Reference Manual

Allen-Bradley

Ethernet Design Considerations

Important User Information

Solid-state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://www.rockwellautomation.com/literature/) describes some important differences between solid-state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid-state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

	**WARNING:** Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
	**ATTENTION:** Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.
	**SHOCK HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
	**BURN HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

This manual contains new and updated information. Changes throughout this revision are marked by change bars, as shown to the right of this paragraph.

New and Updated Information

This table contains the changes made to this revision.

Topic	Page
Studio 5000™ Logix Designer application is the rebranding of RSLogix™ 5000 software	10
Updated switch selection chart	28
Updated information about network address translation (NAT)	38
Added specifications for the 1756-EN2TRXT, 1756-EN2TSC, and 9300-ENA modules	66, 67, 68

Notes:

Notes:

Rockwell Automation uses open network technology for seamless, plant-wide integration. These open networks share a universal set of communication services. As a result, information can be communicated seamlessly throughout the plant and to and from the Internet for e-business applications.

Each Rockwell Automation network is ideal for a wide range of applications, operates with devices manufactured by various vendors, and shares data with industry-standard information networks.

Comparison	EtherNet/IP Network	ControlNet Network	DeviceNet Network
Function	Plant management system tie-in (material handling) with configuration, data collection, and control on a single high-speed network	Supports transmission of time critical data between PLC processors and I/O devices	Connects low-level devices directly to plant-floor controllers without the use of I/O modules
Typical devices networked	• Mainframe computers • Programmable controllers • Robots • HMI • I/O • Drives • Process instruments	• Programmable controllers • I/O chassis • HMIs • Personal computers • Drives • Robots	• Sensors • Motor starters • Drives • Personal computers • Push buttons • Low-end HMIs • Bar code readers • PLC processors • Valve manifolds
Data repetition	Large packets, data sent regularly	Medium-size packets; data transmissions are deterministic and repeatable	Small packets; data sent as needed
Number of nodes, max	No limit	99 nodes	64 total nodes
Data transfer rate	10 Mbps, 100 Mbps, or 1 Gbps	5 Mbps	500, 250, or 125 Kbps
Typical use	Plant-wide architecture High-speed applications	Redundant applications Scheduled communication	Supply power and connectivity to low-level devices

Studio 5000 Environment

The Studio 5000 Engineering and Design Environment combines engineering and design elements into a common environment. The first element in the Studio 5000 environment is the Logix Designer application. The Logix Designer application is the rebranding of RSLogix 5000 software and continues to be the product to program Logix5000™ controllers for discrete, process, batch, motion, safety, and drive-based solutions.

The Studio 5000 environment is the foundation for the future of Rockwell Automation® engineering design tools and capabilities. It is the one place for design engineers to develop all the elements of their control system.

Additional Resources

These documents and websites contain additional information concerning related products from Rockwell Automation.

Table 1 - ODVA Resources

Resource	Description
http://www.odva.org/	Accesses the Open DeviceNet Vendors Association (ODVA) website.
http://www.odva.org/default.aspx?tabid=54	Accesses the CIP Advantage website. The website offers the following: • CIP features and benefits • How to get started
Ethernet Media Planning and Installation Manual, ODVA publication http://www.odva.org/Portals/0/Library/Publications_Numbered/PUB00148R0_EtherNetIP_Media_Planning_and_Installation_Manual.pdf	Describes the required media components and how to plan for, install, verify, troubleshoot, and certify an Ethernet network.
Network Infrastructure for EtherNet/IP: Introduction and Considerations, ODVA publication http://www.odva.org/Portals/0/Library/Publications_Numbered/PUB00035R0_Infrastructure_Guide.pdf	Provides an overview of the technologies used in EtherNet/IP networks and provides guidelines for deploying infrastructure devices in EtherNet/IP networks.

Table 2 - Rockwell Automation Resources

Resource	Description
http://www.ab.com/networks/	Accesses the networks and communication section of the Rockwell Automation website.
http://www.rockwellautomation.com/services/networks/ http://www.rockwellautomation.com/services/security/	Accesses Rockwell Automation network and security services websites.
http://www.ab.com/networks/architectures.html	Links to the Education series webcasts for IT and controls professionals.
EtherNet/IP Embedded Switch Technology Application Guide, publication ENET-AP005	Describes how to install, configure, and maintain linear and device-level ring (DLR) networks by using EtherNet/IP devices with embedded switch technology.
EtherNet/IP QuickConnect Application Technique, publication ENET-AT001	Describes EtherNet/IP QuickConnect technology. QuickConnect technology enables EtherNet/IP devices to quickly power up and join an EtherNet/IP network.
EtherNet/IP Socket Interface Application Technique, publication ENET-AT002	Describes the socket interface used to program MSG instructions to communicate between a Logix5000 controller via an EtherNet/IP module and Ethernet devices that do not support the EtherNet/IP application protocol.
EtherNet/IP Network Configuration User Manual, publication ENET-UM001	Describes how to configure and use EtherNet/IP communication modules with a Logix5000 controller and communicate with various devices on the Ethernet network.

Table 3 - Cisco and Rockwell Automation Alliance Resources

Resource	Description
http://www.ab.com/networks/architectures.html	Links to the Rockwell Automation and Cisco Systems reference architecture website.
Converged Plantwide Ethernet (CPwE) Design and Implementation Guide, publication ENET-TD001	Represents a collaborative development effort from Rockwell Automation and Cisco Systems. The design guide is built on, and adds to, design guidelines from the Cisco Ethernet-to-the-Factory (EttF) solution and the Rockwell Automation Integrated Architecture™. The design guide focuses on the manufacturing industry.
Embedded Switch Technology Reference Architectures, publication ENET-RM003	Provides design recommendations for connecting device-level topologies to networks comprised of Layer 2 switches. It also covers the implementation of embedded switch technology within the Converged Plantwide Ethernet (CPwE) Cell/Area zone.

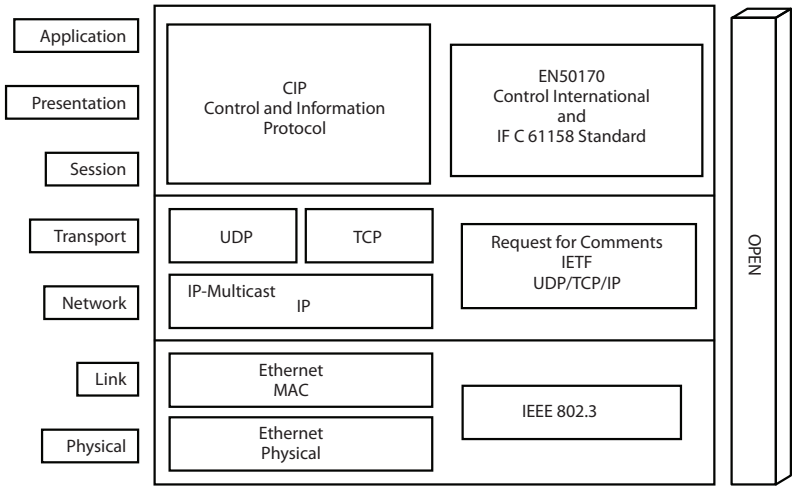
You can view or download Rockwell Automation publications at http:/www.rockwellautomation.com/literature/. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

Notes:

EtherNet/IP Overview

The EtherNet/IP protocol is a multi-discipline, control and information platform for use in industrial environments and time-critical applications. The EtherNet/IP network uses standard Ethernet and TCP/IP technologies and an open, application-layer protocol called the Common Industrial Protocol (CIP).

The open, application-layer protocol makes interoperability and interchangeability of industrial automation and control devices on the EtherNet/IP network a reality for automation and real-time control applications.



The EtherNet/IP protocol follows these standards:

- IEEE 802.3—Standard Ethernet, Precision Time Protocol (IEEE-1588)
- IETF—Internet Engineering Task Force, standard Internet Protocol (IP)
- IEC—International Electrotechnical Commission
- ODVA—Open DeviceNet Vendor Association, Common Industrial Protocol (CIP)

Network Protocols

On the most basic level, Ethernet is a wire or cable that connects computers and peripheral modules so that they can communicate. The actual wire used for the network is referred to as the network medium. Beyond the physical medium, all Ethernet networks support protocols that provide data transfer and network management capability.

Protocol	Description
Common Industrial Protocol (CIP)	CIP applies a common application layer over an Ethernet network by encapsulating messages in TCP/UDP/IP. This common application layer provides interoperability and interchangeability of industrial automation and control modules on an Ethernet network. The EtherNet/IP network supports both real-time I/O (implicit messaging) and explicit messaging.
Transmission Control Protocol/internet Protocol (TCP/IP)	TCP/IP is a transport-layer protocol (TCP) and a network-layer protocol (IP) commonly used in business environments for communication within networks and across internetworks. The EtherNet/IP communication modules use TCP/IP for explicit messaging. Explicit messaging is used by applications when time is not a critical factor, such as uploading or downloading programs.
User Datagram Protocol/ internet Protocol (UDP/IP)	UDP is a much simpler transport protocol. It is connectionless, and provides a simple means of sending datagrams between two modules. UDP is used by applications that implement their own handshaking between modules and require minimal transport service. UDP is smaller, simpler, and faster than TCP and can operate in unicast, multicast, or broadcast mode. The EtherNet/IP communication modules use UDP/IP for real-time I/O messaging.

CIP

CIP is a message-based, application-layer protocol. This protocol implements a relative path to send a message from the producing modules in a system to the consuming modules.

CIP uses the producer/consumer networking model instead of a source/ destination (master/slave) model. The producer/consumer model reduces network traffic and increases speed of transmission.

In traditional I/O systems, controllers poll input modules to obtain their input status. In the CIP system, digital input modules are not polled by a controller. Instead, they produce their data either upon a change of state (COS) or at a requested packet interval (RPI). The frequency of update depends upon the options chosen during configuration and where on the network the input module resides. The input module, therefore, is a producer of input data and the controller is a consumer of the data.

The controller can also produce data for other controllers to consume. The produced and consumed data is accessible by multiple controllers over the Logix backplane and over the EtherNet/IP network. This data exchange conforms to the producer/consumer model.

Configuration Requirements

All devices on Ethernet communicate by using the Ethernet address for the device. This address is sometimes referred to as the hardware address or Media Access Controller (MAC) address. The hardware address is a unique, six-byte address, which is embedded in the circuitry of every device on an Ethernet network. Every vendor of Ethernet products obtains their own unique address range.

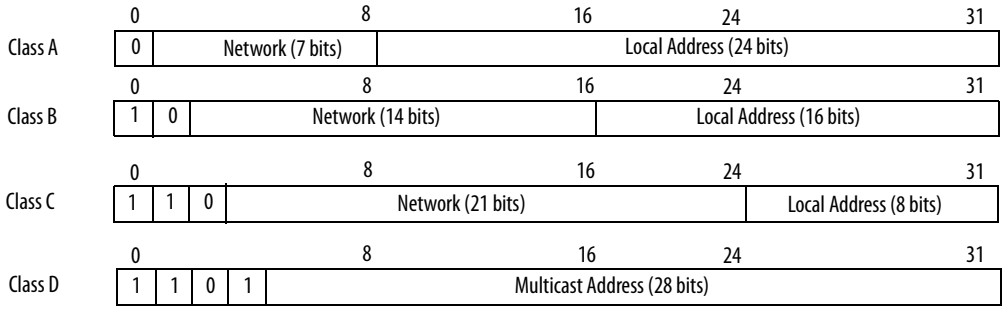
For a device to communicate on an Ethernet network, you must configure its IP address, gateway address, and subnet mask.

IP Address

The IP address identifies each node on the IP network or system of connected networks. Each TCP/IP node on a network must have a unique IP address. The IP address is 32 bits long and has a network ID part and a host ID part. Because networks vary in size, there are four types of networks.

Network Type	Application
Class A	Large networks with many devices
Class B	Medium-sized networks
Class C	Small networks (fewer than 256 devices) Most common for private, industrial networks
Class D	Multicast addresses

The network class determines how an IP address is formatted.



Each node on the same physical network must have an IP address of the same class and must have the same network ID. Each node on the same network must have a different local address (host ID), thus giving it a unique IP address.

IP addresses are written as four-decimal integers (0...255) separated by periods where each integer gives the value of one byte of the IP address.

For example, the following 32-bit IP address is written as 130.0.0.1:

10000010 00000000 00000000 00000001

Class	Leftmost Bits	Start Address	Finish Address
A	0*xxx*	0.0.0.	127.255.255.255
B	10*xx*	128.0.0.0	191.255.255.255
C	110*x*	192.0.0.0	223.255.255.255
D	1110	224.0.0.0	239.255.255.255

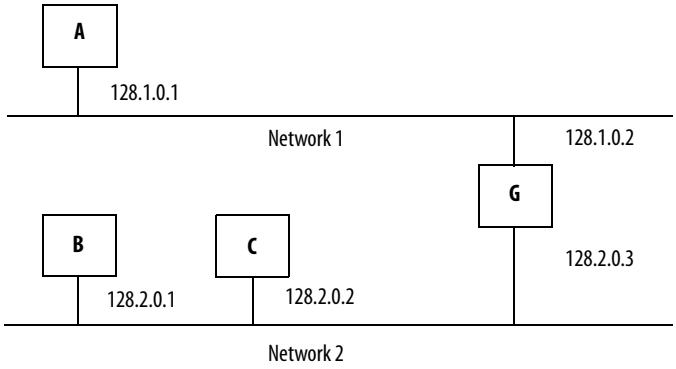
Public IP addresses are for computers and devices connected to the Internet. Devices on industrial networks are not connected to the Internet, but they communicate with each other over an EtherNet/IP network. These devices use private IP addresses that are not routed on the Internet.

Private IP addresses typically start with 10, 172, or 192 as the first part of the address. Private IP addresses are typically connected to the Internet through a Network Address Translation (NAT) device.

For more information about NAT, see page 38.

Gateway Address

A gateway connects individual physical networks into a system of networks. When a node needs to communicate with a node on another network, a gateway transfers the data between the two networks. The following figure shows gateway G connecting Network 1 with Network 2.



When host B with IP address 128.2.0.1 communicates with host C, it knows from C's IP address that C is on the same network. In an Ethernet environment, B can then resolve C's IP address to a MAC address and communicate with C directly.

