Sure Cross® DX80 Network Basics

Instruction Manual

Original Instructions
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more sensors, more solutions

136689

Contents

1 Networks

Networks exist everywhere around us and are a major contributor to the information age. Some of the most interesting recent developments in factory and process automation have been the networking of machines and controls allowing machine control, data collection, and ultimately informed decisions that can improve productivity, save time, and reduce scrap.

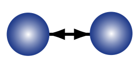
According to Merriam-Webster Online, a network is “a system of computers, peripherals, terminals, and databases connected by [a] communications line.” Today’s implementations of networks also include wireless networks that use the air as the communications line and range in geographic size from a few meters to spanning continents.

Many of Banner’s newest products are part of a network, both wired and wireless. As such, understanding networking basics is important when using or providing technical support to Banner’s products.

There are many network topologies, or arrangements, and each topology contributes to the overall network performance. Many networks combine elements from multiple topologies.

1.1 Point to Point Networks

In a point-to-point network, nodes are connected in a line with a cable between each node. Data typically travels from one node to the next in a specific order.

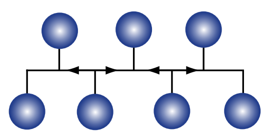


Pros—Simple networking used to establish a permanent link between two points.

Cons—Network communication stops with a single link failure, and chattering results in network failure.

1.2 Bus Networks

In a bus network, the nodes are connected using a common communication path, called a bus. Each node on the bus is assigned a unique ID to receive the messages intended for it. All data is transmitted and received by all nodes connected to the bus, though only the intended target responds.

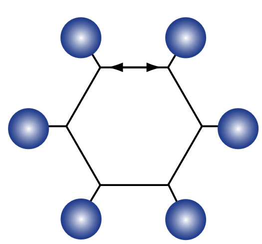


Pros—Devices are easy to connect to the bus.

Cons— Network communication stops with a bus failure or chattering; and total network response time increases when nodes are added to the bus.

1.3 Ring Networks

Ring networks are similar to bus networks except the common cable is looped into a continuous ring. Data is transmitted in one direction and if the link is lost, network communication fails.

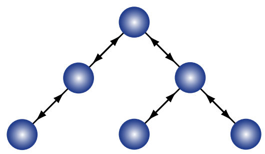


Pros—The signal can reverse direction when a link fails.

Cons—Communication relies on one cable; the total network response time increases when nodes are added to the bus; and chattering results in network failure.

1.4 Tree Networks

In a tree network, the lowest level contains the nodes, referred to as leaves, whose only function is to transmit information to the next highest level, the repeaters. The repeaters forward the data to the gateway.

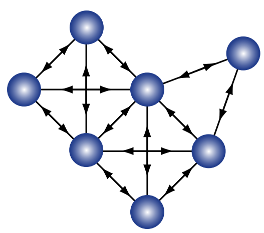


Pros—New nodes added to the system do not slow down the entire network.

Cons—A repeater failure cuts off the nodes from the gateway; there are no redundant communication links between network components; and chattering brings down an entire network branch.

1.5 Mesh Networks

In a mesh network, each node has some routing capabilities and maintains a network connection with at least two other nodes. Most commonly, nodes within a mesh network maintain a link with all nodes within a specified distance.

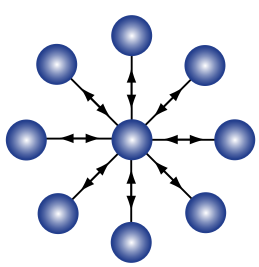


Pros—Information has multiple communication paths to the gateway; the gateway can be positioned anywhere in the network; and chattering nodes are removed from the network.

Cons—A new node adds multiple connections to the other nodes and substantially slows the entire network.

1.6 Star Networks

In a star network, the gateway is in the center with radiating spokes outward to the nodes. Because of its shape, this network is also referred to as a hub and spoke network.

