote device.

Each variable at the remote device (i.e. the liquid-level controlled tank) was allocated a data bit in this sequence. A 1.5 second RTS

Industrial applications for wireless technology

Industry	Existing and future applications for wireless technology in manufacture
Petrochemicals Plants	■ Pipeline monitoring system ■ Controller for pumping station ■ Intelligent controller for LPG bottling ■ Terminal automation system
Power Generation Units	■ Supervisory system for captive power plants ■ Control system for switchyard control, substation and distribution automation ■ Custom solutions, protocol converters and data concentrators ■ Energy management systems ■ Data analysis software for Sequential event recorders ■ Automated meter reading systems
Iron and Steel plants	■ Control system for sintering section, soaking section, electric arc furnace, ■ Ladle furnace and continuous casting machine ■ Subsystem interface development for spectrometers, weighing system and Special purpose controllers
Pulp and Paper	■ Energy monitoring system using pulse transducers ■ Implementation of automated energy audit for various plant sections ■ Supervisory control and monitoring station for digestion station, for the production of chemical pulp, batch process for pulp bleaching, preparing dyes etc.
HVAC	■ Particulate measurement/monitoring systems ■ Control of electrostatic precipitators using automatic voltage controllers ■ Data acquisition and monitoring systems - remote diagnostics ■ SO3/water injection control systems

Systems Components



WIT researchers (left to right) Eoin Croke, Bryan Raleigh, and Dermot Donohoe.

(ready to send) pulse followed by a 0.5 second delay preceded the data. The data sequence of eight 1-second bits corresponded to the status of the remote device. The status signal also contained a parity bit, which was included to improve data reliability.

The parity bit (data bit No. 7) should always read a logic "0' or low. This serial sequence was transmitted wirelessly to the monitoring and controlling station and was sent via a DAQ (Data Acquisition) device to the SCADA system. This worked quite satisfactorily with 1-second/bit pulses. At a total length of ten seconds, the sequence was relatively long, due to the poor timing resolution of the DAQ hardware when scanning pulses and

Further reading

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Benefits of wireless technology in manufacturing

Clearly wireless technology does not replace wired communication. However, there are places where it can provide services otherwise not possible. In many manufacturing concerns, process monitoring utilises significant employee resources. Due to increasing cost pressures, however, it is becoming more and more difficult to justify specialised activities such as the operation of a diagnostics station or the exclusive use of specialists at a single plant.

In contrast, in a centralised remote monitoring facility, specialists can be employed to provide support to a far greater number of plants simultaneously. In such a setting, the majority of the monitoring personnel would be experienced commissioning engineers used to handling non-routine situations. In addition, they could provide support that draws on the manufacturer's entire expertise in process engineering, component design and service. If the remote device is shut down immediately, damage is limited; whereas, if the device can continue in operation up until the next scheduled outage, the operator benefits from its continued availability, reduced maintenance costs and extended service life. An additional advantage for the customer, gained through remote diagnostics, is the manufacturer's access to a very detailed plant operating history. Experienced commissioning engineers can thus analyse whether inspection or maintenance intervals can be extended due to careful operation.

Automated plant diagnostic systems have introduced a real-time monitoring option, allowing customers to remotely monitor their plants over the internet. Using any standard internet web browser, customers can monitor real-time plant performance conditions from anywhere in the world. This new remote monitoring technology lets plant engineers check the conditions of the plant facilities from the convenience of their office, hotel, or home. If a problem occurs, users can view the real-time conditions of the affected plant area, diagnose the problem remotely, and advise the on-site plant engineers how to fix it, thereby minimising costly plant failures and breakdowns.

