CROSSED SIGNALS

Scott Keller, SignalFire Wireless Telemetry, USA, examines how self-configuring mesh networks address the challenges associated with the wireless monitoring of outdoor tank level applications.

Wireless remote monitoring networks provide industries with the capability to automatically track and control field assets. Increasingly, wireless sensor systems can monitor tank levels (and other parameters) and use radio technology to transmit the data to control centres. These wireless systems prove cost-effective by eliminating the need for wiring and trenching, especially in applications covering long distances. This is particularly the case for tank farms.

However, not all wireless remote monitoring systems are the same. In some cases, the radio network limits the control system's effectiveness in certain terrains. The following is a comparison of the three basic radio network schemes:

- A 1:1 system is the simplest network. The most basic configuration of this system is a level switch wirelessly controlling a remote pump/valve. Essentially, this system replicates the sensor signal (a switch) at some other location. For a simple, unmonitored tank application, this type of system can be ideal. It has the control element but does not have any remote monitoring or historical data capabilities.
- The next level of sophistication is a star system featuring multiple wireless nodes that send sensor data into a single point. Because the system involves multiple sources of data, the data must be addressed so its source can be identified.
- Mesh networks are self-forming and self-healing networks where messages are passed from device to device until they arrive at a central point, called a gateway. While similar to the star system, mesh networks improve the robustness of communications. Ranges can be greatly extended and obstacles that might impede transmission can be detoured. When hills, buildings and other obstructions block a radio signal, a star system becomes impractical. The use of long-range radios, coupled with mesh networking technology, resolves the problem faced with obstacles, providing the installer with options to connect every node to the gateway.

Mesh network configuration

Mesh networking is a wireless technology that permits many wireless devices to self-configure into a web-like structure. Each wireless node moves data in a peer-to-peer fashion (from one node to another) until the data reaches the gateway. The route taken will depend on the situation, as a good mesh network will pick the best route from each node to the gateway.

The gateway is a data concentration point typically connected to a local programmable logic controller (PLC) or to an internet device such as a cell modem (Figure 1). The range can be greatly extended due to the multiple 'hops' between the remote monitoring and control points and the central gateway.

Three critical attributes of a well-designed mesh network include:

- The data moves in 'hops' from device to device as it travels from one point in the mesh to another. This hopping permits lower power data transmissions and the placement of devices over a larger area, leading to increased coverage and reduced installation problems.
- Data may also take alternative paths to its ultimate destination, ensuring robust operation should a node become lost. Routing paths are constantly adjusted by the system to ensure optimal paths to the gateway.
- Nodes self-install into the network, with no configuration required.

Most mesh networks use three types of devices:

- Gateway – the interface between the wireless system and another network (often the internet or computer). It often provides administrative functions to manage the mesh. The gateway is the 'centre' of the wireless system.
- Routing nodes – these are standard nodes that connect to devices (sensors, actuators or computers). In addition to monitoring and/or controlling the device, the routing node participates in the mesh network. Routing nodes are usually line/solar powered, but battery operation is practical in some cases.
- Client nodes – clients perform a subset of the functions of a node. Typically, they can send and receive data from the device to which they are attached, but do not participate in the mesh. Clients are usually battery powered as the routing capabilities can be power hungry tasks.

Figure 1. Wireless sensor control systems consist of nodes that integrate with different sensors to send data to a gateway, where it is transferred to a PC, PLC, or other control system.

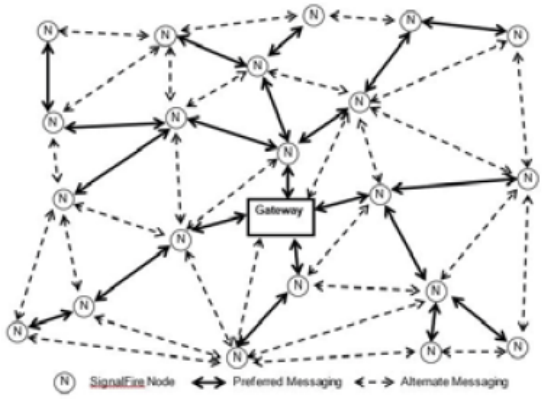

Figure 2. A mesh network permits many wireless devices to self-configure into a web-like structure. In a wireless sensor control system, data moves from one radio node to another or between a node and an external connection (gateway).