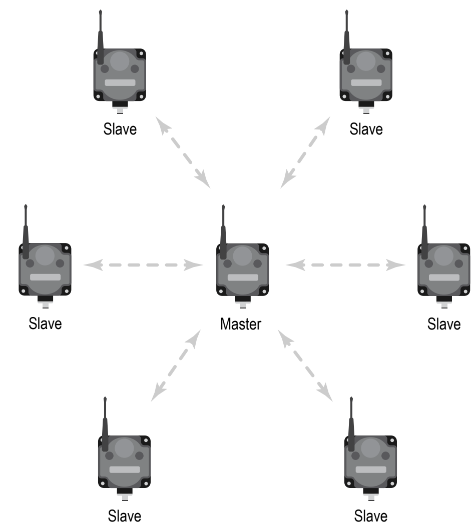


Pros—The gateway maintains a communications connection with each node on a separate communications path; if communication between one node and the gateway fails, the rest of the network is unaffected; and chattering nodes are removed from the network.

Cons—The network suffers from some speed decreases with each additional node added; and a hub failure stops network communications.

2 Banner's Sure Cross® Network

Efficient networking involves three distinct concepts: network topology, master and slave relationships, and Time Division Multiple Access (TDMA) architecture. The network topology describes the physical layout of the network. The master and slave relationship between devices refers to the functional relationship between the devices. TDMA is the method used to allocate data transmission and receive time slots.



Network Topology

Banner's Sure Cross products use a star network layout, or topology, for wireless network communications. In a star topology, the master maintains a communications connection with each node on a separate communications line. Because the communications lines are separate, when communication between one node and the master fails, the rest of the network is unaffected.

The Master/Slave Relationship

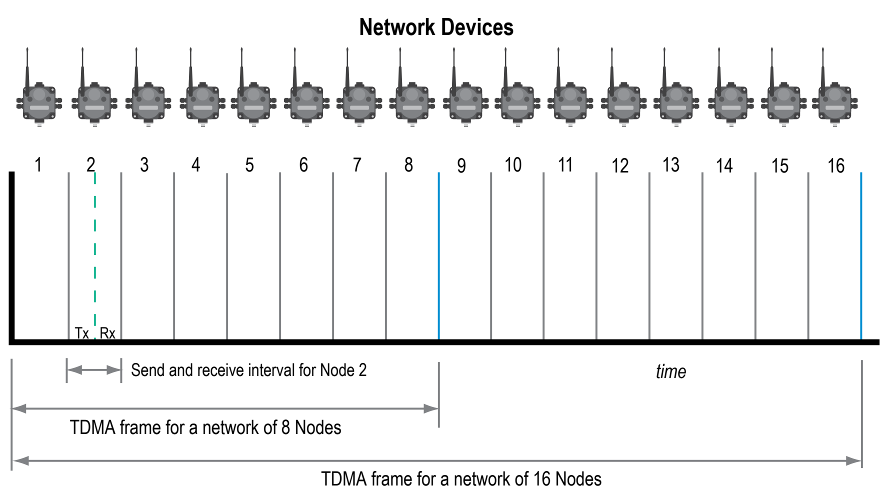
In the Sure Cross DX80 wireless network, the Gateway is the master device and initiates all communications with the slave devices, the DX80 Nodes. The slave devices can not initiate communications with the master device, and the slaves cannot communicate with each other.

Reliable Communication

To ensure each Node can reliably send and receive data to the master device, Time Division Multiple Access (TDMA) architecture assigns each device a specific time period in which to send and receive data. Establishing specific intervals when each device sends and receives data ensures devices do not conflict with each other to send and the master device never has to receive data from more than one slave device at a time, as happens when using a contention-based architecture.

In the Sure Cross system, device identification numbers are used to assign communication slots within the TDMA frame. Device ID number 0 is always reserved for the Gateway, but Nodes may be numbered in any order using device IDs 1 through 47. When all the device IDs are not used, the send and receive frames for those devices are unused.

In addition to ensuring reliable communications, TDMA architecture lends itself to efficient power management techniques. When each Node knows the specific time period to receive or send, the radio doesn't have to 'listen' all the time, nor does it have to continuously send to avoid data collisions. The radio is cycled on at a specific time to send or receive and is turned off to conserve power.



2.1 Network ID

Because the radio network operates over the air, there are limited ways to electrically separate collocated networks. To keep collocated networks separated, Banner uses a network ID number, sometimes abbreviated as NID. Each wireless network operating within radio range is assigned a unique network ID number.

All devices within a network are assigned the same network identification number, which defines a unique frequency hop table. Because networks 1 and 2 use a different sequence of frequency changes, they are not on the same frequency at the same time. This prevents communication between the networks even when they share the same transmission medium.

