Field Automation Networking 101
Remote Well Site Location to Desktop Total Wireless Connectivity

Overview

As the automation of field processes advances due to new technologies, the human imagination continues to see 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 slow and seldom provided coverage to all the automated sites. The technology was therefore difficult to use effectively when only some sites could be remotely monitored.

With the many new telemetry technologies available today, it is common to have 100% communication to all field locations and see data throughput from field sites of 19.2 baud or even 115.2 K baud. Additionally, high speed backbone telemetry is available in the megabits per second range.

The latest telemetry trend is “Wireless Instrumentation,” or analog and digital signals without the constraints of wire. These signals may be used to communicate to and from pressure and temperature transducers, signal plunger arrival, allow remote wireless valve control, signal switch closures, report emergency shut down, or report status change, and contact closures. Processes that until recently had to be hard wired can now be done wirelessly with “spread spectrum radios”.

The latest of these telemetry advances is the “Wireless Network,” in which one radio system communicates from the desktop P.C., through the RTU (Remote Terminal Unit) or PLC (Programmable Logic Controller), all the way to the to the field instrument (i.e. Transducer, valve, ect) without any wired connections. This process is done all on one continuous radio network.

This allows the user to see the health and status of not only the controllers at remote locations, but also at 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 continuous 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 have there been single radio solutions that can offer both technologies in one communication network. These new wireless networks are changing what only a few years ago was the conventional thinking in automation. That 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 had to be hard wired to ensure reliability. Today’s radio technology has been proven to be more secure and reliable than the older hardwire connections.

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 exist two more types of networks. The first is the counterpart of 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 RTU's or EFM's.

This repeater network, depending on which technology is used, offers high speed throughput while also featuring the ability to bridge many physical obstacles, such as hills, valleys, forests, and buildings. Repeaters also allow the user 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, while also extending his network to 100 + miles if need be.

In some telemetry technologies such as spread spectrum radios, the same radio used in the RTU's can act as both a slave to send data back to the SCADA host and as a repeater to other field devices, or other RTU's. 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 also use the radio in the RTU to poll the instrumentation (often referred to as the "Slave/Master" mode). 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 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 wire 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 (such as an electrician) is hired to install these hard wired connections, the costs are about $16.00 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 as a price point, the break-even point for wireless I/O then will be about 50 feet, and that is if we consider only the cost of wire and labor. The cost savings multiply when there are two or more wire runs required for two different locations because the "Slave/Master" radio is already installed in the RTU. Therefore, the only incremental cost is the additional slave radio for the second run. An example might be if an operator wanted to gather casing and tubing pressure from both a well head and then from tank levels at a different part of the location. He can use the one radio in the RTU and two slave radios, one at the well head and one at the tank battery, so the second connection is about half the cost of the first connection. With hard wire it is still

$16.00 dollars per foot and each run just adds to the total footage cost.

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 workdays 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 on the same day and at the same time. 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 to hear people question the reliability of wireless products. As in all changes, or paradigm shifts, new ideas take some adjusting. Radio technology has proved itself in the oil & gas industry as a reliable data highway for remote data collection from RTU's and EFM's for 20 years. Now with the new wireless I/O functionality of the radio networks, the reliability question again becomes a concern and stumbling block for the advancement of this technology. Some of the wireless I/O providers have built safe guards into the network to help operators handle these concerns more effectively. Examples include link alarms, command alarms, & 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.

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. Rust, corrosion, steam, dirt, dust, and water can all affect a wired instrumentation system. The difference is that while wire can not 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 can not 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 will require more power at the RTU to support two radios. This often entails using bigger batteries and solar panels on remote sites. On the slave side (i.e. the well head or the tank battery where the instruments we are monitoring are located), the power draw remains constant. Many of the new wireless I/O radios draw as little as 6 milliamps of current when being polled continuously, or 6 or more 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 7 milliamps per transducer. An example of a typical well head gas field operation using wireless I/O will look something like this:

2 pressure transducers (one for casing and one for tubing pressure) at 7 milliamps each =14 milliamp continuous draw & one wireless I/O radio at 6 milliamps continuous draw. Total power consumption for data collection and transmission to the RTU is 20 milliamps. If we provide an 8 amp hour battery, this site will have 12 ½ days of autonomy and the battery can be recharged with a 2 Watt solar panel. Both the radio and the battery can be housed in a 6"x8"x4" 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 milliamps, 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 looking to understand the future of automation and their decisions today that will affect them for years to come. BP, Chevron, Dominion, Kerr McGee, and others all have internal focus groups whose job it is to provide a "Best Practices" and procedures guideline for the company. This steering committee will then help lead the company through the maze of new products and technologies. Many companies are also trying to bring about standardization in hardware and software across their entire enterprise.

The collection of data from instrumentation and retrieval to a central location has been accepted as the new standard. Not too many years ago, all gas flow and oil production data was gathered by hand or chart. The burning question today is not "is it better to automate?" but rather "which types of automation will be a best fit for our operation?". In trying to gather enough data to answer this question, 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 there local support available?
- Is local or factory training for our personnel available from the manufacturer?
- What are the warranty's time limits and limitations?

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

Today's spread spectrum 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 looks bright.