

# Ethernet for SCADA Systems Explained

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## Executive summary

Open protocols and multi-protocol drivers enable the ability to move data more freely through SCADA Systems that use Ethernet communications. 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 speeds and larger amounts of data. This paper will cover the implementation of Ethernet applications in SCADA system communications and architecture.

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# Executive summary

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# Introduction

Supervisory Control and Data Acquisition (SCADA) systems provide a superior base for better-controlled facilities in the upstream, midstream and pipeline markets for Oil and Gas. Computerised handling of remote installations is integrated with communications and provides a means for reducing operating and maintenance costs and providing 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 Custody Transfer Measurement Systems. In a similar manner, commands sent to remote sites must be promptly executed and their feedback indication sent to the control center.

# The Evolution of SCADA Systems

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

## Monolithic

In its first generation, SCADA was performed by mainframe computers. Networks did not exist at the time. 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 (WANs) were later designed by Remote Terminal Unit (RTU) vendors to enable communication between the RTU and Flow Computer. The communication protocols 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 respective host systems.

## Distributed

In its second generation, the process was distributed across multiple stations that were connected through a Local Area Network (LAN), sharing information in real time. Each station was responsible for a particular task thus making the size and cost of each station less than one used in a Monolithic system. Network protocols were still mostly proprietary. These types of systems continued to require multiple RTUs and EFM's on site, but utilised one host system to communicate to each controller.

## Networked

Networked systems are the current generation of SCADA and EFM Measurement Systems, using open architecture rather than a vendor-controlled proprietary environment. The SCADA system utilises 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 and 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 IP traffic: Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). Of the two, TCP is the most commonly used protocol on SCADA Systems. The reason for this is TCP offers error correction. Where TCP protocol is used there is "guaranteed delivery." This is due largely in part to a method called "flow control" that determines when data needs to be re-sent, and stops the flow of data until previous packets are successfully transferred. If a data packet is sent, a collision or an error in the wireless communications may occur. When this does, the RTU/Client re-requests the packet from the Host/server until the whole packet is complete and is identical to its original.

UDP is another commonly used protocol on the Internet. However, UDP should not be used to send important data such as Custody Transfer Measurement Data, database information, etc; UDP is best-suited 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 desired transmission speeds. UDP is faster than TCP because there is no form of flow control or error correction. However, data sent over the Internet will be affected by collisions, and errors will occur. Remember that UDP is only concerned with speed, not quality. This is mostly why streaming media is not high quality.

There are some radio and host systems that can handle a dropped data packet at the Application Layer, a unique set of instructions that sends confirmation messages back to the Host once the data is received. This is advantageous when transmitting data over communications systems that charge by the byte such as cellular modems.

## TCP vs UDP

Attributes	TCP	UDP
Acronym For	Transmission Control Protocol	User Datagram Protocol or Universal Datagram Protocol
Packet 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	Yes	No
Header size	20 bytes	8 bytes
Usage	Non time-critical applications	Fast transmission of data: This is great for Streaming video or pushing JPEGs
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'	Three packets required to set up a socket connection before any user data can be sent. TCP handles reliability and congestion control.	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	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	TCP is slower than UDP	UDP is faster because there is no error-checking for packets.
Data Reliability	There is an 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 will reach at all.

# SCADA Trends

The trend for HMI/SCADA software and PLC is 'mix and match'. Many exploration and production companies acquire production fields from other companies. These new acquisitions often come with other manufacturer's instrumentation. The end users whose investments were restricted to only one vendor's hardware solution found problems. By the late 1990s, instead of using serial RS-485, the shift to open communications continued, including the SCADA Remote Telemetry Manufacturers (RTUs), 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. Traditionally, SCADA and Measurement Instrumentation were two different pieces of equipment. As technology improved, many companies combined their EFMs and SCADA Instrumentation into one controller. This reduced the cost of the overall system. With open Ethernet communication protocols like Modbus TCP, Modbus UDP, and DNP3 WAN/LAN, it became much simpler to integrate data through a networked SCADA Communications System. Mixing and matching of products from different vendors for developing better solutions became possible because of the use of open architecture SCADA systems and hence were better than the solutions 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 TCP/IP protocols. However, due to certain frame-based, network technology characteristics like synchronisation, environment suitability, protocol selection and