2.2 Device ID

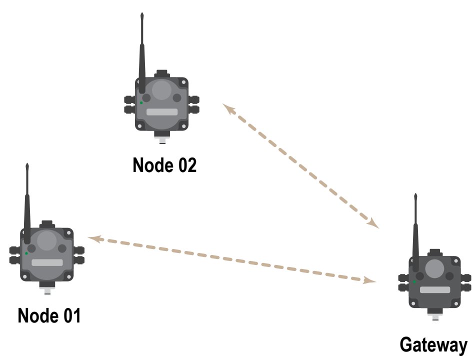
To route communication between devices, device identification numbers are assigned to each device in a network.

In the Sure Cross® Performance network, device 0 is always the master device, the Gateway. The Nodes are assigned device identification numbers from 1 through 47. If not all 47 Nodes are installed, the TDMA frame can be resized to improve network speed.

2.3 Basic Wireless Network

In the most basic wireless network, input devices are wired to inputs on DX80 devices. The data created by the input device is transmitted to the specified output on another device. A device wired to that output performs a task based on the received data.

The simple wireless network shown illustrates a very basic wireless network containing only two Nodes and a Gateway. More complicated wireless networks might include multiple input and output devices wired to each Node and several Nodes installed in the network.



In our simple example, a sensor wired to Node 1 is an input device connected to Node 1's input. Data is transmitted to Node 2 and a device connected to Node 2's output performs a task, for example, turning on a light.

This standard wireless system with I/O is a simple network with no interfaces to the outside world other than the I/O. To bridge the gap between the wireless network and the outside world, the Gateway also functions as a Modbus 485 slave, interfacing between two networks: the wireless network and a Modbus 485 network.

3 Modbus 485

Modbus Remote Terminal Unit (RTU) running over RS-485 cabling is sometimes abbreviated as Modbus 485 and is a master-slave communications protocol typically used for industrial applications. RS-485 refers to the physical layer of the network.

Modbus 485 is used for the hard-wired interface on Sure Cross® wireless products. The particular variation of RS-485 chosen for the Sure Cross wired network is 2-wire RS-485 running at 19.2 kilobits per second (kbps).

All connections between a DX83 Ethernet Bridge and a DX80 Gateway are via Modbus 485, as are connections between DX80 devices and the DX85 Expanded Remote I/O modules. A basic DX80 Gateway can be connected to a PLC or other process controller using the Modbus 485 network.

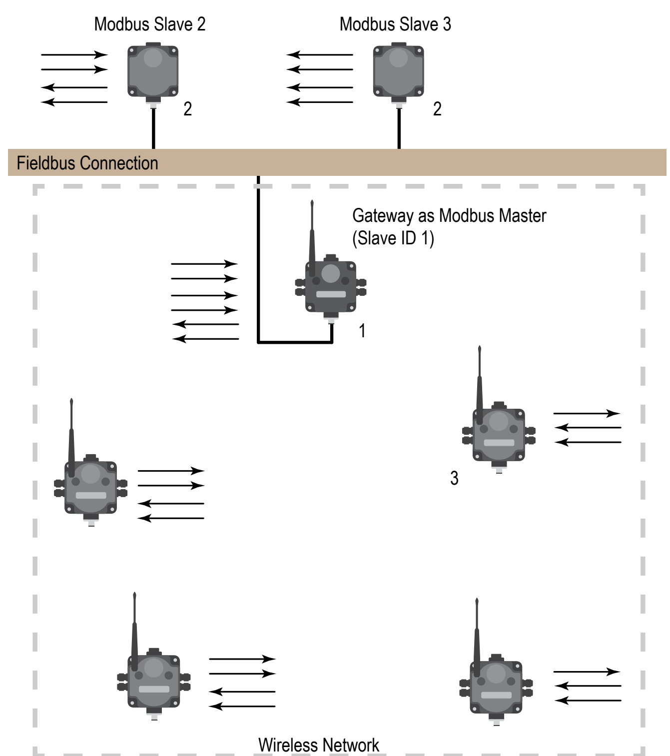
One Modbus master and up to 247 slave nodes may be connected to the bus at any given time, with the slave devices assigned unique slave identification numbers.

