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ETHERNET FOR SCADA SYSTEMS

Class # 3125.1

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Abstract

This paper will cover the implementation of Ethernet applications in SCADA system communications and architecture. Supervisory Control and Data acquisition (SCADA) systems provide a superior base for better controlled facilities in the upstream, midstream and pipelines for oil and gas facilities. Computerized handling of remote installations is integrated with communications and provides means for reducing the operating cost, cost of maintenance and effective handling of the Oil and Gas network. System parameters communicated via wireless data network must present true conditions related to the status of the field equipment including the Custody Transfer Measurement Systems. In likewise manner, commands sent to remote sites must be promptly executed and the back indication is to be sent to the control center.

SCADA systems have evolved through three generations of architectures as follows:

Monolithic:

In the first generation, SCADA was performed by mainframe computers. Networks did not exist at the time SCADA was developed. Thus SCADA systems were independent systems with no connectivity to other systems such as Gas Measurement Systems connected to Control Systems. Common Wide area networks were later designed by RTU vendors to communicate with the RTU and Flow Computer. The communication protocols used were proprietary at that time. In these types of systems it was necessary to have two different networks to the individual collection systems. This meant multiple controllers and different communication systems to communicate to their respectable host systems.

Distributed:

The process was distributed across multiple stations which were connected through a LAN and they shared information in real time. Each station was responsible for a particular task thus making the size and cost of each station less than the one used in a Monolithic system. The network protocols used were still mostly proprietary. These type of systems still required multiple RTU's and EFM's on site, but utilized one host system to communicate to each controller.

Networked:

Network Systems are the current generation SCADA and EFM Measurement Systems which use open architecture rather than a vendor controlled proprietary environment. The SCADA system utilizes open standards and protocols, thus distributing functionality across a WAN rather than a LAN. It is easier to connect third party peripheral systems such as Wireless Communication Infrastructure Monitoring Systems, Network Monitoring Systems (SNMP) due to the use of open architecture. WAN protocols such as Internet Protocols (IP) are used for communications between the master station and communications equipment.

Ethernet Protocols:

There are two types of Internet Protocol (IP) traffic. They are TCP or Transmission Control Protocol and UDP or User Datagram Protocol. TCP (Transmission Control Protocol) is the most commonly used protocol on SCADA Systems. The reason for this is because TCP offers error correction. When the TCP protocol is used there is a "guaranteed delivery." This is due largely in part to a method called "flow control." Flow control determines when data needs to be re-sent, and stops the flow of data until previous packets are successfully transferred. This

works because if a packet of data is sent, a collision may occur or an error in the wireless communications. When this happens, the RTU/Client re-requests the packet from the Host/server until the whole packet is complete and is identical to its original.

UDP (User Datagram Protocol) is another commonly used protocol on the Internet. However, UDP should not used to send important data such as Custody Transfer Measurement Data, database information, etc; UDP is commonly used for streaming audio and video. Streaming media such as JPEGS, Windows Media audio files (.WMA) , Real Player (.RM), and others use UDP because it offers speed! The reason UDP is faster than TCP is because there is no form of flow control or error correction. The data sent over the Internet is affected by collisions, and errors will be present. Remember that UDP is only concerned with speed. This is the main reason why streaming media is not high quality. However there are some radio systems and host systems that handle dropped packet at the application layer. This is a unique set of instructions that sends confirmation messages back to the Host once the data is received. In the case of these advanced application ability SCADA Communications Systems EFM Data could be sent. This is advantages when transmitting data over communications systems that charge by the byte such as cellular modems.

Ethernet VS UDP

Attributes	TCP	UDP
Acronym For	Transmission Control Protocol	User Datagram Protocol or Universal Datagram Protocol
Ordering	TCP rearranges data packets in the order specified.	UDP does not order packets. If ordering is required, it has to be managed by the application layer.
Error checking	TCP does error checking	UDP does not have an option for error checking.
Header size	TCP header size is 20 bytes	UDP Header size is 8 bytes. Great for win paying by the byte.
Usage	TCP is used in case of non-time critical applications.	UDP is used for applications that require fast transmission of data. This is great for Streaming video or pushing JPEG's
Function	As a message makes its way across the internet from one computer to another. This is connection based.	UDP is also a protocol used in message transport or transfer. This is not connection based which means that one program can send a load of packets to another and that would be the end of the relationship.
Weight	TCP requires three packets to set up a socket connection, before any user data can be sent. TCP handles reliability and congestion control.	UDP is lightweight. There is no ordering of messages, no tracking connections, etc. It is a small transport layer designed on top of IP.

Streaming of Data continued on next page	Data is read as a byte stream, no distinguishing indications are transmitted to signal message (segment) boundaries.	Packets are sent individually and are checked for integrity only if they arrive. Packets have definite boundaries which are honored upon receipt, meaning a read operation at the receiver socket will yield an entire message as it was originally sent.
Speed of Transfer	The speed for TCP in comparison with UDP is slower.	UDP is faster because there is no error-checking for packets.
Data Reliability	There is absolute guarantee that the data transferred remains intact and arrives in the same order in which it was sent.	There is no guarantee that the messages or packets sent would reach at all.