When host B communicates with host A, it knows from A's IP address that A is on another network because the network IDs differ. To send data to A, B must have the IP address of the gateway connecting the two networks. In this example, the gateway's IP address on Network 2 is 128.2.0.3.

The gateway has two IP addresses (128.1.0.2 and 128.2.0.3). Network 1 hosts must use the first IP address, and Network 2 hosts must use the second IP address. To be usable, a host's gateway IP address must match its own net ID.

Devices with IP address switches use the default gateway address of either 192.168.1.1 or 0.0.0.0. Check your product information to determine which gateway address applies for your device.

Subnet Mask

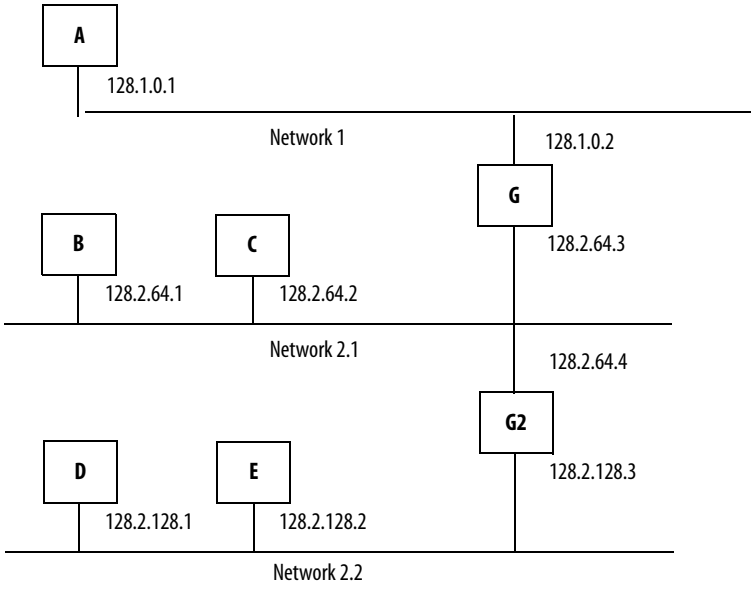
Subnet addressing is an extension of the IP address scheme. It enables a site to use a single net ID for multiple physical networks. Routing outside of the site continues by dividing the IP address into a net ID and a host ID via the IP class. Inside a site, the subnet mask is used to redivide the IP address into a custom net ID portion and host ID portion.

A subnet mask determines which of the 32 bits in the IP address are part of the network ID and which are part of the unique node identification. This also determines the size of the network or subnetwork.

Take Network 2 (a Class B network) in the previous example and add another physical network. Selecting this subnet mask adds two additional net ID bits providing for four physical networks.

11111111 11111111 11111111 00000000 = 255.255.255.0

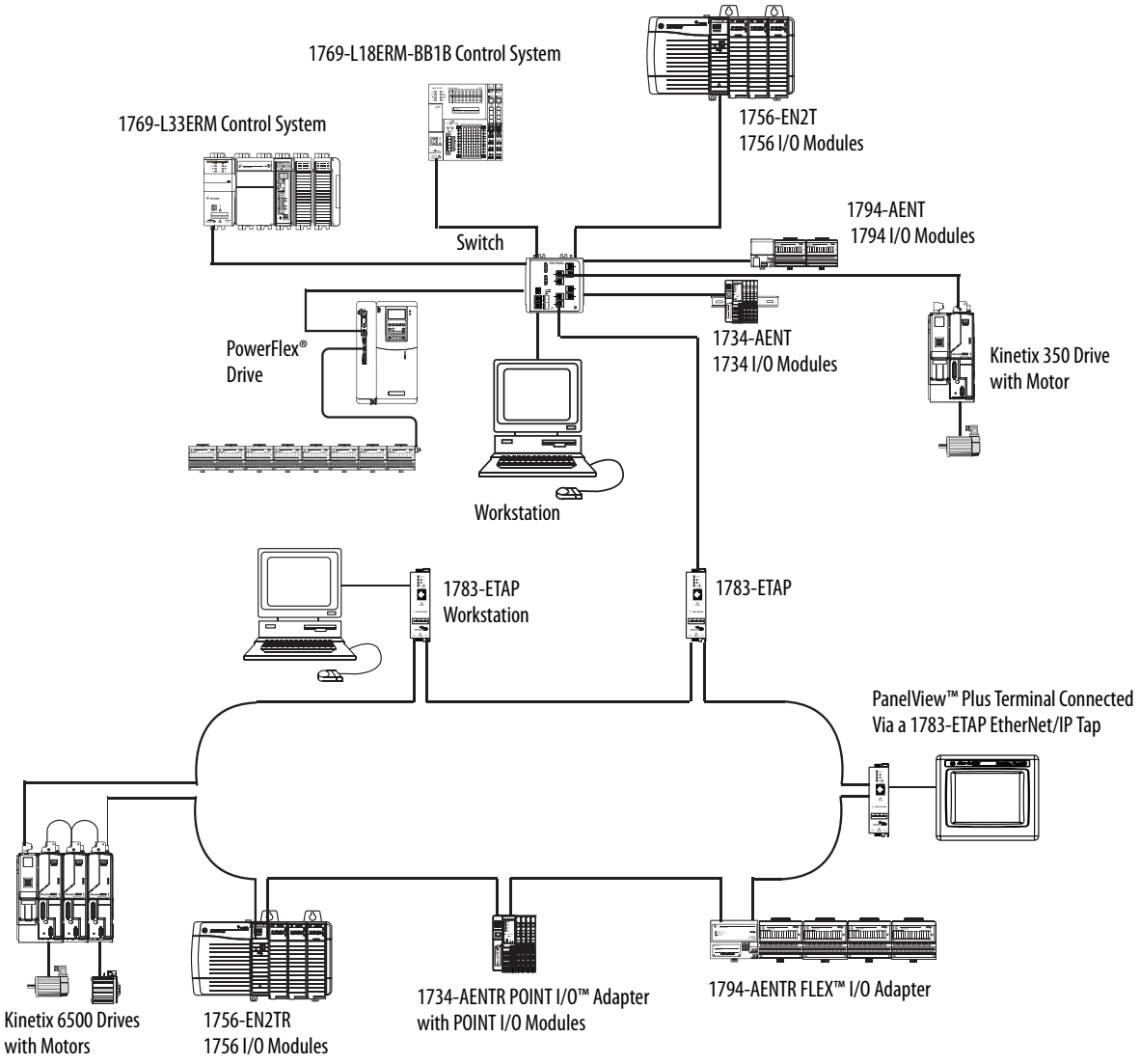
Two bits of the Class B host ID have been used to extend the net ID. Each unique combination of bits in the part of the host ID where subnet mask bits are 1 specifies a different physical network.



A second network with hosts D and E has been added. Gateway G2 connects network 2.1 with network 2.2. Hosts D and E use gateway G2 to communicate with hosts not on network 2.2. Hosts B and C use gateway G to communicate with hosts not on network 2.1. When B is communicating with D, G (the configured gateway for B) routes the data from B to D through G2.

EtherNet/IP Modules in a Control System

The following diagram shows how EtherNet/IP communication modules can fit into a control system.



In this example, the following actions can occur:

- Controllers produce and consume tags with each other.
- Controllers initiate MSG instructions to send/receive data or configure devices.
- Controllers control I/O and drives.
- Workstations can upload/download projects to the controllers.
- Workstations can configure devices on the EtherNet/IP network.

Bridge across Networks

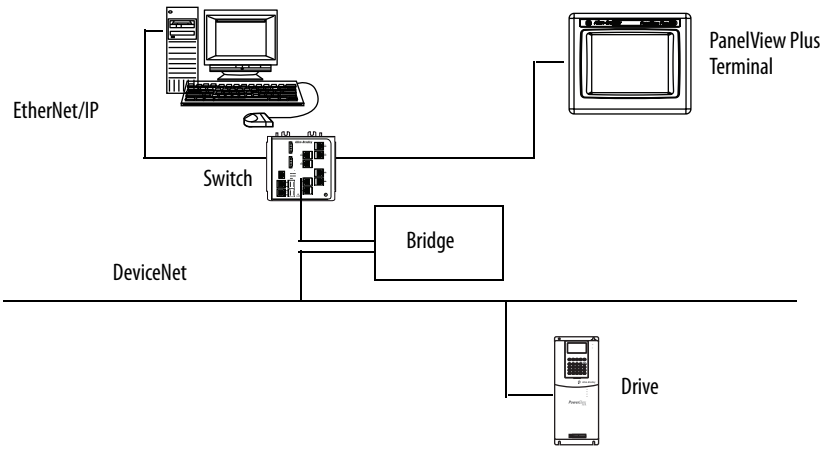
Some EtherNet/IP communication modules support the ability to bridge or route communication through devices, depending on the capabilities of the platform and communication devices.

You have a bridge when you have a connection between communication devices on two networks. For example, the bridge device has both EtherNet/IP and DeviceNet connections, enabling Device 1 on the EtherNet/IP network to communicate with Device 2 on a DeviceNet network through the bridge.

The bridge device can be an EtherNet/IP-to-DeviceNet bridging device or a Logix5000 system with an EtherNet/IP communication module and a DeviceNet communication module.

CIP messages originating on this network	Can bridge to this network			
	EtherNet/IP	ControlNet	DeviceNet	RS-232 Serial
EtherNet/IP	Yes	Yes	Yes	Yes
ControlNet	Yes	Yes	Yes	Yes
RS-232	Yes	Yes	Yes	Yes

In the following example graphic, a workstation configures a drive on a DeviceNet network and bridges EtherNet/IP networks to reach the drive.



IMPORTANT You can bridge between devices on different networks for only messaging.

You **cannot bridge** from one network to another for **I/O control or produced and consumed tags**. This restriction applies regardless of whether the two networks are either of the following:

- Same type, such as an EtherNet/IP network to an EtherNet/IP network
- Different types, such as an EtherNet/IP network to a ControlNet network

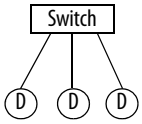
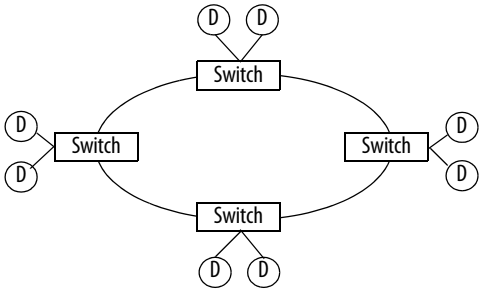
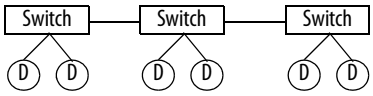
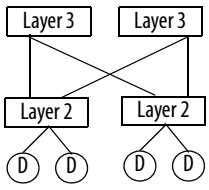
Ethernet Infrastructure Components

The topology and cable layout of the Ethernet network is part of the physical layer. Ethernet systems require various infrastructure components to connect individual network segments.

Topologies

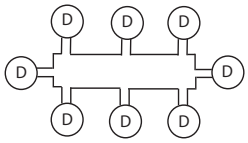
Ethernet networks are laid out in point-to-point configurations with one cable for each device. Ethernet networks have active infrastructures that rely on switches. You can design a network with individual switch devices and devices with embedded switch technology.

Table 4 - Topologies with an Individual Switch

Topology	Description	
Star 	The most common EtherNet/IP network topology is a star, where end devices are connected and communicate with each other via a switch. In a star topology, nodes are typically grouped closely together.	
	Advantages • Easy to design, configure, and implement • Direct path between the infrastructure device and the end device • Remove and add devices without affecting the rest of the network • Increase port capacity on the switch to add more devices • Centralization can ease troubleshooting, because the switch sees the activities of all of the connected devices	**Disadvantages** • Loss of network service in case of connection failure (no resiliency) • Primarily the single point of failure of the centralized switch
Ring—switch based 	A ring network is a single-fault tolerant ring network intended for the interconnection of automation devices.	
	Advantages • Ability to survive a single point of failure or a device being powered down on the ring. • Simplified cabling • Ability to cover long distances with 100 m between each copper segment	**Disadvantages** • Additional configuration complexity • Longer convergence times • Variable number of hops can make performance difficult to predict
Linear—switch based 	A linear network is a collection of devices that are daisy-chained together. A linear topology works best for a limited number of nodes.	
	Advantages • Easy to design, configure, and implement • Least amount of cabling • Minimal amount of cable needed • Ability to cover long distances with 100 m between each link	**Disadvantages** • Loss of network service in case of connection failure (no resiliency) • Creates the potential for bottlenecks • Variable number of hops can make performance difficult to predict • Powering down a device or the failure of a device in the center of the network affects connectivity between any of the devices on either side • Each link in the chain represents network delay
Redundant star 	In a redundant star topology, every Layer 2 access switch has dual connections to a Layer 3 distribution switch. Devices are connected to the Layer 2 switches.	
	Advantages • Resiliency from multiple connection failures • Faster convergence to connection loss • Consistent number of hops provide predictable and consistent performance • Fewer bottlenecks	**Disadvantages** • Additional wiring and ports required • Additional configuration complexity

The EtherNet/IP embedded switch technology offers alternative network topologies by embedding switches into the end devices themselves.