Only the Modbus master is allowed to initiate communications on a Modbus network. Messages from the master indicate for which slave device a message is intended and only the slave addressed by the master is allowed to respond. This allows the Modbus protocol to work well with a physical “party line,” where everyone “hears” all the network traffic, but only the addressed slave device can respond.

In a traditional Modbus network, the slave devices cannot alert the master when an event occurs. Instead the master must continually poll each slave device to observe changes.

3.1 Sure Cross and Modbus

All standard Gateways ship from the factory configured as Modbus slaves with their Modbus slave ID number set to 1. To avoid communications problems, do not connect the Sure Cross Gateway to a Modbus network already containing a slave ID 1 device.



As shown, the DX80 Gateway is a slave device within the Modbus network but remains the master device of the wireless network. In this way, the DX80 Gateway behaves as a true networking gateway by bridging communications between the wireless network and the Modbus RTU network.

The Modbus register map of the Gateway is fixed; there is no set up, programming, or customization needed to use Modbus to access the I/O points on wireless network device.

When a new Node is powered up and added to the wireless network, the Modbus registers are activated at a unique location saved for each wireless network Node device. Refer to Banner's Host Controller System Instruction Manual (p/n *132114*) for more information about the Modbus register map.

The DX85 Expanded Remote I/O device and many other Modbus slave devices cannot be used on a network without a Modbus master, so the DX80 Gateway includes Modbus master functionality. Because a Modbus network can only have one master, the network cannot include the PLC if the Gateway must have direct control over DX85 devices.

The Gateway is configured with a table of external connections that allow the DX85 Expanded I/O devices, as Modbus slaves, to communicate with the wireless Nodes.

For examples of additional Modbus RTU configurations, refer to System Layouts (Examples) (p/n *133601*).

4 Modbus/TCP and EtherNet/IP™ Networks

Attaching host devices to the Modbus network using standard Ethernet hardware requires using one of several Ethernet-based communications protocols.

Modbus/TCP is an open standard protocol developed by the Modbus IDA (www.modbus.org). It is very similar to Modbus RTU except that it uses standard Internet communication protocols, just like Web communications or e-mail. The master is referred to as the client and the slave is the server. Modbus/TCP follows the same structure as Modbus RTU: clients initiate all communications, servers can only respond, etc. However, given the power of TCP/IP, many client/server connections can be open at the same time, with one device functioning both as a client and as a slave.

EtherNet/IP™ is an open standard protocol developed by Allen-Bradley, but managed by the ODVA, (www.odva.org). EtherNet/IP is an adaptation of the DeviceNet serial fieldbus protocol using Internet communication protocols. EtherNet/IP stands for Ethernet Industrial Protocol, not Ethernet Internet Protocol. EtherNet/IP is DeviceNet over Ethernet.

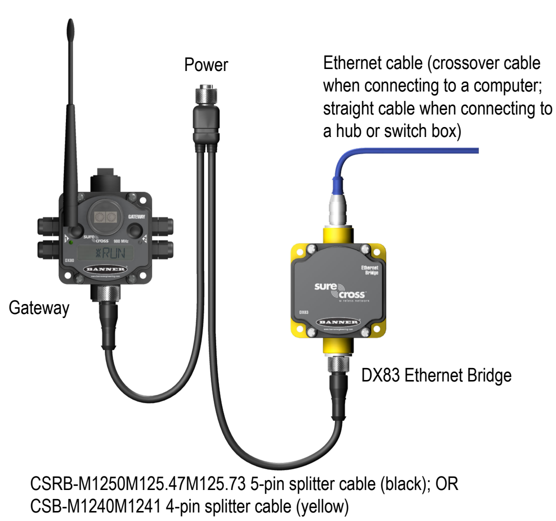
Serial and Ethernet Versions of Automation Protocols	
Serial	Ethernet
Modbus RTU	Modbus/TCP
DeviceNet	EtherNet/IP

4.1 DX83 Ethernet Bridge Overview

Connecting a Modbus RTU network to an Ethernet-based network requires using another type of networking gateway, the DX83 Ethernet Bridge. The DX83 Ethernet Bridge device acts as a communications bridge between the Modbus RTU network (Gateway) and Modbus/TCP or EtherNet/IP (host system).

