Field Automation Networking 101

Total Connectivity from Remote Well Site to Desktop

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In this article, examples of systems and equipment used in oil and gas production fields are referenced. However, the ideas and implementations described herein can easily be applied to water and waste water systems, electrical grid control and monitoring, or virtually any field automation project.

As the automation of field processes advances as a result of new technologies, the human imagination continues to find new ways to use this technology and push technology providers for more powerful tools. Fifteen years ago, even the more advanced automation systems seldom had telemetry, and if they did, the data throughput was extremely low and seldom provided coverage to all remote sites. The usefulness of the technology was limited when only some sites could be remotely monitored.

With the many new telemetry technologies available today, it is common to have 100 percent communication to all field locations and achieve data throughput from field sites of 9,600 bps or even 115.2 kbps. Additionally, high speed backbone telemetry is now available in the megabits per second range.

A recent trend is "wireless instrumentation," or the collection of analog and digital signals by an RTU (remote terminal unit) PLC (programmable logic controller) or EFM (electronic flow meter) from remote equipment and sensors without the constraints of hard-wiring. These signals may indicate or provide for pressure and temperature, plunger arrival, remote wireless valve control, switch closures, emergency shut down, or status change. Processes that until recently had to be hard-wired can now be done wirelessly with radio.

However, the very latest of these advances is the "wireless network", in which one radio system communicates from the desktop PC, through the RTU or PLC, all the way to the to the field instrument (i.e. transducer, sensor, valve, etc.) without any hard-wired connections. This system operates all on one common radio network.

This allows the user to see the health and status of not only the controllers at remote locations, but also of the instrumentation attached to the controllers and the telemetry system. This diagnostics and troubleshooting capability is available to the user throughout the entire SCADA system, again available on one common radio network.

There are several manufacturers who make radios that can retrieve data from remote locations. There are several manufacturers who make wireless I/O (Inputs and Outputs), but only recently are there single radio solutions that can offer both technologies in one common communication network. These new wireless networks are challenging the conventional thinking in automation.

The earlier school of thought was based on the idea that the long haul for data from the remote site back to the host could be reliably done by telemetry, but that the local area connections to the instruments must be hard-wired to ensure reliability. For several reasons, today's radio technology has been proven to be more secure and reliable than the older hard-wired connections to sensors.

Networks

When most of us think of a network connection, we envision a Cat 5 cable running through an office, connecting the various computers in the office to the server. In field automation, there are two more types of networks. The first is the WAN (Wide Area Network), which can be a very wide area, sometimes covering 40 to 100 miles. This is often referred to as the "backbone" or "skeleton" of the radio network. The construction of this backbone or WAN consists of a series of repeaters and slave radios that connect the host computer to all of the remote locations and field RTUs, PLCs or EFMs.

This repeater network, depending on which technology is used, offers high speed throughput while also offering the ability to bridge many physical obstacles, such as hills, valleys, forests and buildings. Repeaters allow the system operator to cover distances far greater than any single radio link alone can cover. A single radio link may be only 20 to 30 miles, but by using multiple repeaters the user can rebroadcast his data and regain full signal strength at every repeater, thereby extending his network to 100 plus miles if need be.

Real world example of a remote monitoring system using a slave/repeater design

In some telemetry technologies whether using spread spectrum radios or licensed radios, the same radio used in the RTUs can act as both a slave to send data back to the SCADA host, and as a repeater to other field devices, or other RTUs. This functionality is commonly called "slave/repeater" mode. This capability allows the user to be able to both expand his network (WAN) almost limitlessly by utilizing his remote sites to act as a series of repeaters, and to use the radio in the RTU to poll the instrumentation. This ability to poll the instrumentation creates a second network of instruments wirelessly reporting back to the RTU. This short-haul network is the equivalent of a LAN (Local Area Network). It may be easiest to think of all of the instrumentation on one well site such as casing or tubing pressure, wirelessly talking to the RTU as the LAN, and the various well sites talking back to the field office as the WAN.

Now we have two interlacing networks in which the WAN and the LAN are working on one radio system and using a common connection. This common connection is the slave/master switchable functionality of the single radio used in the RTU. The radio installed in the RTU functions as both a slave to the SCADA host, responding whenever the host requests data, and a master to the wireless I/O when the RTU requests data from the instruments.

Economics

The wireless I/O is less expensive than conventional hard-wired systems and much easier to install. In a typical oil & gas well location, the operator will want to bring measurements from multiple locations back to the RTU or EFM. When a contractor (perhaps a licensed electrician) is hired to install these hard-wired connections in field automation, the costs are about $16 per foot (cost estimate derived from averaging prices from different areas of the country). Costs remain similar whether the install is direct burial cable or conduit and wire.

Using this cost as a reference, the break-even point for wireless I/O then is around 50 feet and that is if we consider only the cost of wire and labor. The cost savings are far greater when there are two or more wire runs required at the same remote site. This is because the only additional cost is for the second slave radio located at the additional cluster of sensors. For example, an operator wants to gather casing and tubing pressure from a well head and also monitor tank levels at a different section of the remote site. He can use the one radio already in the RTU, and only one additional slave radio. He saves $16 a foot for both clusters of sensors.

Time is another factor in the true cost of installation. Again, using the typical oil and gas well site as our example, it is a full day's work for a crew to install wire and trenching for a well head to retrieve casing and tubing pressure, plunger arrival and control lines for the valve. Conversely, the wireless I/O radio can be installed in just 20 minutes. If the installation is done by the operator's personnel, the cost savings are two man-days per location, assuming a two-man crew for one day to install with hard wire.