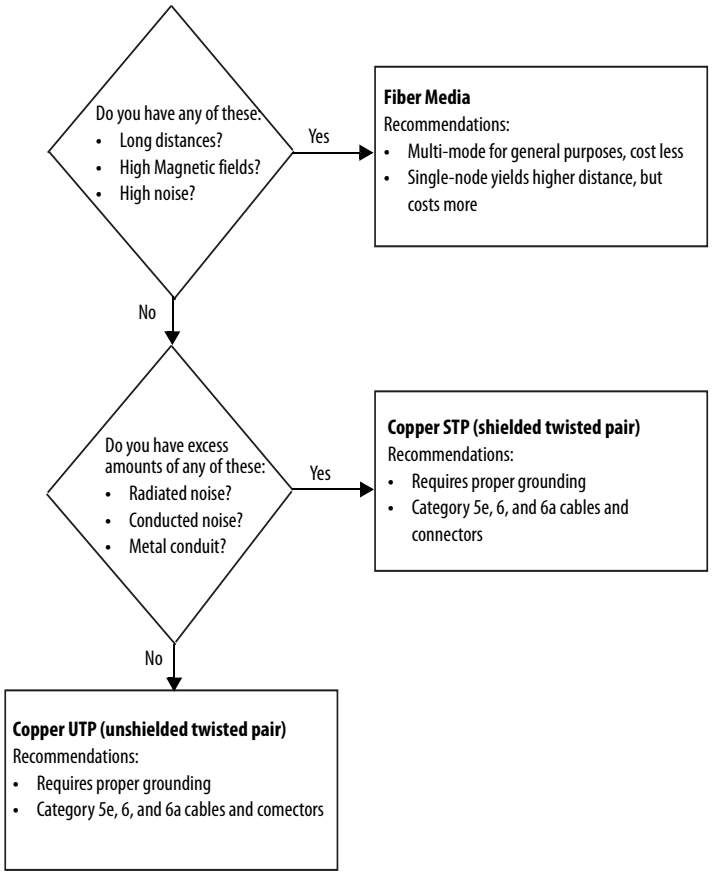
Table 5 - Topologies with Embedded Switch Technology

Topology	Description	
Device-level ring (DLR)—embedded switch 	A DLR network is a single-fault tolerant ring network intended for the interconnection of automation devices. This topology is also implemented at the device level. No additional switches are required.	
	Advantages • Ability to survive a single point of failure or a device being powered down on the ring. • Simplified cabling • Ability to cover long distances with 100 m between each copper segment • Very fast network convergence	**Disadvantages** • Supervisor-node configuration required • Additional configuration complexity • Variable number of hops can make performance difficult to predict
Linear—embedded switch	A linear network is a collection of devices that are daisy-chained together. The EtherNet/IP embedded switch technology enables this topology to be implemented at the device level. No additional switches are required. A linear topology works best for a limited number of nodes.	
	Advantages • Easy to design, configure, and implement • Least amount of cabling • Minimal amount of cable needed • Ability to cover long distances with 100 m between each link	**Disadvantages** • Loss of network service in case of connection failure (no resiliency) • Creates the potential for bottlenecks • Variable number of hops can make performance difficult to predict • Powering down a device or the failure of a device in the center of the network affects connectivity between any of the devices on either side • Each link in the chain represents network delay

Media

The actual wire used for the network is referred to as the physical media. Generally, shorter cable runs are less susceptible to EMI (electromagnetic interference) and RFI (radio-frequency interference) from electrical circuits, motors, and other machinery.

Figure 1 - Select Ethernet Media

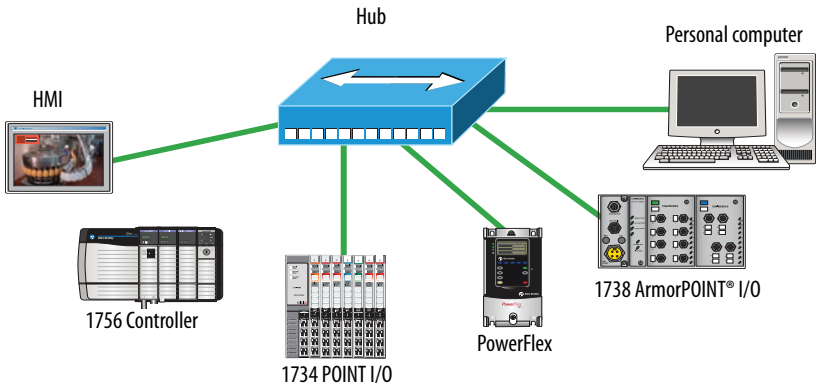


For more information about the media options, see the Ethernet section of the Network Media Catalog, publication M116-CA552.

Hubs

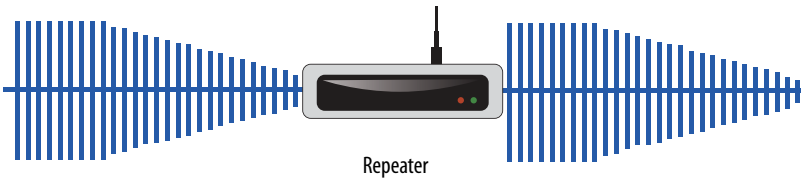
Hubs are multiport repeaters. They are based on older technology, which has been largely replaced by network switches at Layer 2, but they are still used as network diagnostic tools to analyze network traffic:

- A hub is at the center of a star topology.
- Hubs can connect together with a variety of media as a backbone between hubs.
- A hub broadcasts everything it receives on any channel out all other channels.



Repeaters

A repeater recreates the incoming signal and re-transmits it without noise or distortion that can have affected the signal as it was transmitted down the cable. Repeaters are generally used in older networks to increase the network length. More modern networks use fiber media or switches to increase network length.

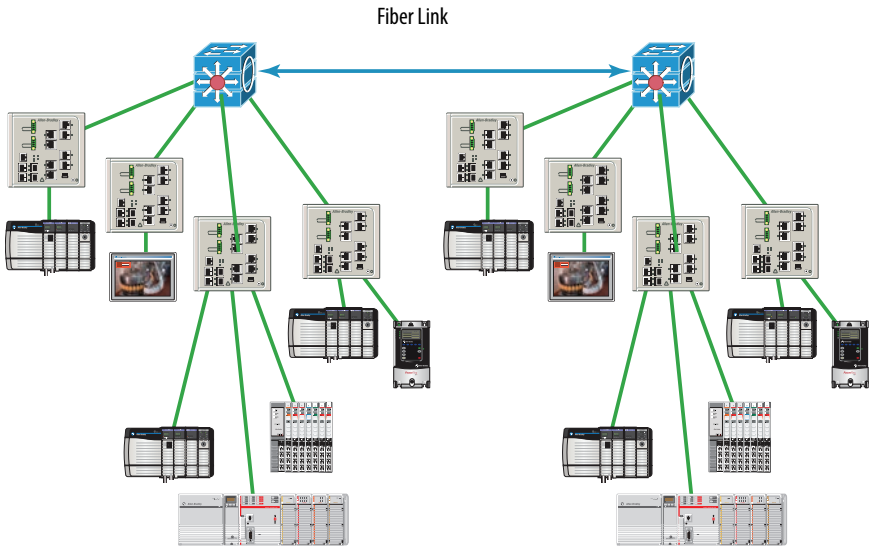


Media Converters

Media converters let you mix fiber and copper (twisted-pair) cables in the same system.

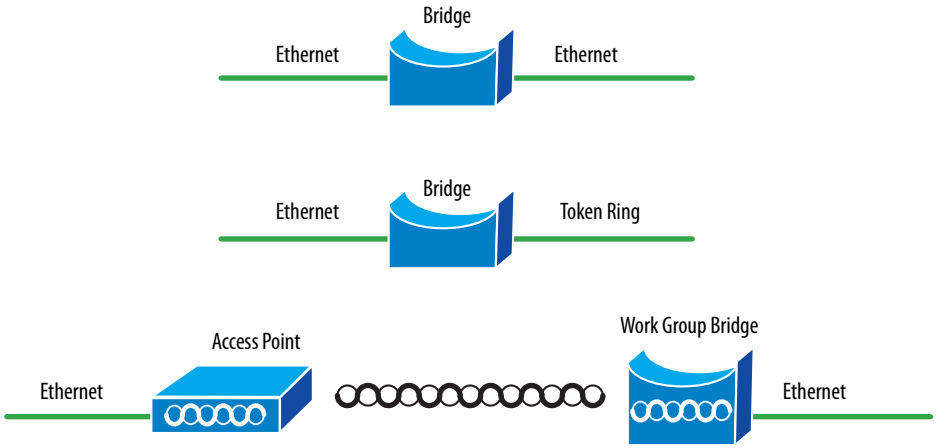
Use a switch to mix media:

- Physical layer devices offer no buffering or advanced diagnostic features.
- Physical layer devices are easily overrun by an EtherNet/IP system (no buffering = lost data).
- Layer 2 devices have buffering, QoS, and other management features.



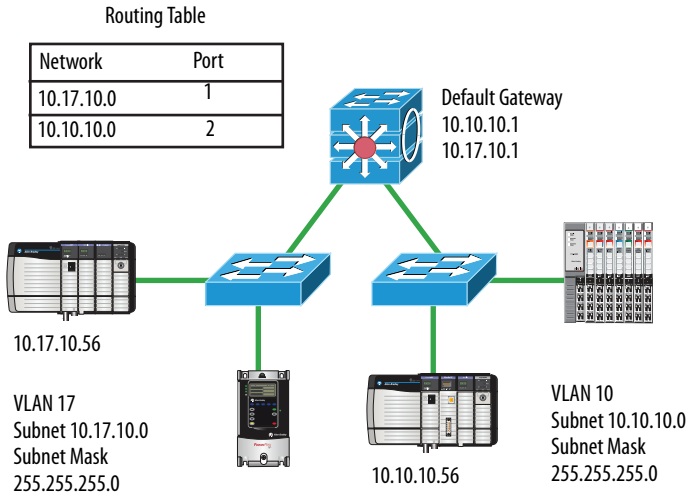
Bridges

A bridge is a device that isolates traffic between segments by selectively forwarding frames to their proper destination. A bridge is transparent to the network and protocol independent. More advanced devices that perform the same bridging function are commonly used instead of a bridge.



Routers and Gateways

Routers and gateways use the network portion of IP addresses to identify the location of networks. A routing table lets a device know from which port to transmit a message, so the message can get to a particular network. If that network is not directly attached to the device, it forwards the message to the next gateway or router in the path for further routing.

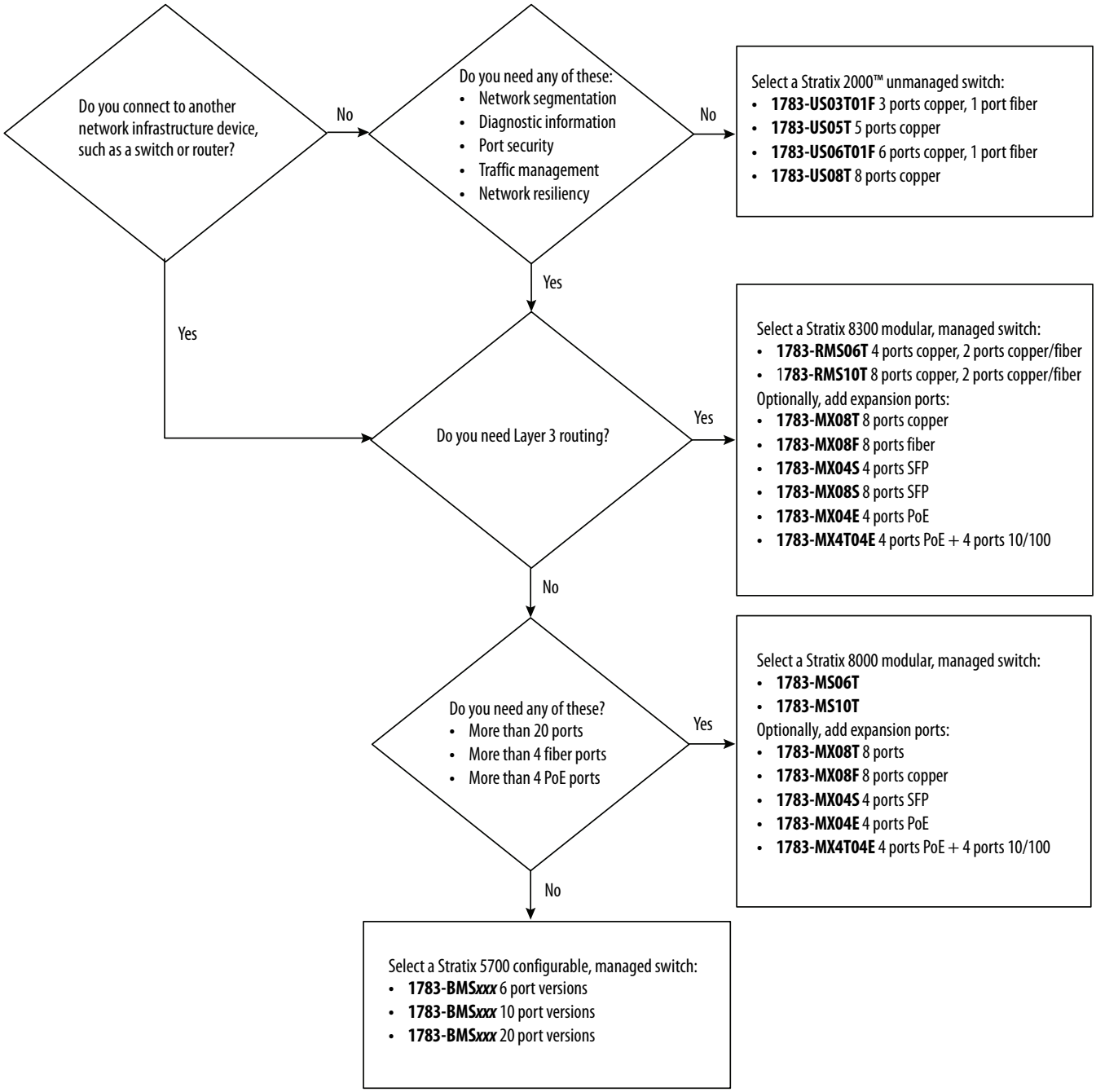


Switches

Switches provide determinism and throughput required for control applications. Industrial-rated switches are recommended for connecting computers and other devices to each other and to higher-level networks in the network reference architecture. Ethernet switches perform the following:

- Operate in Full-duplex mode to eliminate collisions
- Include managed switch features for advanced network functionality

Figure 2 - Select an Ethernet Switch



For more information, see the Stratix Switch Reference Chart, publication ENET-QR001.

Unmanaged versus Managed Switches

Unmanaged switches are relatively inexpensive and simple to set up, but they do not provide any management capabilities, security, or diagnostic information. Therefore, they are difficult to troubleshoot.

As a general rule for unmanaged switches, make sure of the following:

- Your application does not contain I/O traffic

  or

- Your application has I/O control and the following is true:
  - The network is not directly connected to the IT network
  - All nodes on the network are Rockwell Automation devices
  - There is no potential to overload a device with traffic

Managed switches are typically more expensive than unmanaged switches and require some level of support for initial configuration and replacement. However, managed switches provide advanced features, which can enable better network performance in your control system. Managed switches are able to manage multicast traffic and provide diagnostics data, security options, and other advanced features.