In the Modbus RTU network, the DX83 Ethernet Bridge is the Modbus 485 master and the Gateway is set to the default Modbus slave setting. A DX83 Ethernet Bridge connected to a DX80 Gateway functions similar to a DX80 GatewayPro with I/O points. The DX83 Ethernet Bridge adds the Web page configuration ability to a Gateway-Node wireless network and interfaces to Ethernet using Modbus/TCP or EtherNet/IP protocols.

There are two basic DX83 models:
- **DX83T** acts as a protocol converter only, offering the Modbus/TCP or EtherNet/IP communication protocols.
- **DX83A** includes DX80 wireless network configuration, Modbus RTU master, Modbus/TCP client/server, Script Basic, e-mail, data logging, and trending.



Connect a DX83 Ethernet Bridge to a host system using the industrial Ethernet connection on the DX83. To connect the DX83 directly to the host system without using an Ethernet switchbox/hub, some host systems may require a crossover cable.

By default, the DX83 is configured to use Modbus/TCP. To use EtherNet/IP, you must connect the DX83 to a managed switch and you must use the Web Configuration tool to select EtherNet/IP (see *SureCross Wireless I/O Product Manual* or *Host Configuration Manual*).

4.1.1 DX83 Services

For Industrial Ethernet, the Ethernet Bridge functions as a slave device. In the Network 3 image shown, the computer functions as the master industrial Ethernet device. Like the Gateway, the Ethernet Bridge can act as both a master and slave device for the various networks.

The following are some of the services provided by the Ethernet Bridge:

Service	Purpose
http, Web server	Set up and configuration of the Gateway, wireless network I/O, and Ethernet Bridge
Ping	Sends a signal to a specific device and waits for a response to determine the communication link status
Modbus/TCP	Provides command and control functions to other industrial devices using Modbus/TCP
EtherNet/IP™	Provides command and control functions to Allen-Bradley deivces (both CIP and PCCC sub-protocols are supported)

The Web page interface accessed using the Ethernet Bridge provides a mechanism for setting parameters on the wireless network. Although most wireless parameters are initially configured at Banner, some of the parameters not configured include using the Gateway hardware as a Modbus RTU master, setting up I/O maps for the Modbus master actions, backup and restoring network configurations, changing the IP address of the Gateway, and enabling the EtherNet/IP protocol.

The Ping interface checks to see if a device is present at a particular IP address via the network. This is a troubleshooting tool.

When the DX83 Ethernet Bridge acts as the Modbus/TCP client, the user can set a polling rate and a series of reads and writes on the Ethernet Bridge. This feature allows a network of Ethernet Bridges or GatewayPros over Ethernet with longer cable runs and larger network sizes than would be possible with a network of standard Gateways on a Modbus 485 network.

Register maps for the Modbus TCP/IP server and EtherNet/IP slave connections are fixed, just like the register maps for the Modbus RTU interface on the Gateway. The Modbus TCP/IP and EtherNet/IP protocols require the use of a DX83 Ethernet Bridge or a DX80 GatewayPro.

4.2 GatewayPro

A GatewayPro combines the wireless capability of the standard Gateway with the protocol converter of a DX83 Ethernet Bridge, resulting in a device that is the master of the wireless network and a slave to an Industrial Ethernet network.

The GatewayPro is treated the same as a standard Gateway, with the GatewayPro providing Modbus/TCP or EtherNet/IP slave access to all the information on the wireless network instead of the Modbus 485 slave interface the standard Gateway provides. There are two basic models of the GatewayPro:

- **DX80P*T6*.** The T6 model acts as a protocol converter only, offering the Modbus/TCP or EtherNet/IP communication protocols.
- **DX80P*A6*.** The A6 model includes DX80 wireless network configuration, Modbus RTU master, Modbus/TCP client/ server, Script Basic, e-mail, data logging, and trending.

Connect a host controller system to the GatewayPro using its industrial Ethernet connection. To connect the GatewayPro to the host system without using an Ethernet switchbox/hub, some host systems may require a crossover cable.

By default, the GatewayPro is configured to use Modbus/TCP. To use EtherNet/IP, connect the GatewayPro to a managed switch and you must use the Web Configuration tool to select EtherNet/IP. For more information, see *SureCross Wireless I/O Product Manual* or *Host Configuration Manual*.

5 The OSI Seven Layer Model

The Open Systems Interconnection (OSI) seven layer model attempts to describe network communication protocols as a layered series of steps necessary to transmit information between dissimilar devices or networks.