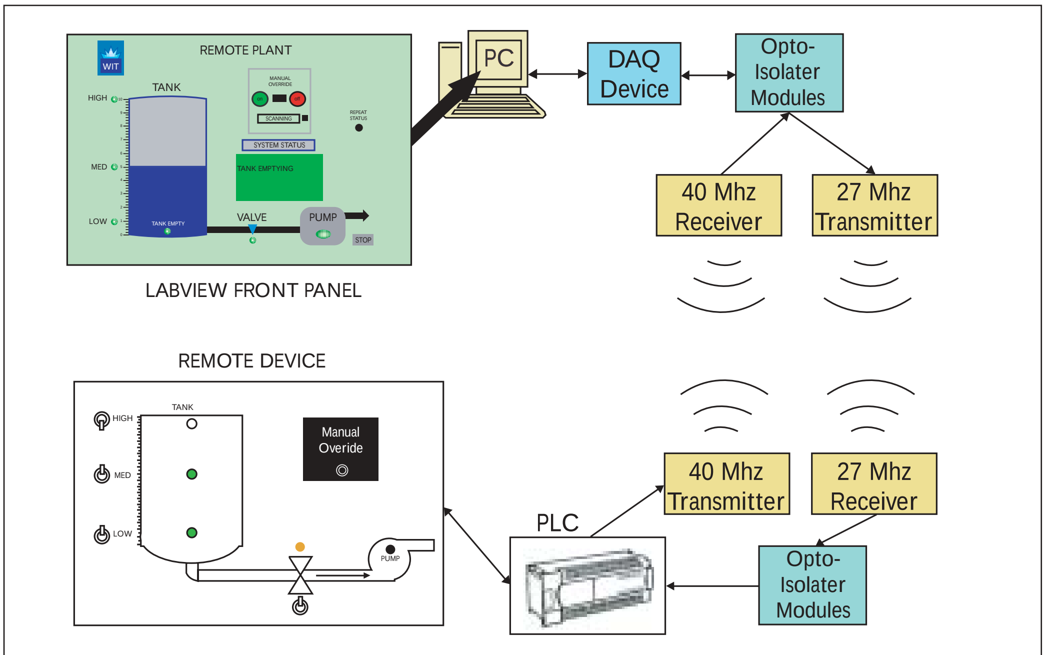

Figure 3: System Hardware

Systems components: The primary elements of the system are the remote plant, the monitoring & Ccontrolling station and the communication between the two units. A SCADA system was integrated to perform the duties of the monitoring & controlling station.

its reduced accuracy at high speeds. The timing limitation meant that the SCADA software took 20 seconds to update the device status. Attempts were made to reduce the pulse duration with a view to reducing the overall scan time. However, these attempts proved unsuccessfully as the data returned were inconsistent.

The transmitters and receivers used were very basic (from toy remote control cars) and although, very low cost, they performed more than adequately. The system components offered reliable data transmission within a range of about fifteen to twenty metres. The use of more advanced transmitters and receivers would allow a greater communication range and may facilitate improved data accuracy. The use of a simple serial signal to transmit the system status allowed the number of system components being monitored to be extended indefinitely. Expansion in this way would involve the allocation of bits at the end of the serial sequence to the additional system variables.

The SCADA system was programmed to constantly scan for status signals and only allow control signals to be transmitted if a status signal was not being received. In other words, it was not possible to simultaneously transmit a control signal and receive a status signal.

The GUI front panel of the SCADA system was developed using a number of indicators and controls, which were the interactive input and output terminals. Controls simulated instruments input devices and supplied data to the application. Indicators simulated instrument output devices and displayed the data that the SCADA system acquired or generated. The relevant indicators on the front panel were updated to display a representation of the remote device in its current status. The SCADA system allowed a wireless control signal to be transmitted to the PLC at the remote device. This signal could be used to rectify faults, override device settings, request a system status signal and activate or de-activate systems.

Applications

Our research has show that simple wireless communications can be implemented between existing manufacturing control equipment in a low-cost manner. Although data transmission rates and range were limited by some of the components used, the system was very robust. It is envisaged that such communications techniques and associated simple protocols will be deployed extensively in the manufacturing environment of the future.

The technology would appear to be particularly apt for certain applications, since use of standard components such as the PLC and the SCADA software allow it to be integrated with relative ease into manufacturing equipment in power stations, generators, chemical treatment, AGVs, and materials processing equipment.

In particular, further work is to be carried out in the monitoring and control of AGVs. As each vehicle is equipped with a PLC, this would allow the incorporation of simple wireless communications to and from each AGV and, hence, the monitoring of material movement throughout a factory. One central SCADA monitoring station would be able to address each AGV in pooling all AGVs with an ID code, and only the relevant vehicle would respond ■

This article is based on a paper presented by Eoin Croke, Dermot Donohoe and Bryan Raleigh, at School of Engineering Technology, Waterford Institute of Technology during IMC 20, the 20th International Manufacturing Conference "Knowledge Driven Manufacturing' run this September by Cork Institute of Technology in association with University College Cork. Eoin Croke and Dermot Donohoe are both 2003 honours graduates from WIT's degree in Computer Aided Manufacturing. Bryan Raleigh is a lecturer in Mechanical Engineering at WIT, with research interests in automation, AMT and robotics.