Switch Type	Advantages	Disadvantages
Managed	• Ability to manage multicast traffic • Diagnostics data • Security options • Additional advanced features • Network segmentation features • Network resiliency features	• More expensive • Requires some level of support and configuration to start up and replace
Unmanaged	• Inexpensive • Simple to set up • 'No Config' replacement	• No network segmentation • No dagnostic information • No port security • No traffic management • No network resiliency

Autonegotiation

Autonegotiation lets devices select the optimal way to communicate without requiring you to configure the devices. However, if you connect a manually-configured device to an autonegotiation device, a high rate of data transmission errors can occur.

All 100 Mbps devices are required to support autonegotiation, but most existing 10 Mbps devices do not. Select a switch that supports both speeds to enable you to connect to existing devices that use the slower rate.

Full-duplex Mode

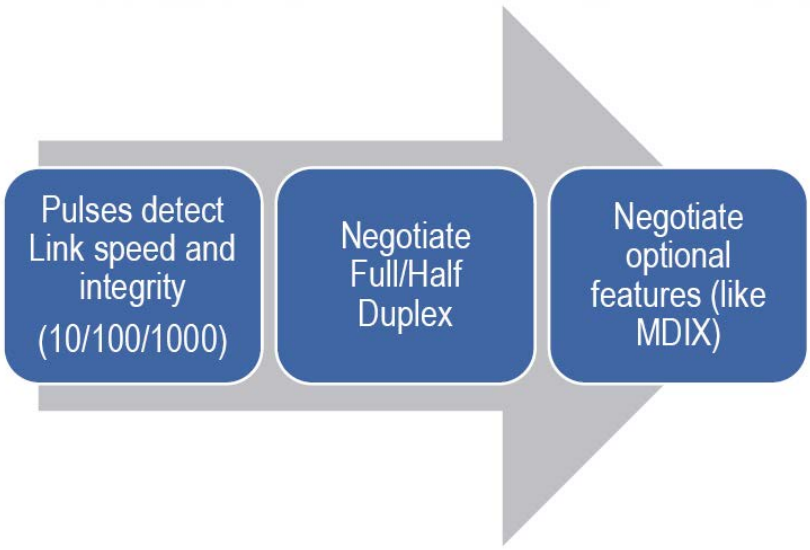
Ethernet is based on Carrier Sense Multiple Access/Collision Detect (CSMA/CD) technology. This technology places all nodes on a common circuit so they can all communicate as needed. The nodes must handle collisions (multiple devices talking at the same time) and monitor their own transmissions so that other nodes have transmission time.

The data transmission mode you configure determines how devices transmit and receive data.

Transmission Mode	Features
Full-duplex	Deterministic • Transmit and receive at the same time • Transmit on the transmit pair and receive on the receive pairs • No collision detection, backoff, or retry • Collision free
Half- duplex	Nondeterministic • One station transmits and the others listen • While transmitting, you do not receive, as no one else is transmitting • If someone else transmits while you are transmitting, then a collision occurs • Any Receive-while-Transmit condition is considered a collision

Full-duplex mode eliminates collisions. Combined with the speed of the switches available today, you can eliminate the delays related to collisions or traffic in the switch. A a result, the EtherNet/IP network becomes a highly deterministic network well-suited for I/O control:

- If you are autonegotiating, make sure you verify the connection.
- If you are forcing speed and duplex on any link, make sure you force at both ends of the link. If you force on one side of the link, the autonegotiating side always goes to half-duplex.

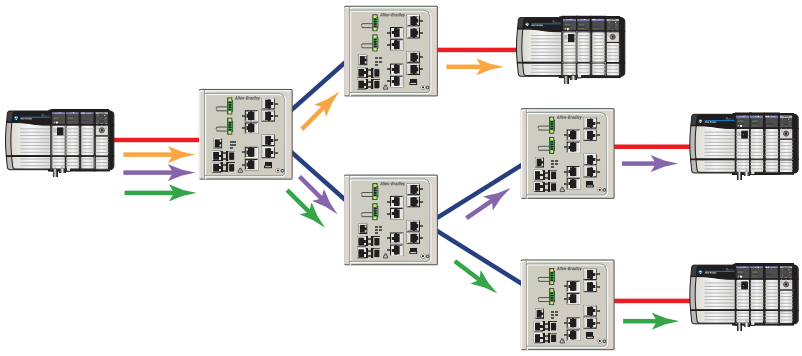
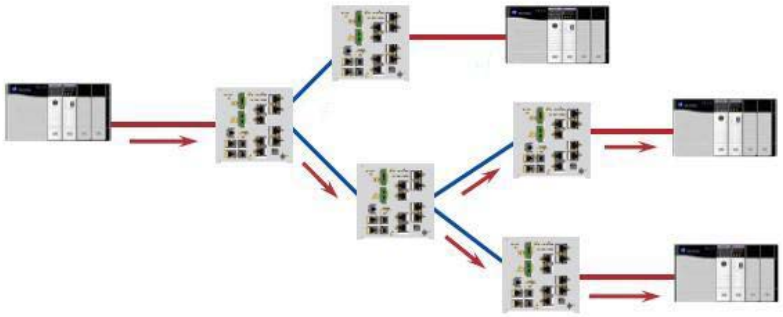
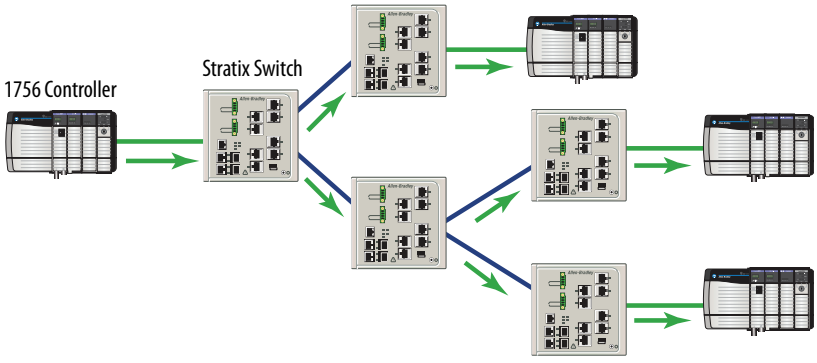


Ethernet Infrastructure Features

When you use the EtherNet/IP network for time-critical control, there are several features available in switches that are required or recommended.

Transmission Packets

Data is transmitted over the EtherNet/IP network in packets. There are transmission methods for transporting data on the network.

Packet Type	Destination	Description
Unicast	A single node	Unicast connections are point-to-point transmissions between a source node and destination node on the network. A frame is sent to a single destination. 
Multicast	Multiple nodes simultaneously	Multicast connections deliver information from one sender to multiple receivers simultaneously. Copies of a single frame are passed to a selected subset of possible destinations. 
Broadcast	All nodes	Broadcast connections transmit information to every device on the network. A frame is delivered to all hosts on the network. 

Limit the amount of broadcast and multicast traffic on the supervisory control network:

- Eliminating unwanted traffic reduces the load on devices, switches, and the network.
- Eliminating unnecessary incoming broadcast traffic also minimizes network load.

It is important to prevent network traffic from coming into the supervisory control (level 2) and manufacturing operations (level 3) network from other levels. Likewise, it is equally important to make sure that traffic on the control system network does not get propagated into the plant enterprise network

Default Setting in the Studio 5000 Environment

The support for unicast communication and the default settings in the Studio 5000 environment depend on the version of software. Later versions include the unicast features of earlier versions.

Studio 5000 Version	Unicast Support and Default Setting
20.01.00	Safety I/O unicast support added Unicast default
19.01.00	Safety produce/consume unicast support added Unicast default
18.02.00	Standard I/O unicast support added Multicast default
16.03.00	Standard produce/consume unicast support added Multicast default

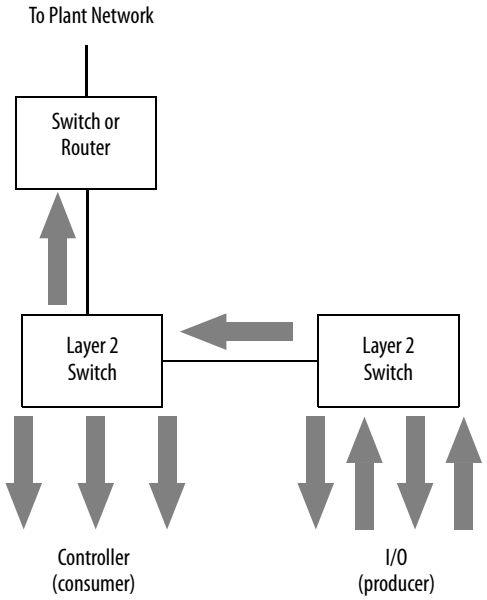
For a compatibility chart of products see Knowledgebase answer ID 66324 at http://www.rockwellautomation.com/knowledgebase/.

Frames

Use multicast frames in these situations:

- Redundancy applications
- Communication with more than one destination

  Multicast is more efficient than sending multiple, unicast streams to multiple nodes.
- Video streaming



You must use unicast communication if the transmission routes through a Layer 3 device.

I/O devices generally produce at very fast rates, such as 10 ms, so it is easy to flood the network with multicast traffic and force each end device to spend time deciding whether to discard numerous multicast frames. If there are a lot of I/O devices, they can easily use up a significant part of a router's CPU time.

You must consider control network traffic propagating onto the plant information network, as well as, plant information network traffic propagating onto the control network. Some best practices include the following:

- Minimize device load due to unwanted IP multicast traffic
- Minimize switch load due to unwanted IP multicast traffic
- Minimize network load due to unwanted incoming IP multicast or broadcast traffic
- Block IP multicast traffic generated within the EtherNet/IP subnet from propagating onto the plant network
- Implement standard network troubleshooting tools

For more information, see Virtual LANs and Segmentation on page 42 and Internet Group Management Protocol (IGMP) on page 55.

Multicast Address Limit

In multicast communication, EtherNet/IP interfaces support a maximum of 32 devices that transmit multicast.

EXAMPLE	An Ethernet adapter that produces data uses a unique multicast address for each I/O connection.

EXAMPLE	A Logix controller that produces tags uses a unique multicast address for each produced tag.

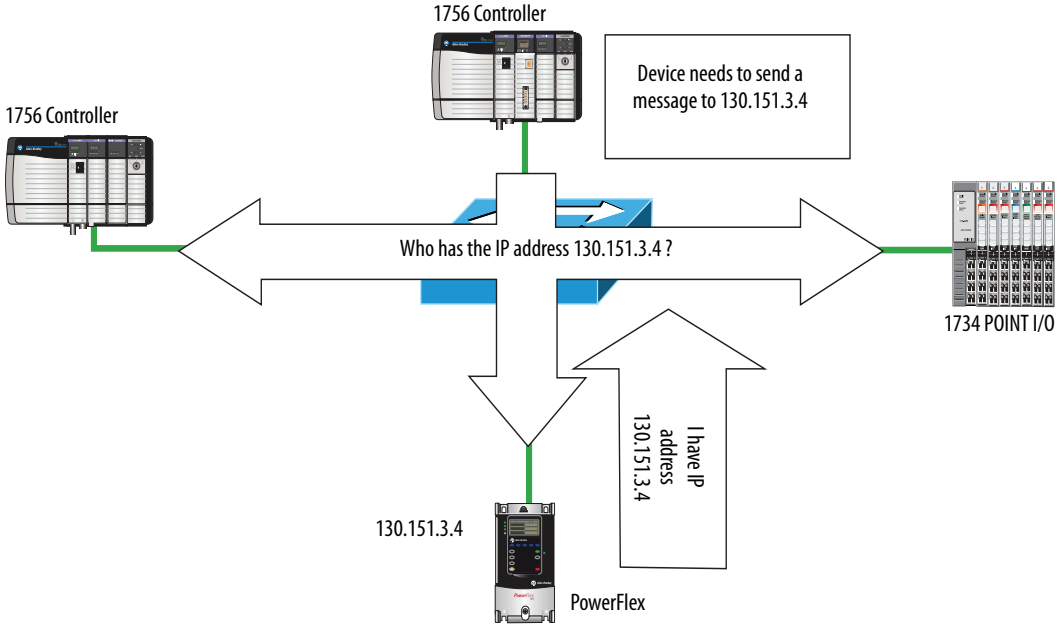
The multicast address limit is independent of the connection limit for a device. Not all connections require a multicast address. In the case of produced and consumed tags, one produced tag requires one multicast address, but it also requires one connection for each consumer. If there are multiple consumers, the one multicast address must use multiple connections.

Transmission Protocols

The network layer (Layer 3) provides switching and routing that create logical paths, known as virtual circuits, for transmitting data from node to node. Routing and forwarding are functions of this layer, as well as addressing and internetworking.

Address Resolution Protocol (ARP)

An ARP request is a broadcast message that asks 'who has this IP address?'. The device that has that IP address responds and the requestor adds the IP address and hardware address pair to its ARP cache. The original device can now send the message. This protocol enables the network to learn and adapt to changes.



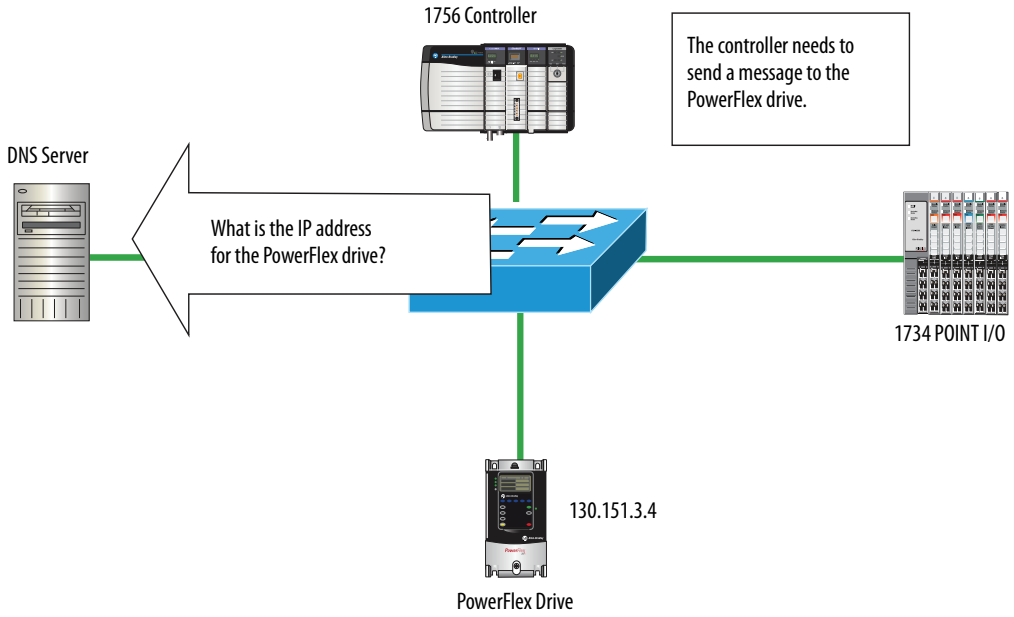
If you replace a Rockwell Automation EtherNet/IP communication module with a new module, the new module has a different MAC ID. The ARP cache entries in other devices are now invalid because the MAC ID corresponding to the module's IP address has changed. This can cause a delay in reestablishing communication with the replacement module. The delay varies depending on the module and the network configuration in use.