determinism, certain issues in the adoption of Ethernet in some specialised applications have been created. 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, 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, and want them all to be interconnected. Ethernet technology allows for companies to interlink these diverse and yet equally business-critical networks together while preserving communication integrity, simplifying control and minimising the staff needed to operate these facilities.

Ethernet offers the SCADA designer scalability. There is no theoretical limit to the number of stations in a network. The data transfer rate of a serial communications system such as RS232, is about 19.2k. 100Base-T Ethernet provides 5000x that of RS232. When looking at cabling distance (without repetition) for RS232, the limit it is 23m (~75ft). Ethernet over low-voltage, CAT3 cable is 91m (~300ft). Wireless Ethernet can span 96Kms (60mi) or more via link bridge repeaters. Industrial Ethernet products can offer continuous operating temperature ranges from -40 to +75°C (-40 to +167°F), environmental conditions for shake and vibration, and can be installed in hazardous environments that meet Class I Div 2 ratings in 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 is required.

A SCADA system typically consists of the following subsystems:

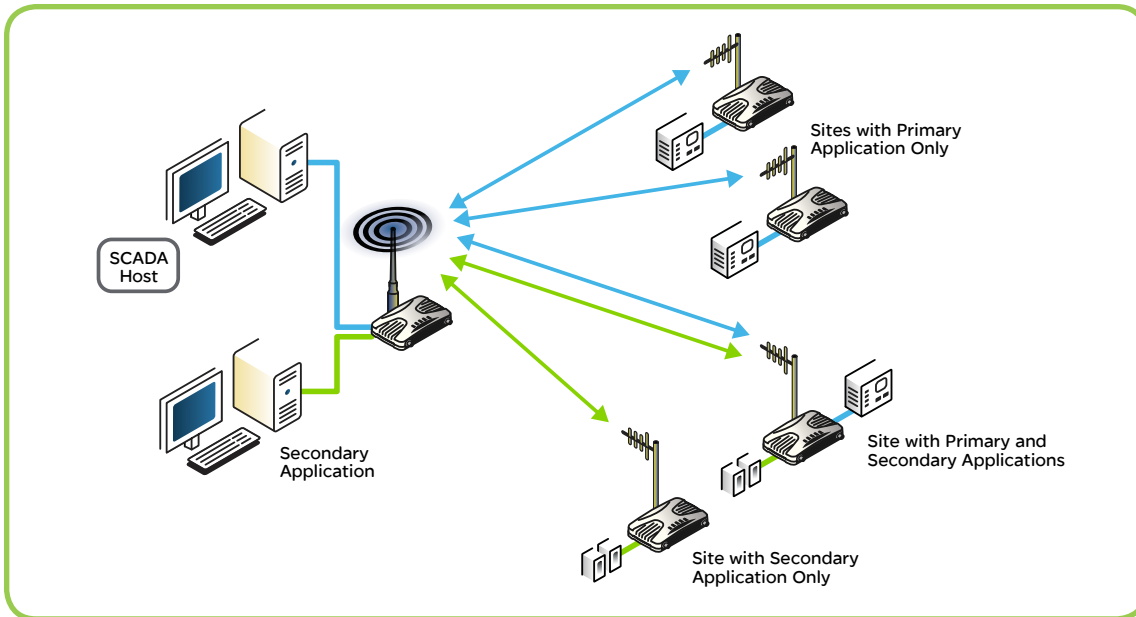
- A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the process.
- RTUs connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system. RTUs have multiple communications ports: RS232/485, USB and Ethernet.
- Programmable Logic Controllers (PLCs) used as field devices because they are more economical, versatile, flexible, and configurable than special-purpose RTUs. PLCs are used to alarm monitor and control a process.
- Electronic Flow Meters (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 flow volumes at base conditions.