The lowest level of the model is the physical level and pertains to the actual transfer media (air, wires), connector types, voltages, and signaling speeds for a specific type of network. Layers two and three also deal with data transfer at the hardware level.

Layers four through six typically are involved with data addressing - getting the data to the proper end location.

The seventh and highest level of the model is the application layer. The application layer is the interface between the user and the network.

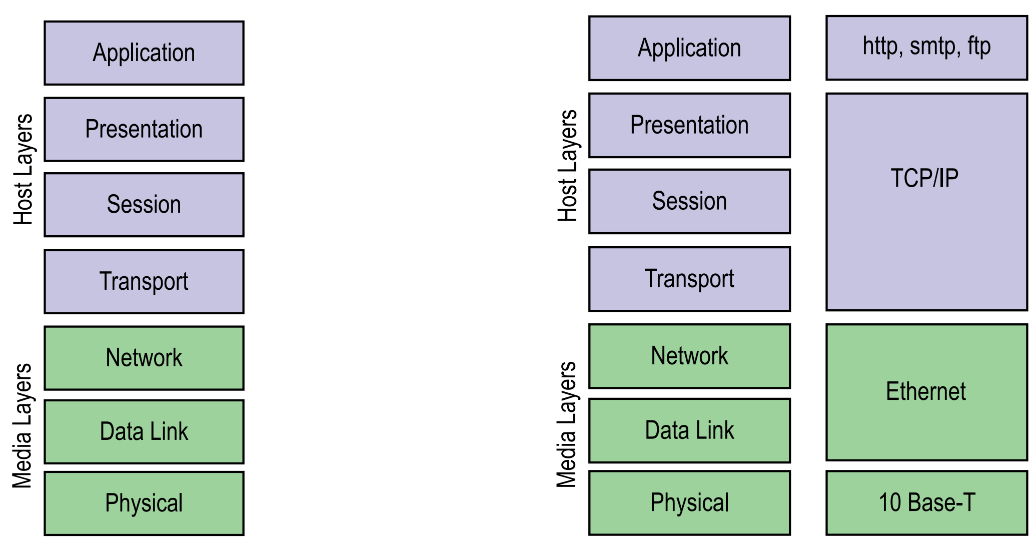
Between each layer are protocols translating the information from one layer to the next. The OSI seven layer model only loosely applies to most communications protocols because several layers may be combined together, especially the layers involved in TCP/IP communications protocols used in the Internet.

The acronym TCP/IP refers protocols used in the network level (IP) and the transport level (TCP). The TCP/IP layers control how sessions are established, error corrections, and other data transportation issues and encompass multiple layers of the OSI model.

In the Internet example, the application layer includes the protocols for http (Internet website access), smtp (e-mail), and ftp (file transfers) to name just a few.

The networking term “stack” has been used to describe the seven layers. Data must move up and down the same stack to be interpreted correctly.

OSI Seven Layer Model	OSI Seven Layer Model + Internet

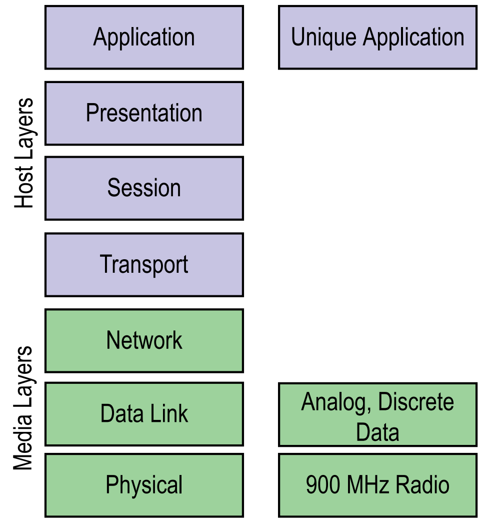


5.1 OSI and Wireless Networks

Although the SureCross wireless product is a proprietary wireless network and the various protocol layers are proprietary, the wireless network can be compared to the standard seven layer model.

Instead of wires creating a connection, the 900 MHz or 2.4 GHz radio signal transmits the binary data, creating a radio signal "link."

There are many other technologies and layers, but the most important result is at the application layer where the data exchanged between network nodes is used to monitor and control events.