When a Rockwell Automation EtherNet/IP device starts up, it issues a gratuitous ARP that causes other devices to update their ARP caches. This generally results in a quick recovery of communication with the replacement module (less than a minute). However, some switches do not forward the gratuitous ARP message onto the network, such as if the Spanning Tree Protocol is enabled on that port.

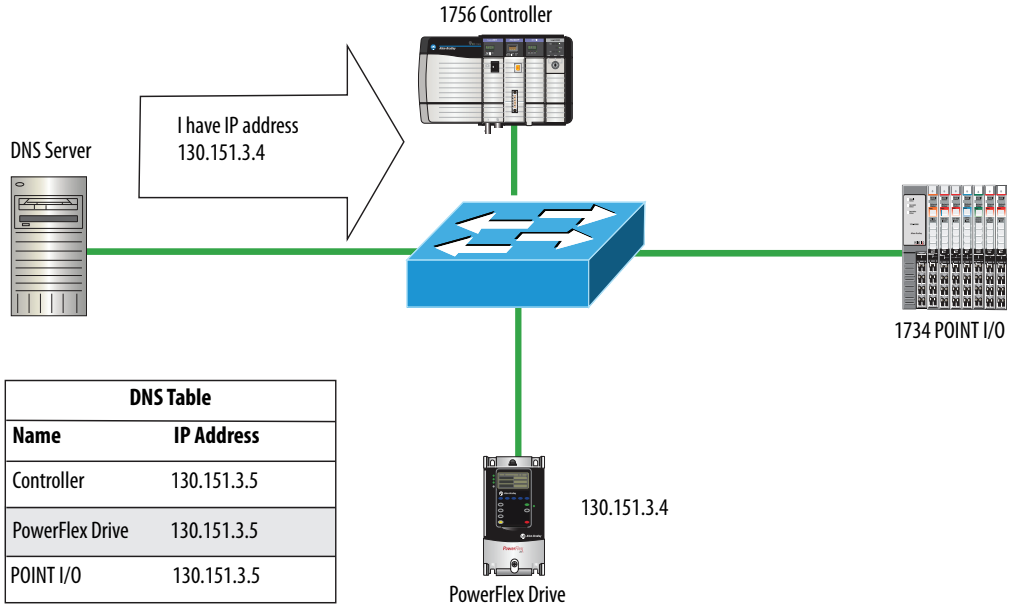
We recommend that you disable the Spanning Tree Protocol on ports to which EtherNet/IP communication modules are directly connected, but not on ports that are linked to other switches. In the worst case, if the gratuitous ARP is not seen, an originating device can wait as long as 10 minutes for the ARP cache entry to age out and be deleted.

Domain Name System (DNS)

DNS is a name resolution protocol that enables you to identify devices by names rather than IP addresses. For DNS to work, a DNS server is configured to hold a table of names and the associated IP addresses. When a device attempts to send a message to a device with an unknown name, it requests the IP address of the named device from the DNS server.



The DNS server refers to its table and sends back an IP address for the requested name. Once the client device receives the IP address for a name, it stores it in its own table so it does not have to ask for the IP address every time. The device still sends an ARP request if it needs to decode the IP address into a hardware address.



DNS Table	
Name	**IP Address**
Controller	130.151.3.5
PowerFlex Drive	130.151.3.5
POINT I/O	130.151.3.5

Network Address Translation

Network address translation (NAT) enables a single device to act as an agent between the public network (commonly the plant network) and the private network (machine network). This facilitates communication between a group of computers with preset IP addresses on a private network by mapping each preset IP address to a valid IP address on the public network.

These are two types of NAT implementations:

- One-to-many—Multiple nodes are mapped to a single public identity to get onto the Internet, such as in a home network. This type of implementation conserves public IP addresses and offers some protection against attacks from the Internet.
- One-to-one—Each node on the network translates to another identity on another network. This type of implementation is used in manufacturing to integrate machinery onto a larger network without requiring addressing changes at the machine level.

Allen-Bradley Products That Support NAT

The table summarizes features of the two products that support one-to-one NAT.

Feature	9300-ENA Device	Stratix 5700 Switch
NAT architecture	Standalone device	Integrated into switch hardware
Performance	500 messages/s	Wire-speed translations
Number of translations, max	128	128 devices or subnets(1)
Supported network topologies	Star	• Star • Redundant star • Ring
Configuration	Web interface	• Device Manager Web interface • Studio 5000 environment • Command-line interface (CLI)

(1) One subnet translation can include translations for 16…65,000 devices.