The flow data is made available externally through an electronic interface allowing other computers to download the information for the purposes of supervision, accounting or auditing. Many types of flow meter equipment implement flow computers intrinsically. There are dedicated flow meters and various RTUs that can be used as flow computers, most notably from Schneider Electric, Eagle Research Corp., Fisher/Rosemount, Totalflow, Bristol-Babcock, Emerson, and Omni.

- Ethernet radios bring wireless Ethernet connectivity to the field. These radios transmit over the 900MHz and 2.4GHz license-free frequencies. Data throughput on a pair of radios range from 256K to 512K baud. Recently, technology has been developed in the 400MHz licensed frequencies to support longer range communications. However, data throughput is reduced at these lower frequencies. Some of the more advanced radios come with multiple Ethernet and serial ports. This enables a serial device to connect easily to a network system. Packet-routing is based on the IP address & port number that's used.



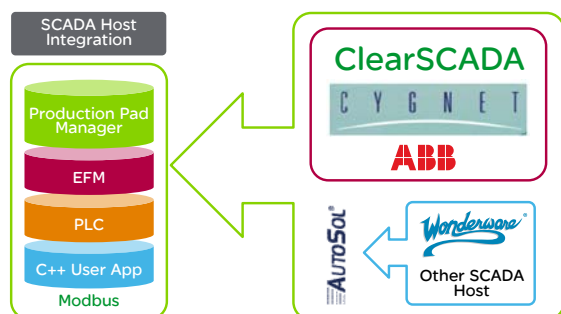
## Ethernet Radio Communication for Multiple Applications



- Device Servers are gateway devices that connect serial communication ports to a network connection. These devices can be powered by 12V solar-powered systems. A Device Server is a great way to connect legacy serial data systems to the network.
- Ethernet switches 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. In 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 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 Users

## Automation / SCADA Tech



The following describes how having Ethernet communication architecture all the way into an Oil & Gas Field can be simultaneously valuable to all users of the data.

- Operator - Offering the operator complete visibility to all aspects of the application with an easy-to-navigate local HMI. On a Plunger Lift System a plunger arrival record allows the operator to see what has happened in previous cycles, via an HMI-based display. Thanks to the Ethernet connection, this can happen simultaneously while his supervisor is connected to the display via the Ethernet connection. The operator can then walk the supervisor through the display.
- Automation/SCADA Technician - Due to each of the sub-components having its own Ethernet connection, the Automation/SCADA Technician has access to traditional operational data and custody transfer. A configurable platform, extendable as a PLC for other site requirements, allows standardisation and rapid deployment using templates and easy migration with existing automation hardware. This can be done simultaneously and wirelessly 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 API Ch 21 Custody Transfer information from the Flow Computer. In addition, a Bluetooth-to-Ethernet converter can be plugged-in, enabling the Measurement Technician to calibrate the sensors to the Flow Computer, wirelessly.
- Production Supervisor - Offering the Production Supervisor assurance through compliance with regulatory requirements (VRU, gas detection, flare, etc.) as well as timely production data for delivery commitments and forecasting.
- Production Analyst - Offering the Production Analyst high-resolution data for all operational measurements, and a detailed plunger arrival log. It has proven optimisation methodologies including critical flow, flow permissives and overrides, and resides on a proven hardware platform. Normally large amounts of data would be exchanged. Due to the Ethernet connection exchanging data at higher speeds, communication latency is reduced.
- Asset Manager – Offering the Asset Manager an infrastructure for same day flowback on new drills, thereby maximising new gas opportunities. Standardisation of processes are empowered and enforced, and a 'future-proof' platform prepares the manager for future production optimisation technologies.

# Conclusion

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, utilising 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 speeds and larger amounts of data. We now live in the age of information. The more real-time information you have in your business the better a company can reduce operating cost and most importantly, improve safety.

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