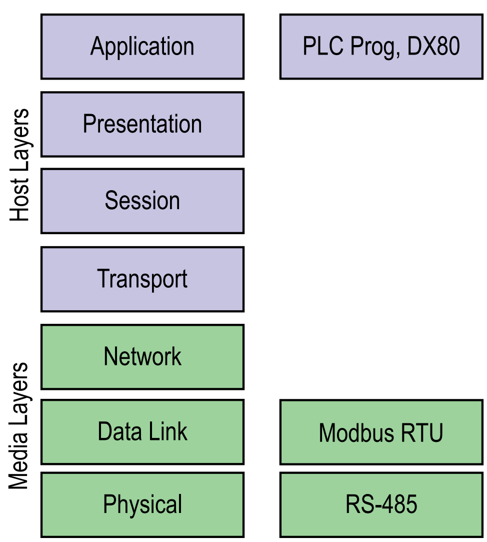


5.2 OSI and Modbus

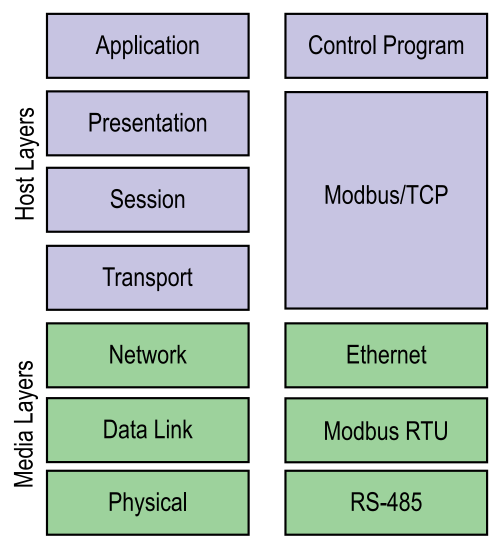
Applying this analogy to Modbus RTU, the lowest layer is defined by RS-485. Modbus RTU functions at the data link layer. The application layer is the PLC program on a PLC or the analogous control program on any host device.

Continuing with the OSI example, Modbus/TCP packages Modbus data packets inside the standard Internet TCP/IP protocols. EtherNet/IP functions the same way. Data moves from the data link layer up to the top of the stack and provides consistently structured data to use with a control program.

OSI Seven Layer + Modbus RTU Network Model



OSI Seven Layer + Modbus/TCP Model



6 Network Basics Glossary

DX83 Ethernet Bridge	The Ethernet Bridge acts as a communications bridge between the Modbus RTU network (Gateway) and Modbus/TCP or EtherNet/IP host systems and includes the ability to configure the network using a Web browser interface.
Ethernet	Ethernet is an access method for computer network (Local Area Networks) communications, defined by IEEE as the 802 standard.
EtherNet/IP™	EtherNet/IP is Allen-Bradley's DeviceNet running over Ethernet hardware.
gateway	A gateway is a general network device that connects two different networks.
Gateway	A Sure Cross® Gateway is the wireless sensor network master device used to control network timing and schedule communication traffic. Similar to how a gateway device on a wired network acts as a "portal" between networks, the Sure Cross Gateway acts as the portal between the wireless network and the central control process. Every wireless I/O sensor network requires one Gateway device. Every Sure Cross device is a transceiver, meaning it can transmit and receive data.
GatewayPro	The GatewayPro combines the standard Gateway and the DX83 Ethernet Bridge into one device.
master/slave relationship	The master/slave relationships is the model for a communication protocol between devices or processes in which one device initiates commands (master) and other devices respond (slave). The Sure Cross network is a master/slave network with the Gateway acting as the master device to the Nodes, which are the slave devices. A PC can also be a master device to a wireless sensor network. See *Star Network*.
Modbus	Modbus is a master-slave communications protocol typically used for industrial applications.
Modbus/TCP	Modbus/TCP is an open standard protocol very similar to Modbus RTU except that it uses standard Internet communication protocols.
Node	Nodes are remote I/O slave devices within Banner's wireless sensor networks. Sensors and other devices connect to the Node's inputs or outputs, allowing the Node to collect sensor data and wirelessly transmit it to the Gateway. Every Sure Cross device is a transceiver, meaning it can transmit and receive data.
TCP/IP	TCP/IP stands for Transfer Control Protocol / Internet Protocol and describe several layers in the OSI model that control the transfer and addressing of information.