Supported NAT Topologies

Figure 3 - Switch-level Ring (REP) with Stratix 5700 Switch

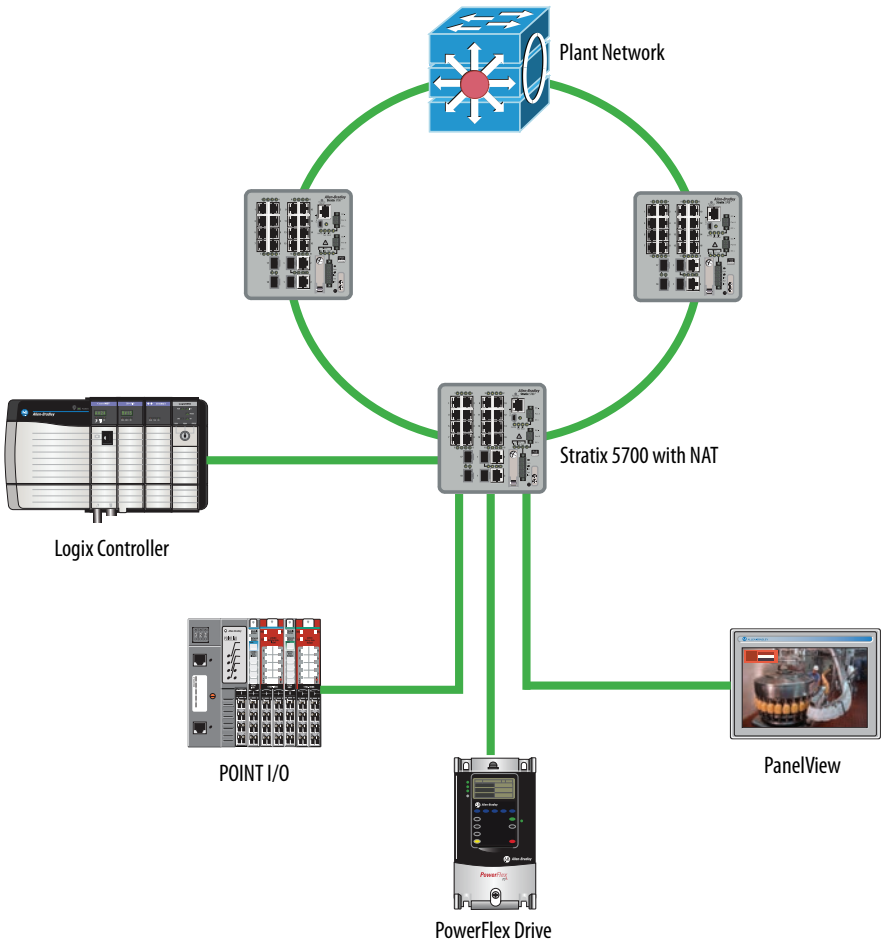


Figure 4 - Star with 9300-ENA Device

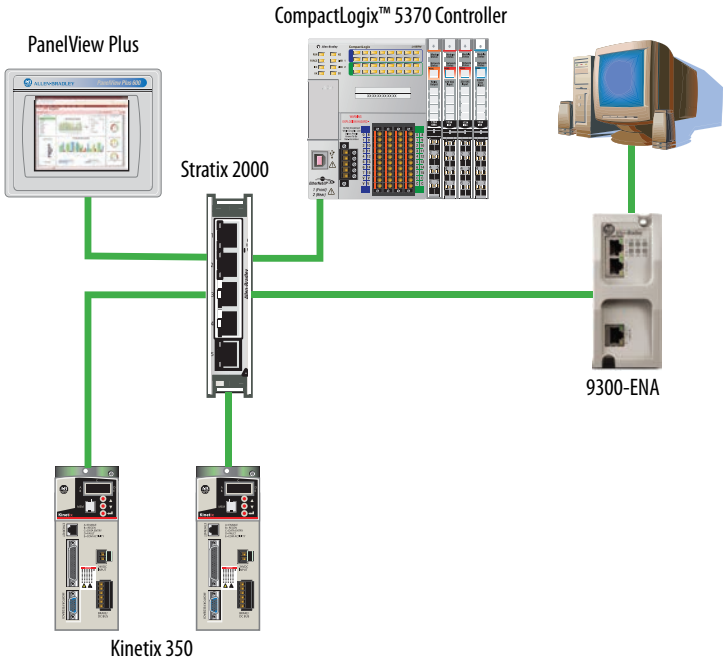


Figure 5 - Star with Stratix 5700 Switch

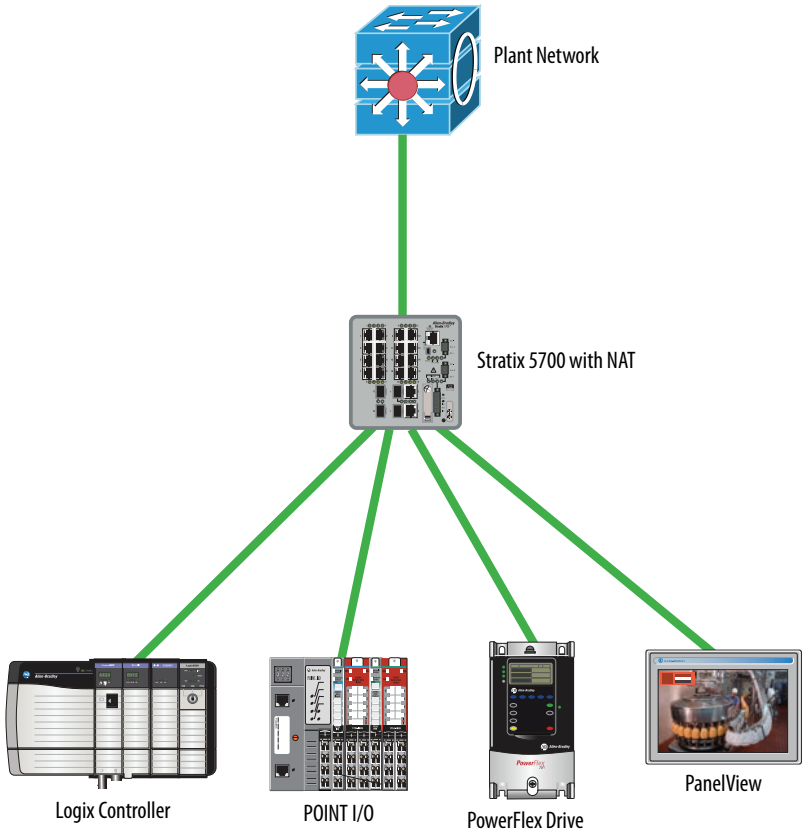


Figure 6 - Redundant Star with Stratix 5700 Switch

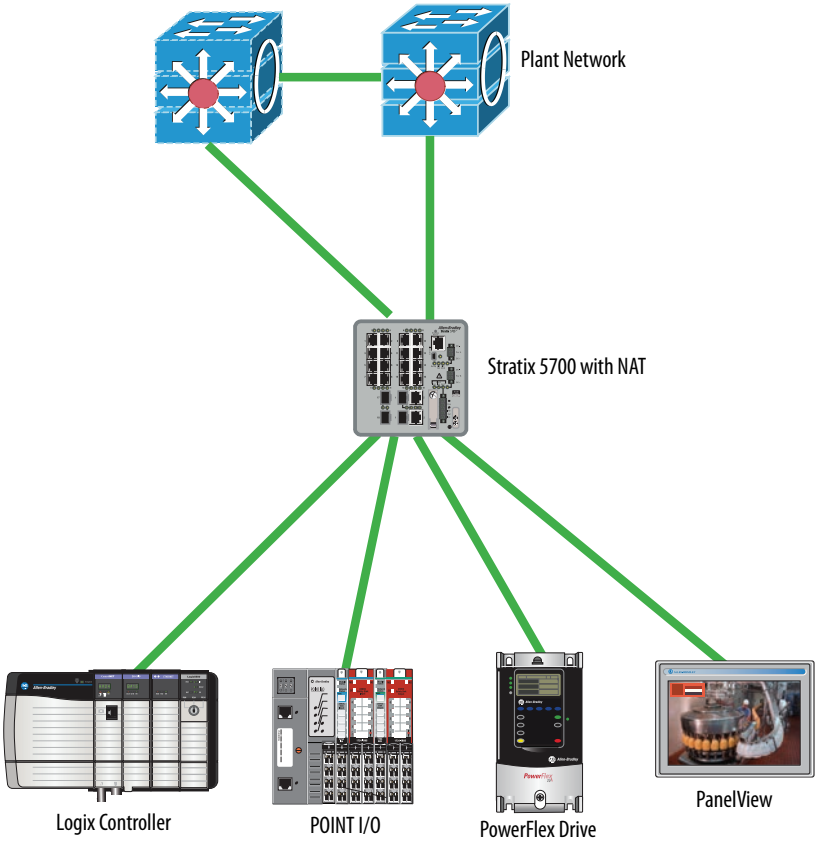
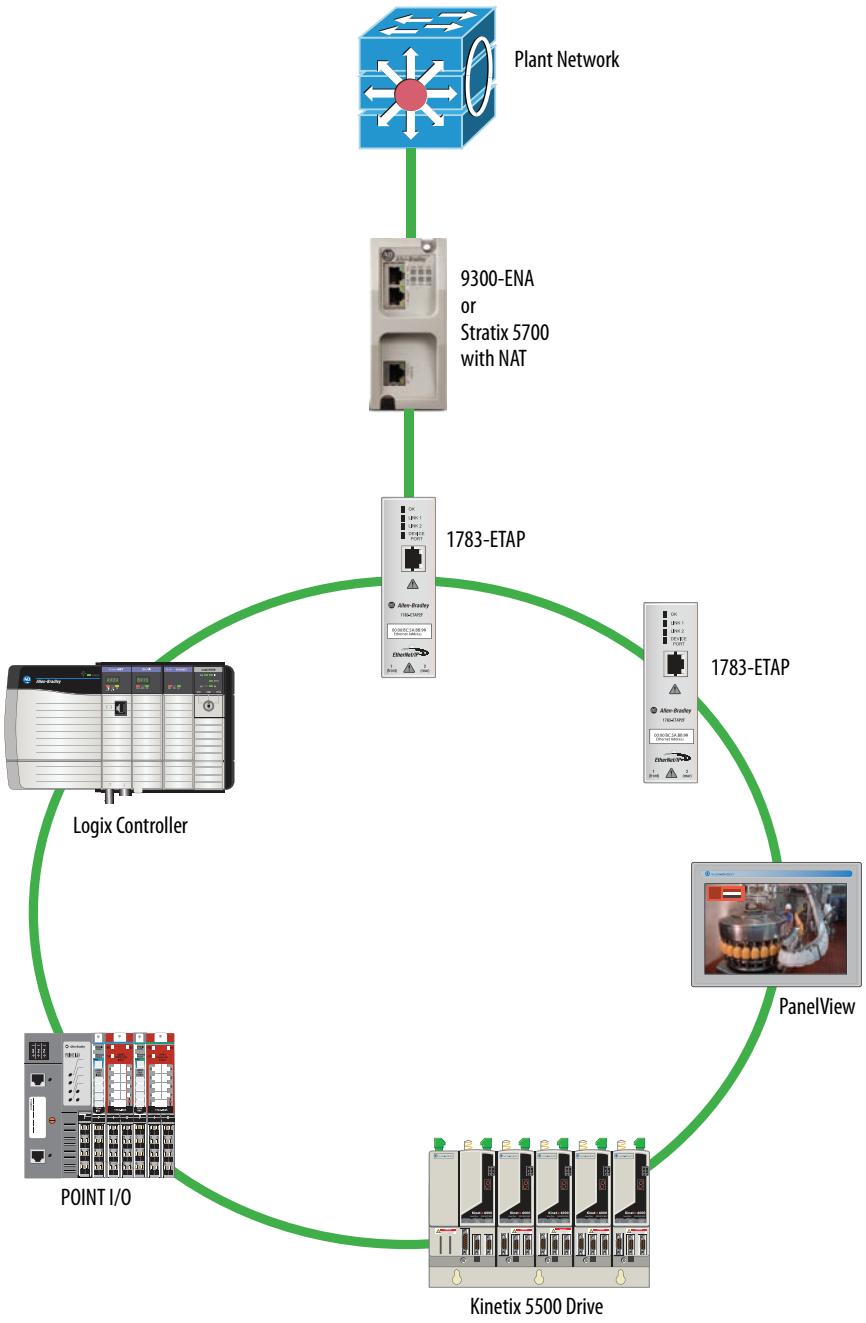


Figure 7 - Star with Device-level Ring



Virtual LANs and Segmentation

A virtual LAN (VLAN) is a switched network segmented on a functional application or organizational basis rather than a physical or geographical basis. Switches filter destination MAC addresses and forward VLAN frames to ports that serve the VLAN only to which the traffic belongs. A VLAN consists of several end systems. These systems are either hosts or network equipment, such as switches and routers, that are members of a single logical broadcast domain. A VLAN does not have physical proximity constraints for the broadcast domain.

With VLANs, you can configure a switch to share two isolated networks without the traffic from one network burdening the other. IP multicast traffic from VLAN 1 does not reach VLAN 2. A VLAN blocks broadcast traffic and adds a measure of security between networks.

A VLAN also gives you the ability to control access and security to a group of devices independent of their physical location.

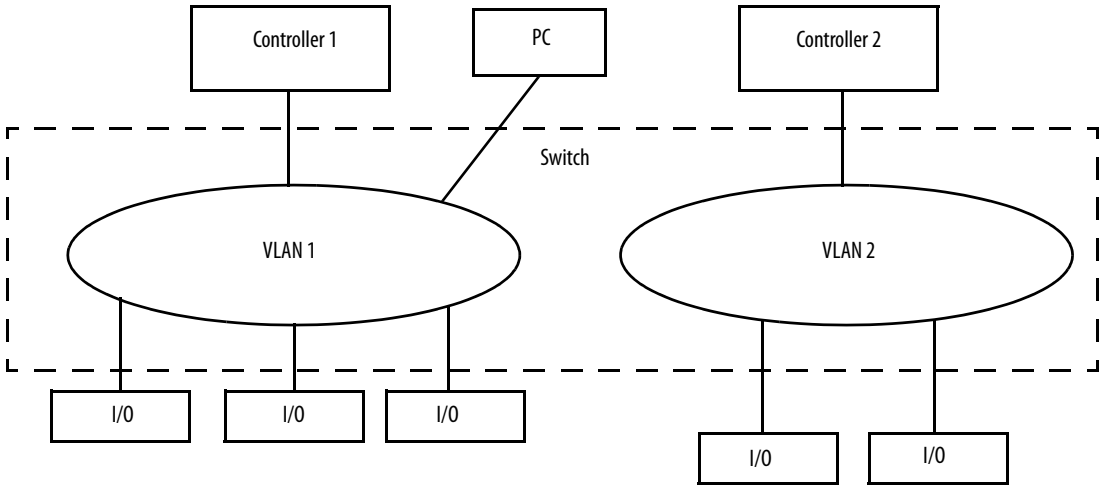
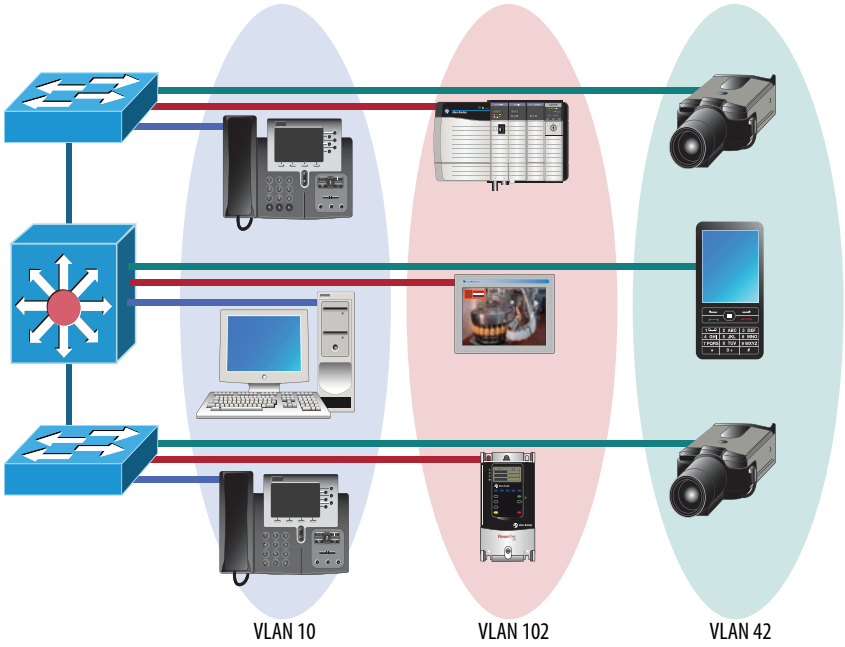


Table 6 - VLAN Features

Feature	Description
Broadcast control	Just as switches isolate collision domains for attached hosts and forward appropriate traffic out a particular port, VLANs refine this concept and provide complete isolation between VLANs. A VLAN is a bridging domain, and all broadcast and multicast traffic is contained within it.
Security	High-security users can be grouped into a VLAN, possibly on the same physical segment, and no users outside of that VLAN can communicate with them. VLANs can also assist in securing plant-floor systems by limiting access of production floor personnel, such as a vendor or contractor, to certain functional areas of the production floor.
Performance	The logical grouping of devices prevents traffic on one VLAN from burdening other network resources. Performance within the VLAN is also improved because the VLAN acts as a dedicated LAN.
Network management	You can logically move a device from one VLAN to another by configuring a port into a VLAN. The device does not have to be physically disconnected from one network and reconnected to another, which can result in expensive, time-consuming recabling.

Segmentation is the process of outlining which endpoints need to be in the same LAN. Segmentation is a key consideration for a cell or area network. Segmentation is important to help manage the real-time communication properties of the network, and yet support the requirements as defined by the network traffic flows. Security is also an important consideration in making segmentation decisions.

A security policy can call for limiting access of factory floor personnel, such as a vendor or contractor, to certain areas of the production floor, such as a functional area. Segmenting these areas into distinct VLANs greatly assists in the application of these types of security considerations.



All level 0...2 devices that need to communicate multicast I/O between each other must be in the same LAN. The smaller the VLAN, the easier it is to manage and maintain real-time communication. Real-time communication is harder to maintain as the number of switches, devices, and the amount of network traffic increase in a LAN.

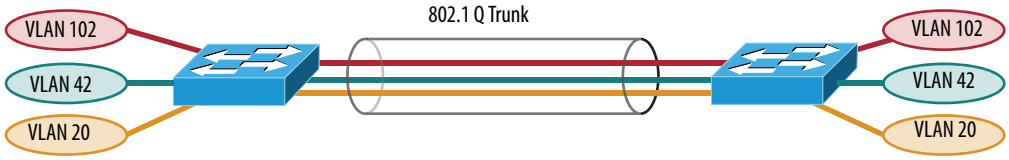
Typically control networks are segmented from business networks. You can also segment networks based on function, logical layout, and traffic types. Choose from the following options to segment control.

Table 7 - Segment Control Options

Segmentation Option	Description
Physical isolation	• Physically isolate networks • Each network is a separate subnet creating clusters of control • No IT involvement
ControlLogix® gateway	• A separate ControlLogix EtherNet/IP bridge module is dedicated to each subnet • The chassis backplane provides isolation of Ethernet traffic • Only CIP traffic can be shared between subnets • No IT involvement
VLANs	• Ports on a managed switch are assigned to a specific VLAN • Data is forwarded to ports within only the same VLAN • Can require IT involvement

VLAN Trunking

Trunking enables a VLAN to span multiple switches.



VLANs and Segmentation Guidelines

Configure separate VLANs for different work cells or areas of your plant. Configure one VLAN for all data traffic relevant to one particular area or cell zone. Because 80...90% of traffic is local to one cell, this is the optimal design. All devices with multicast connections must be on the same VLAN. Within a VLAN, multicast and unicast traffic can be mixed depending on application requirements. The default communication type of unicast must be used for point-to-point communication to minimize device, network, and infrastructure loading:

- Design small cell or area zones, each with a dedicated VLAN and IP subnet.
- Restrict data flow out of the cell or area zone unless plantwide operations explicitly require it.
- Segment traffic types into VLANs and IP subnets to better manage the traffic and simplify security management.
- Within the cell or area zone, use Layer 2 VLAN trunking between switches with similar traffic types. When trunking, use 802.1Q, VTP in transparent mode.
- Use Layer 3 distribution switches to route information between cell or area Zone VLANs and plantwide operations in the Industrial Zone.
- Enable IP directed broadcast on cell or area zone VLANs with EtherNet/IP traffic for easy configuration and maintenance from control systems, such as RSLinx® software.
- Avoid large Layer 2 networks to simplify network management.
- Select switches based on the VLAN features you need:
  - Stratix 6000 switches support VLANs.
  - Stratix 8000 and Stratix 8300 switches support VLANs and VLAN trunking, as well as Layer 3 switching (enables routing across VLANs and subnets).

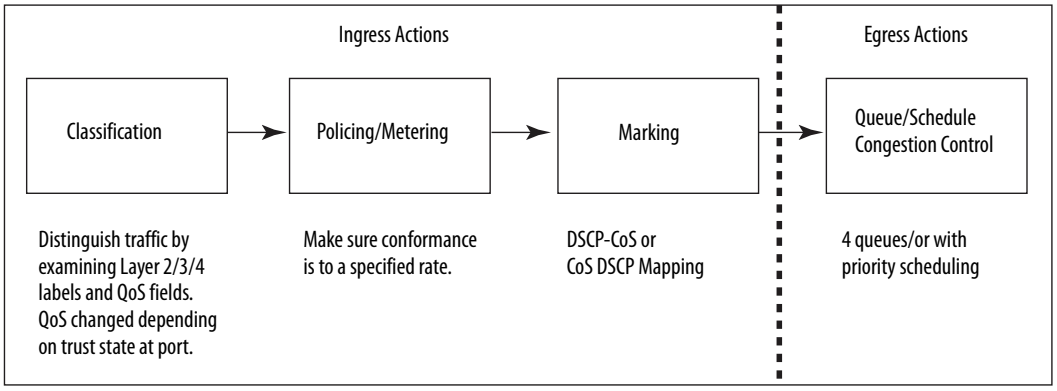
Quality of Service (QoS)

Quality of service determines how packets are marked, classified, and treated based on traffic type. Rockwell Automation EtherNet/IP devices prioritize traffic internally. Implementing QoS at the switch level adds another level of prioritization. QoS does not increase bandwidth—QoS gives preferential treatment to some network traffic at the expense of others.

Not all network traffic can be treated equally. To minimize application latency and jitter, control data must have priority within the cell or area zone. QoS gives preferential treatment to some network traffic at the expense of others. Control data is more sensitive to latency and jitter than information data.

To explain how QoS works, think about the last time you boarded a plane at the airport. As boarding time gets close, everyone starts to crowd around the gate. It is impossible for everyone to go down the jetway to the plane at once, so the airline establishes a boarding procedure to avoid chaos. This can be compared to the use of QoS on an Ethernet network. The network can have motion traffic, voice traffic, and email traffic all being transmitted at the same time over the network.