SCADA Trends:

The trend for HMI/SCADA software and PLC is more 'mix and match'. Many Exploration and Production companies acquire production fields from other companies. These new acquisitions often come with other manufactures instrumentation. The end users whose investments were restricted in only one vendor's hardware solution found problems. By the late 1990s instead of using the RS-485, the shift for open communications continued including the SCADA Remote Telemetry Manufacturers (RTU), who used open message structures like Modbus ASCII and Modbus RTU (both developed by Modicon). By 2000, almost all the RTU makers offered fully open interfacing such as Modbus TCP/IP. Traditionally SCADA and Measurement Instrumentation were two different pieces of equipment. As technology improved many companies are now combining their EFM's and SCADA Instrumentation into one controller. This reduces the cost of the overall system. With the open Ethernet communication protocols like the Modbus TCP/IP, Modbus UDP, and DNP3 WAN/LAN it became a lot simpler to integrate all the data trough a networked SCADA Communications Systems. The mixing and matching of the products from different vendors for developing better solutions is possible because of the use of the Open architecture SCADA systems and hence were better than the solutions which were developed when the choices were restricted to one vendor's products..

SCADA systems are now in line with the standard networking technologies. The old proprietary standards are being replaced by the TCP/IP protocols. But due to certain special frame-based network communication technology characteristics like synchronization, environment suitability, protocol selection and determinism have created certain issues in the adoption of the Ethernet in some specialized applications, Ethernet networks have been accepted by the Oil & Gas market for HMI SCADA.

With the integration of Ethernet into SCADA, the ability to remotely control, monitor, and troubleshoot network devices has increased. This increase in visibility and availability has led many energy companies with vast geographical areas, such as Production, Pipeline and Distribution Companies, to question the ideas of traditional LAN networks and to test new distance requirements and features.

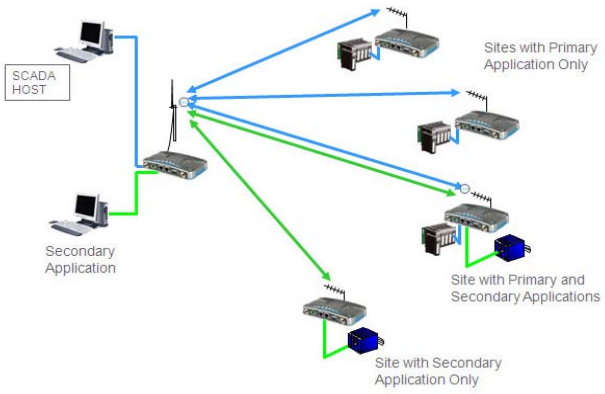
For example, a modern energy company might have Dry Natural Gas Production facilities in the Barnett Shale, Wet Gas Production Facilities in the Eagle Ford Shale and Processing Facilities in Oklahoma want them all to be interconnected. Ethernet technology allows for companies to interlink these diverse, and yet equally business-critical, networks together while preserving the integrity of the communication, simplifying the control, and minimizing the staff needed to operate these facilities.

Ethernet offers SCADA designers scalability. There is not a theoretical limit to the number of stations in a network. When comparing bandwidth of a serial communications system such as RS232 the transfer Rate is about 19.2k. 100 Base Ethernet provides 5000x that of RS232. When looking at distance of cabling without repetition for RS232 it is 75 feet. Ethernet over low voltage cat 3 cable is 300 feet. Wireless Ethernet can range 60 miles or more via link bridge repeaters. Industrial Ethernet products can offer continuous operating temp ranges from -40C to +75C and environmental conditions for shake and vibration and Industrial Ethernet can be installed in hazardous environments that meet Class 1 Div 2 ratings for Hazardous Environments for Oil and Gas facilities.

Common System Components

In order to understand how Ethernet Communications work in Oil & Gas applications a look at the different components that make up an Ethernet SCADA System needs to be explained. A SCADA System usually consists of the following subsystems:

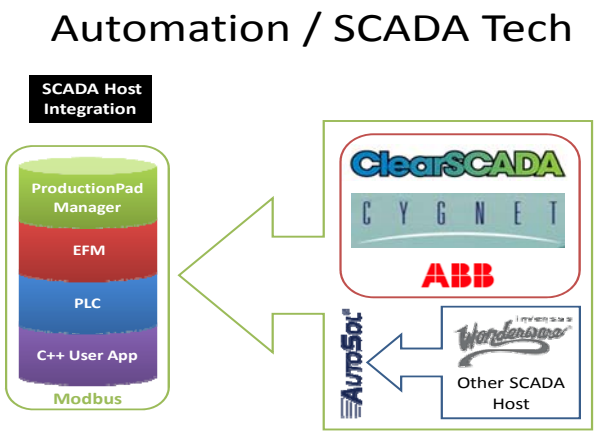
- A Human-Machine Interface or HMI is the apparatus which presents process data to a human operator, and through this, the human operator monitors and controls the process.
- A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the process.
- Remote Terminal Units (RTUs) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system. RTU's have multiple communications ports from RS232/485, USB and Ethernet.
- Programmable Logic Controller (PLC's) used as field devices because they are more economical, versatile, flexible, and configurable than special-purpose RTUs. PLC's are used to alarm monitor and control a process.
- Electronic Flow Meter (EFM/Flow Computer) is an electronic computational device which implements the required algorithms to turn the raw data received from flow meters to which it is connected into volumes at base conditions. The flow data is made available externally through an electronic interface so that other computers can download the information for the purposes of supervision, accounting or auditing. Many types of flow meter equipment implement flow computers intrinsically. Many different types of RTUs that can be used as flow computers are available, most notably from Eagle Research Corp., Fisher/Rosemount, Totalflow, Bristol-Babcock, Emerson, Control Microsystems, and Omni.
- Ethernet Radios (Wireless Radios) bring wireless Ethernet connectivity to the field. These radios transmit over the 900 and 2.4 GHZ unlicensed frequencies. Data throughput on a pair of radios range from 256K to 512K baud. Recently technology has developed in the 400 MHz licensed frequencies where longer range communications are needed. Data throughput is reduced at these lower frequencies. Some of the more advanced radios come with multiple Ethernet and serial ports. This enables serial device to connect easily to a network system. Packets routing is based on the IP address & port number used.



Ethernet Radio Communication for Multiple Applications

- Device Servers (Gateways) are devices that connect serial communication ports to a network connection. These devices can be powered by 12 volt solar powered systems. A Device Servers is a great way to connect legacy serial data systems to the network.
- Ethernet Switches (Mounted in the RTU) connect communication processors and other devices to the wide area network. Ethernet switches allow any Ethernet capable device to be connected to the network. This device is a natural choice for SCADA Systems that require Ethernet communications. By replacing Ethernet hubs in existing networks this unit reduces the amount of wiring by concentrating Ethernet lines, and provides increased bandwidth performance by eliminating message collisions.
- Cellular Modems.(Mounted in RTU) are wireless Ethernet modems that work over the cellular phone infrastructure. When the remote communication infrastructure is not large enough to install a radio communications system, Cellular Modems are used.
- .Human Machine Interface (HMI) is the apparatus which presents process data to a human operator, and through which the operator controls the process. A typical HMI used in the SCADA system is a display. With Ethernet as a standard option on many models, you can network-enable any serial devices connected to the display.

Ethernet Value to the Users



Below describes how having Ethernet communications architecture all the way into a Oil & Gas Field can be valuable to all users of the data simultaneously.

- Operator - It offers the operator complete visibility to all aspects of the application with an easy to navigate local HMI. On a Plunger Lift System there is a plunger arrival record so he can see what's happened in previous cycles being displayed on the HMI. Due to the Ethernet connection this can be simultaneously while his supervisor is connected to the display via the Ethernet connection and can walk him through the display.
- Automation/SCADA Technician - Due to each of the sub components having an Ethernet connection on it, It offers the Automation/SCADA Technician access to traditional operational data, custody, a configurable platform extendable as a PLC for other site requirements, allows standardization and rapid deployment using templates and easy migration with existing automation hardware. This can be done simultaneously and wireless while the other users are connected to the system from anywhere in the system including at another well.
- Measurement Technician – With the Flow computer connected through an Ethernet Switch, The Measurement Technician can retrieve the API Ch 21 Custody Transfer information from the Flow Computer. In addition a Bluetooth to Ethernet converter could be plugged in and then the Measurement Technician can calibrate the sensors to the Flow Computer wirelessly.
- Production Supervisor - It offers the Production Supervisor assurance with regulatory requirements (VRU, gas detection, flare, etc.) as well as timely production data for delivery commitments and forecasting.

- Production Analyst - It offers the Production Analyst high resolution data for all operational measurements and a detailed plunger arrival log. It has a proven optimization methodologies including critical flow, flow permissives, overrides and resides on a proven hardware platform. Normally this would be large amounts of data that he would be exchanging. Due to the Ethernet connection exchanging data at a higher speed, this cuts down on communications latency.
- Asset Manager - It offers the Asset Manager an infrastructure for same day flow back on new drills maximizing new gas opportunities. Empowers and enforces standardization of processes where a future proof platform prepares them for what's next in production optimization.

Summary:

Open Protocols and Multi Protocol Drivers enable the ability to move data more freely through SCADA Systems that use Ethernet Communications all the way to the RTU/Flow Computer. This ability allows multiple users utilizing different databases to get simultaneous real time access to the process. As technology advances in wireless communications, bandwidths will increase allowing the user to have greater transmission speed to larger amounts of data. We now live in the age of information. The more real time information you have on your business the more a company can reduce operating cost and most importantly improve safety.