One of the other intangible expenses associated with installation is that it seems to be an unwritten law that jobs can never be completed in one day. There are always the scheduling conflicts and associated logistical problems of getting the contractors and end users on location at the same time on the same day. Invariably, someone always has to go back to the location and ensure that everything is complete. With the 20 minute install of the wireless I/O radio, one man can start and complete the job rapidly and then move to his next assignment.

Reliability

It is common for people to question the reliability of wireless products. As in all changes or paradigm shifts, people take some time to adopt new ideas. Radio technology has proved itself in the oil & gas industry as a reliable data highway for remote data collection from RTUs and EFMs for more than 20 years. Now with the new wireless I/O functionality of radio networks, the reliability question again is a concern and stumbling block for the advancement of this technology. Some wireless I/O equipment providers have built safe guards into their equipment and networks to address these concerns. Examples include link alarms, command alarms and autonomous collection mode:

• Link alarms let the operator know if the signal between the I/O slave and the RTU has been lost. The operator then knows that he is no longer receiving data from the instrument.

• Command alarms warn the operator that while the link is still operational, the command to change (i.e. command to shut a valve) could not be executed. The reason may be mechanical or electrical, but in either case, the "need to know" is critical and the wireless I/O can supply this alarm.

• Autonomous mode means that if the RTU loses its radio link to the SCADA (Supervisory Control And Data Acquisition) software, hosts in the wireless I/O radio and the radio in the RTU will continue to communicate. The RTU is programmed to be the control on the location; therefore if a tank reaches the high level mark, the RTU will receive this information from the wireless I/O radio and send the command to shut the valve to the tank.

In remote and rugged conditions, reliability of your communications system is paramount

Bear in mind, no system is completely immune to signal loss. Wired systems are prone to having wires cut when a new gathering line is laid, or a new control line is installed after the original system is installed. Moreover, with lengthy cables connecting equipment and sensors, there is the very real threat of lightning damaging expensive remote site equipment. Rust, corrosion, steam, dirt, dust, and water can all affect a wired instrumentation system. The difference is that while wire cannot tell you if it has a problem, a radio can. Wireless I/O can provide an alarm when the connection is lost. This feature is operationalized as a digital input at the RTU. Wireless I/O can also provide command alarms as a digital input when the radio cannot perform the function it was commanded to perform.

Power Requirements

We have discussed the ability of some radios to operate in slave/master mode, in which the LAN and WAN networks use the radio in the RTU as the common link between the two systems. While this is an elegant way to operate when installing new equipment, many end users and operators have legacy systems using older technologies that do not support this functionality. In these cases, it is still a viable option to have two radio systems. This can be done by using the legacy system as the long haul (WAN) back to the host computer, and then installing a new LAN radio system at the wellhead to collect the local data wirelessly for the RTU or EFM.

This second solution is still economically superior to running conduit or trenching at distances over about 50 feet. The two radio solution consumes more power at the RTU. Typically at remote sites, this means larger batteries and larger solar panels. On the slave side where the sensors and instrumentation is located, the power consumption remains constant. Many of the new wireless I/O radios draw as little as 6 mA of current when being polled continuously, or six plus times per second. Many of the newer pressure transducers are very low power and also feature 1 to 5 volt output signals, while also drawing only 7 mA per transducer. An example of a typical well head gas field operation using wireless I/O will look like this:

Two pressure transducers (one for casing and one for tubing pressure) at 7 mA each equals 14 mA continuous draw. One wireless I/O radio has a 6 mA continuous draw. Total current draw for data collection and transmission for the RTU is 20 mA. If we provide an 8 amp hour battery, this site will have 12 ½ days of autonomy and the battery charge can be maintained with a 2 Watt solar panel. Both the radio and the battery can be housed in a 6 by 8 by 4 inch NEMA-4 enclosure. The battery and solar panel required can be sized according to the load that each site will require. For example, if the operator only wants one analog input, the power consumption drops by 7 mA, or about 1/3 of the previous calculation. The site can then be powered by a 5 amp hour battery with about the same autonomy.

Summary

Many oil & gas companies are seeking to understand the future of automation, and their decisions today will affect them for years to come. BP, Chevron, Dominion, Kerr McGee and others all have internal focus groups whose objective is to provide "Best Practices" and procedural guidelines. These steering committees then provide guidance through the maze of new products and technologies. Many companies are also trying to achieve standardization in hardware and software across their entire operation for ease of support and maintenance.

In the past, all gas flow and oil production data was gathered by hand. Today, the collection of data from instrumentation and transmission to a central location is accepted as the new standard. The relevant question today is not "should we automate?" but rather "which types of automation will be a best fit for your operation?" Before choosing an equipment or solution provider, operators need to ask themselves the following questions:

• Will this technology reduce expenses?
• Will this technology help optimize production by giving us real time alarms and remote control of our process?
• Will this technology save us man-power and time?
• Does this technology allow us to share data between field offices and other locations?
• Is this technology affordable?
• Will this technology provider be here for the long haul?
• Does the manufacturer support the end user before, during, and after the sale?
• Does the factory have 24-hour telephone technical support?
• Is local field support available?
• Is local or factory training for our personnel available from the manufacturer?
• Are the time limits and limitations of the manufacturer's warranty acceptable?

With the emergence of robust wireless field automation, the end user can easily find manufacturers where the answer to all of these questions is Yes.

Today's spread spectrum and licensed radio technologies allow field operators to build WAN's and LAN's comparable to what has been available in the office and the wired world for several years. With the advent of short range radios, wireless I/O radios, Ethernet radios, GPS location device radios, and long haul data retrieval radios all working together in one seamless network, the future of field automation has never looked brighter.

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