In the airline example, first class passengers board first, followed by families with small children, followed by frequent flyers, and followed by the coach cabin starting at the back of the plane. Similarly, QoS lets you set up priority queues in the managed switches on the network. In the automation example, equate motion traffic to the first class passengers and give it the highest priority for network usage. Voice traffic can go second (it also has low tolerance for delay), and email traffic has the lowest priority queue. This results in the least amount of delay possible on the motion control.



QoS Guidelines

Follow these guidelines with QoS:

- Manage the output queues based on application needs. Schedule precision and motion control packets in the highest priority queue.
- QoS gives preferential treatment to Industrial Automation and Control System Network traffic at the expense of other network traffic.
- QoS is integrated into the Stratix 8000 and Stratix 8300 switch configurations.
- Deploy QoS consistently throughout Industrial Automation and Control System Network.

Resiliency

A resiliency protocol maintains parallel links for redundancy while avoiding loops. Network convergence time is a measure of how long it takes to detect a fault, find an alternate path, and recover from the fault:

- During the network convergence time, some portion of the traffic is dropped by the network because interconnectivity does not exist.
- Communication drops if the convergence time is longer than the Logix connection timeout.

Time Calculations in a Logix5000 System

Network convergence must occur before the control system is impacted:

- Logix message instruction (MSG) time out (explicit, CIP Class 3)
- I/O connection timeout (implicit, CIP Class 1), 4 x RPI, 100 ms minimum
- Logix Producer/Consumer connection timeout (implicit, CIP Class 1), 4 x RPI, 100 ms minimum
- Safety I/O connection timeout (implicit, CIP Class 1), 4 x RPI (default)

Resiliency Protocols

- Spanning Tree Protocol (STP), Rapid STP (RSTP), Multiple Instance STP (MSTP)
  - Stratix 8000 and Stratix 8300–MSTP default
  - Rapid Per VLAN Spanning Tree Plus (rPVST+); Cisco Technology
- Resilient Ethernet Protocol (REP); Cisco Technology
- EtherChannel Link Aggregation Control Protocol (LACP); IEEE
- Flex Links; Cisco Technology
- Device-level ring; topology option

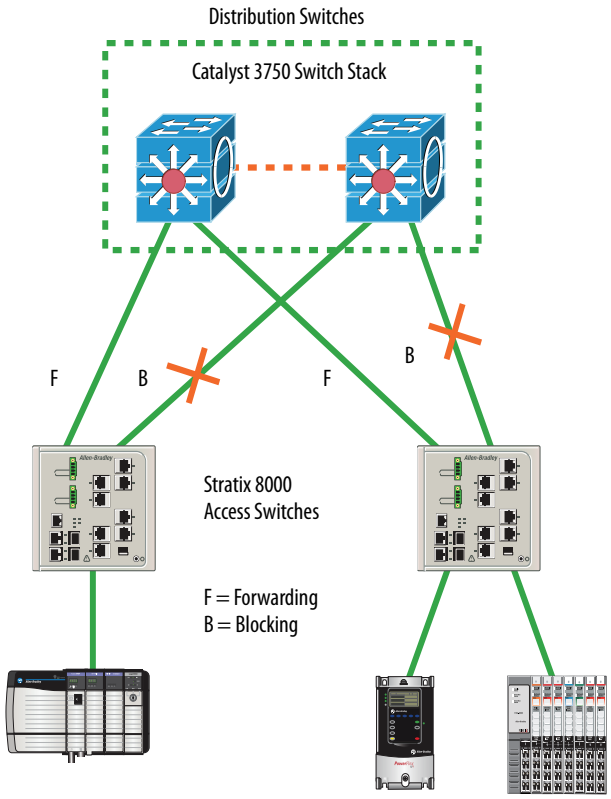
Resiliency Protocol	Mixed Vendor	Ring	Redundant Star	Network Convergence > 250 ms	Network Convergence > 70 ms	Network Convergence > 1 ms
STP	X	X	X			
RSTP	X	X	X			
MSTP	X	X	X	X		
PVST+		X	X	X		
REP		X			X	
EtherChannel	X		X		X	
Flex Links	X		X		X	
DLR	X	X				X

Spanning Tree Protocol (STP) and Rapid STP (RSTP)

Spanning Tree Protocol (STP) prevents loops on the network that occur when there is more than one open path active at once on the network. The convergence rate can take up to 50 seconds.

Rapid Spanning Tree Protocol (RSTP) is designed for faster network convergence and eliminates the forwarding delay on point-to-point links by using explicit handshaking protocol. The convergence rate is significantly faster than STP:

- Only standard protocol for network resiliency—IEEE 802.1D
- Built into Stratix 8000 and Stratix 8300 switches
- Requires redundant star or ring topology
- Provides alternate path in case of failures, avoiding loops
- Unmanaged switches do not support STP or RSTP, or any other resiliency protocol



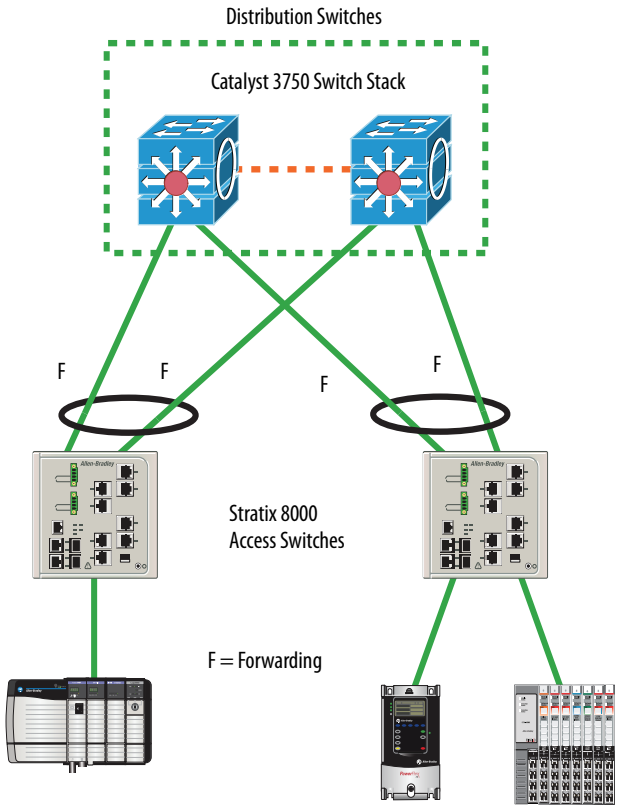
EtherChannel Protocol

The EtherChannel protocol combines multiple physical switch ports into one logical connection to increase bandwidth through load balancing, as well as physical connection redundancy.

This protocol groups several physical Ethernet links to create one logical Ethernet link for the purpose of providing fault-tolerance and high-speed links between switches, routers, and servers. An EtherChannel can combine 2...8 active Fast Ethernet or Gigabit Ethernet ports:

- Link Aggregation Control Protocol (LACP) port aggregation—IEEE 802.3ad
- Built into Stratix 8000 and Stratix 8300 switches
- Requires a redundant star topology
- Provides resiliency between connected switches if a connection is broken

Fault-tolerance is a key aspect of EtherChannel. If a link fails, the EtherChannel technology automatically redistributes traffic across the remaining links. This automatic recovery takes less than one second and is transparent to network applications and the end user. This makes it very resilient.

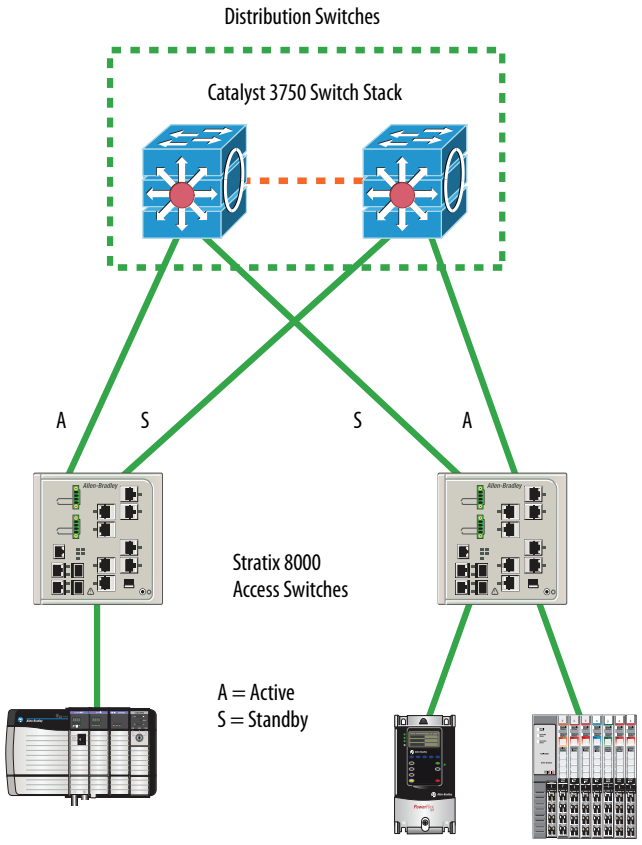


STP can be used with an EtherChannel. STP treats all the links as a single connection. Without the use of an EtherChannel, STP shuts down any redundant links between switches until one connection goes down. This is where an EtherChannel is most desirable because it enables full use of all available links between two devices.

Flex Links Protocol

The Flex Links protocol provides link-level, physical redundancy in redundant star topologies. A pair of Layer 2 switch ports are configured to act as a backup to each other:

- Built into Stratix 8000 and Stratix 8300 switches
- Requires redundant star topology
- Active/standby port scheme
  - Provides an alternate path in case of failures, avoiding loops
  - No bandwidth aggregation
  - Equal speed ports recommended
  - Provides fast fail over for multicast traffic



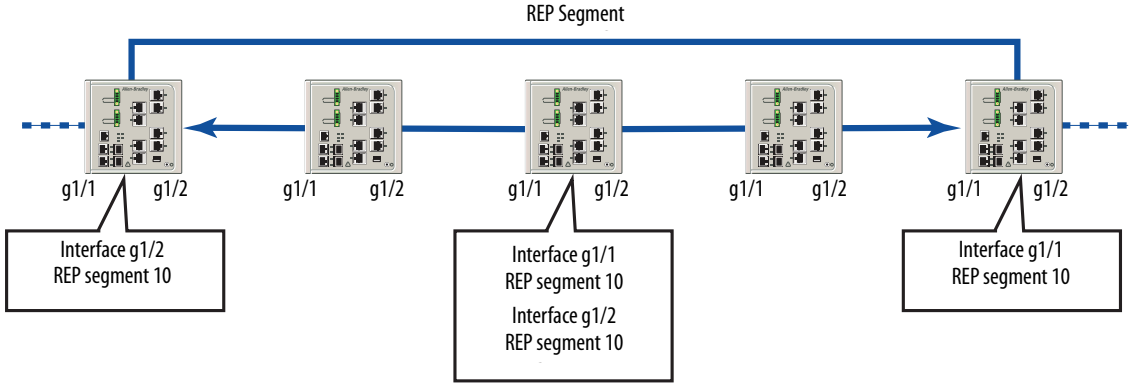
Resilient Ethernet Protocol (REP)

REP operates on chain of bridges called segments. A port is assigned to a unique segment. A segment can have up to two ports on a given bridge. REP is built in to Stratix 8000 and Stratix 8300 switches.

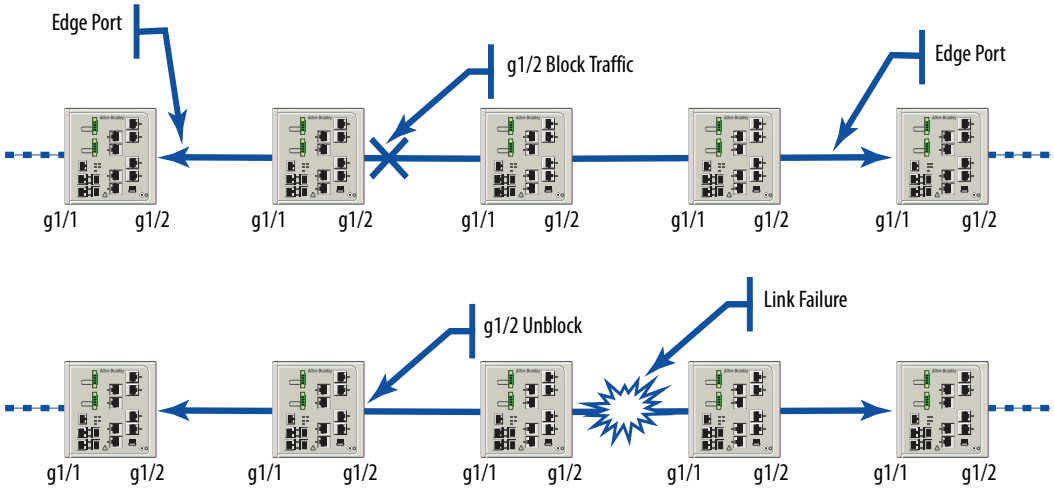
REP supports closed and open rings in various topologies:

- Redundant networks can be built with REP segments
- Only ring resiliency protocol applicable to both Industrial and IT applications
- Ring recovery time is less than 70 ms for both unicast and multicast traffic in fiber implementations

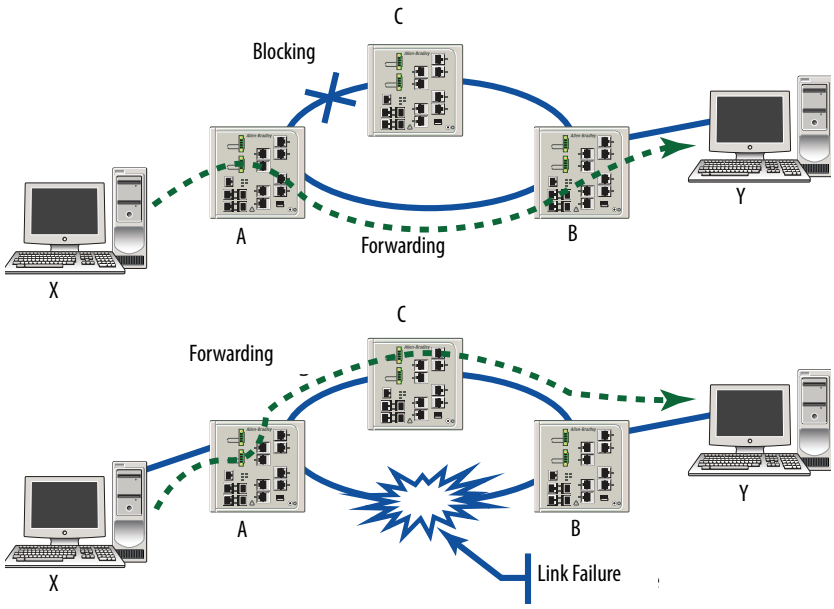
REP is a segment concept. A segment is a chain of bridges.