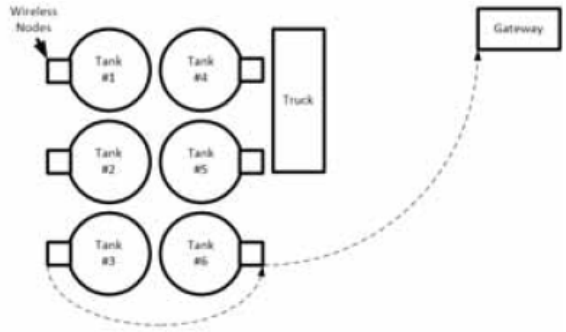

Figure 3. When a truck blocked radio nodes from directly communicating to a gateway in a tank level monitoring application, a mesh network enabled those nodes to automatically reroute their message path.

In outdoor environments, a wireless system may spread over many square miles. When hills and buildings obstruct a radio signal, a mesh network allows wireless nodes to utilise neighbouring nodes to relay or 'hop' messages to a central location (gateway) (Figure 2). Each node determines the 'best path' to the gateway, based on the information derived from the nearby nodes. The intuitiveness of the nodes allows the system to automatically adjust to changes so that the data can find and take alternative routes, when necessary, to its ultimate destination.

Mesh network at work in a tank level application

The self-configuring capability of the mesh network proved essential in the following tank level monitoring application that required frequent network changes.

In the original configuration of a network supporting the wireless remote monitoring of tank levels, eight short-range wireless nodes were measuring tank levels and checking into a gateway approximately 1000 ft away. The hydrostatic pressure sensors that were monitoring the tank level, as well as the wireless nodes, were installed at ground level. However, four of the nodes were on the 'wrong' side of the tank battery and had to transmit a signal 'through' the tanks in order to deliver data to the gateway. This configuration worked well until a tanker truck parked between the tanks and the gateway. Once the tanker was in the way, a few of the nodes on the far side of the tank battery could not directly reach the gateway.

The solution

The problem was solved by solar powering one of the nodes that was located on the near side of the tank battery, which allowed it to forward messages automatically, if and when it was necessary. When the truck was not present, all nodes were able to check into the gateway directly. However, when the truck came back to offload oil and again blocked some of the nodes on the backside of the tank battery, those nodes would automatically reroute (Figure 3) their message path through the always-on node on the front. Once the truck moved away, those nodes reverted back to direct communications with the gateway.

Without the mesh networking capability, the wireless remote monitoring and control system would not work under varying circumstances. No configuration or setup is needed with a true mesh system as it operates automatically, freeing the installer of complicated radio frequency (RF) concerns.

The outdoor challenge

In outdoor applications that monitor assets such as tank levels, operators often do not have control over the location of wireless nodes or what might be placed between each node and the gateway. In this instance, having a robust mesh capability can help with this problem as the unique network enables clever monitoring schemes.

For example, when monitoring assets that are located outside, it is unlikely that all wireless nodes at each site will be able to reach a central gateway. To combat this, the placement of a high power, long-range node along with low powered nodes that can operate in hazardous areas will (automatically without configuration) connect to the gateway through the long-range node. The use of a mesh network allowed the wireless nodes to utilise neighbouring nodes to relay or 'hop' messages to a central location.

Conclusion

Mesh networking overcomes the limitations experienced by older telemetry systems. It provides the power and stability needed for reliable data transfer, especially for widely dispersed assets (up to three miles point-to-point) that transfer simple data in small volumes. The use of long-range radios addresses the problems with hills and buildings causing obstructions, while the self-configuration feature eliminates the burden of a reconfiguring system as changes are made to the sensor network. T&T