When all links are operational, a unique port blocks the traffic on the segment. If any failure occurs within the segment, the blocked port goes forwarding.



Segments can be wrapped into a ring. Identification of edge ports requires additional configuration.

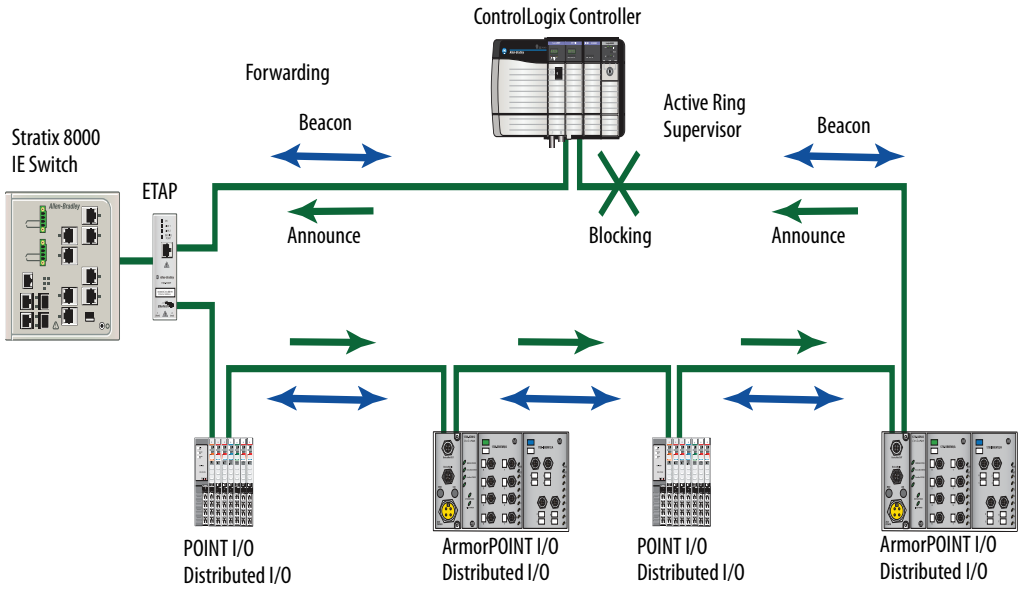


Device-level Ring (DLR)

The DLR protocol is a layer 2 protocol that provides link-level, physical redundancy that provides network convergence in the 1...3 ms range for simple automation device networks. The other resiliency protocols apply to only infrastructure (switches and routers). DLR provides resiliency directly to an end device directly (such as an I/O module, drive, or controller).

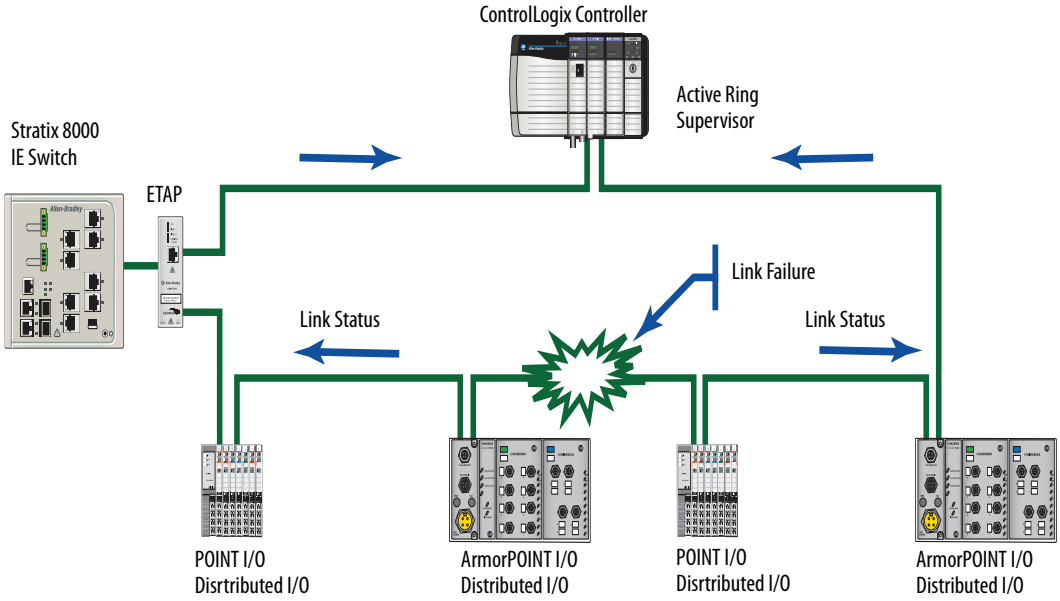
Some control applications, such as safety and motion require network convergence times faster than what switch-oriented resiliency protocols can provide. Most control applications suffer connection timeouts with switch-oriented resiliency protocols.

A DLR network is a single-fault tolerant network. Network traffic is managed to make sure critical data is delivered in a timely manner.



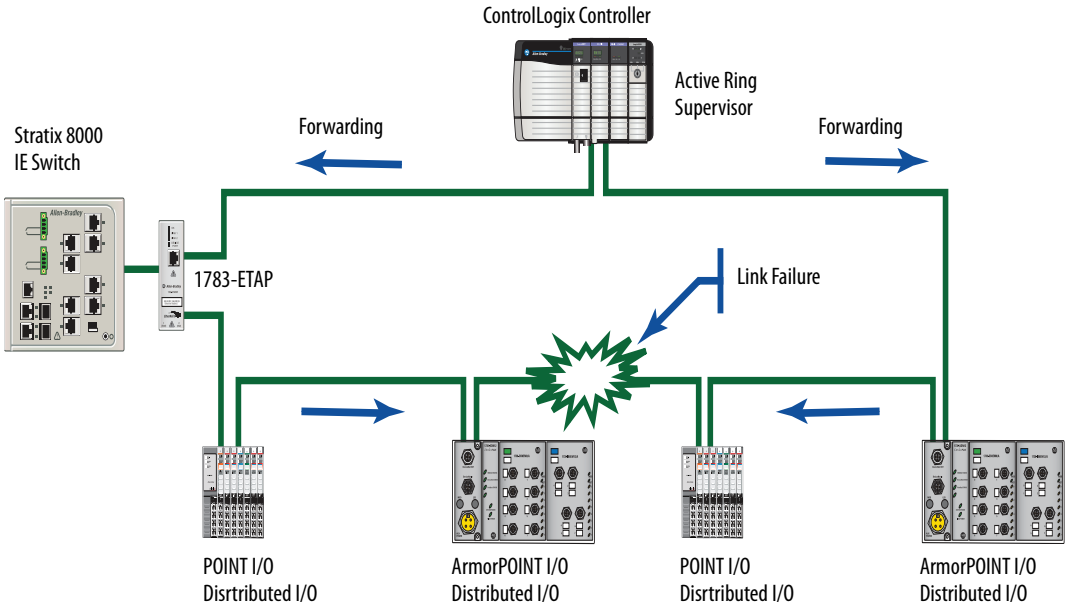
Physical layer failure includes the following:

- All faults that are detectable at physical layer
- Physical layer failure detected by protocol-aware node
- Status message sent by ring node and received by ring supervisor

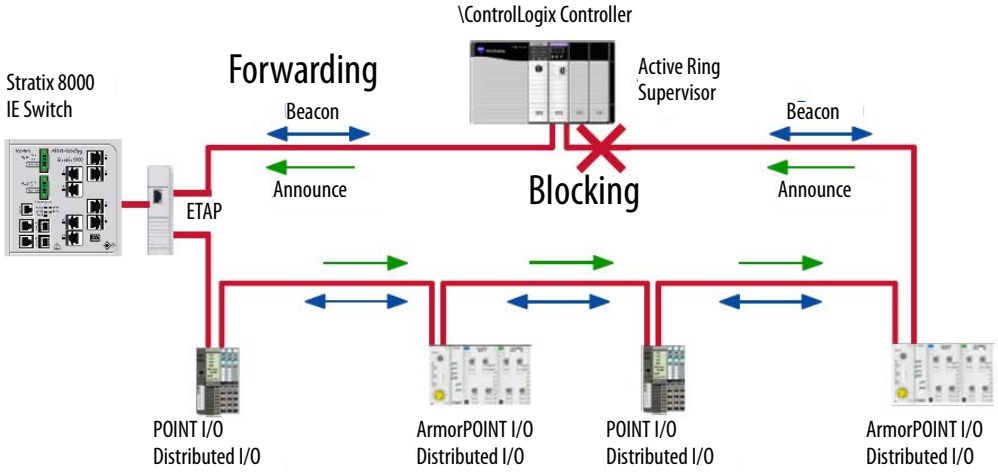


Network convergence includes the following:

- After failure detection, ring supervisor unblocks blocked port
- Network configuration is now a linear topology
- Fault location is readily available via diagnostics



Once ring is restored, the supervisor hears the beacon on both ports and transitions to normal ring mode by blocking one port.



Internet Group Management Protocol (IGMP)

The IGMP is a communication protocol used to manage the membership of IP multicast groups. Much of EtherNet/IP implicit (I/O) messaging uses IP multicast to distribute I/O control data, which is consistent with the CIP produced/consumer model. Without IGMP, switches treat multicast packets the same as broadcast packets. Multicast packets are re-transmitted to all ports.

The behavior of an unmanaged switch is to flood multicast packets to all ports within the same VLAN. This behavior is not typically desirable. To resolve this the following occurs:

- Querier functionality manages a table that lists the devices that are participating in multicast groups.
- Snooping functionality inspects packets from devices and forwards multicast data to devices that only request the data.

IGMP snooping constrains the flooding of multicast traffic by dynamically configuring switch ports so that multicast traffic is forwarded to ports associated with only a particular IP multicast group.

If you have a router (Layer 3 device) on the network, make it the querier. IGMP protocol has versions 1, 2, and 3. Rockwell Automation products support versions 1 or 2. IGMP protocol version 2 negotiates the active querier automatically and that task is assigned to the IGMP capable device with the lowest IP address on a given VLAN. Therefore, assign the first available IP address on a given VLAN to the router (Layer 3 device).

If you do not have a router, the querier function must be placed on a centrally located IGMP capable device on the network by configuring it to the first available IP address on a given VLAN.

Port Security

The switch has dynamic and static methods for limiting the MAC addresses (MAC IDs) that can access a given port.

Dynamic Secure MAC Address (MAC ID)

With Stratix 8000 and Stratix 8300 switches, the Smartport roles have a maximum number of MAC IDs that can use that port. For example, the Smartport role 'Automation Device' sets up the port for a maximum of one MAC ID. The MAC ID is dynamic, meaning the switch learns the first source MAC ID to use the port. Attempts by any other MAC ID to access the port is denied. If the link becomes inactive, the switch dynamically relearns the MAC ID to be secured.

Smartport Role	Number of MAC IDs, max
Automation Device	1
Automation Device with QoS	1
Desktop for Automation	1
Switch for Automation	Not restricted
Router	Not restricted
I/P Phone + Desktop	3
Access Point	Not restricted
Port Mirroring	Not restricted
None	Not restricted

Static Secure MAC Address (MAC ID)

With Stratix 6000, Stratix 8000, and Stratix 8300 switches, the other method of limiting MAC IDs is to statically configure a single MAC ID for a port. MAC IDs that communicate on a given switch port become part of the saved configuration of the switch. This method provides strong security but requires reconfiguration whenever the device connected to the port is replaced, because the new device has a different MAC ID from the old device.

When you use the Studio 5000 environment to configure a Stratix 8000 and Stratix 8300 switches, you can use the static secure method. However, this method is not available with the Device Manager Web interface. For a Stratix 6000 switch the port security options are configured via the web browser or Logix5000 controller.

Security Violations

In the event of a security violation with a Stratix 8000 or Stratix 8300 switch, one of these situations occurs:

- The maximum number of secure MAC addresses that have been configured for a port have been added to the address table, and a station whose MAC address is not in the address table attempts to access the interface.

- An address learned or configured on one secure interface is seen on another secure interface in the same VLAN. When a violation occurs, the port goes into the Restrict mode. In this mode, packets with unknown source addresses are dropped and you are notified that a security violation has occurred. An SNMP trap is sent, a syslog message is logged, and the violation counter increments.

In the event of a security violation with a Stratix 6000 switch, the switch notifies the controller of the event (via an input bit) and the controller program decides how to proceed (such as shut that switch port down, send an alarm to the HMI, or shut the machine down). The switch does not make a decision on how to handle the security violation.

Device Commissioning

There are multiple methods for assigning IP addresses. Switches on the product, such as thumbwheels, push buttons, or HIM modules, provide a static address that survives power cycles.

Stratix switches support DHCP port allocation. DHCP port allocation is a hybrid solution for IP addressing because it provides easy device replacement, but is topology dependant.

Option	Description
Static	Devices are hard-coded with an IP address. **Advantage** Simple to commission and replace **Disadvantage** In large environments, can be burdensome to maintain
Static via BOOTP configuration	A server assigns devices an IP address. Precursor to DHCP **Advantage** Supported by every device **Disadvantages** • Requires technician to configure IP address/MAC address when a device is replaced • Requires a PC for commissioning and replacement (unless there are switches to set the address offline) • Adds complexity and point of failure
DHCP	A server assigns IP addresses from a pool (not recommended). **Advantages** • Efficient use of IP address range • Can reduce administration work load **Disadvantages** • More complex to implement and adds a point of failure • Devices get different IP addresses when they reboot
DHCP option 82	A server assigns consistent IP addresses from a pool (not recommended). **Advantages** • Efficient use of IP address range • Can reduce administration work load **Disadvantages** • More complex to implement and adds a point of failure • Mixed environments do not always work
DHCP port-based allocation	IP addresses are automatically assigned per physical switch port. **Advantages** • Efficient use of IP address range • Eases maintenance and replacement in large environments **Disadvantage** Requires some maintenance and upkeep on a per switch basis

EtherNet/IP Protocol

The EtherNet/IP protocol is standard Ethernet and standard IP technologies with standard CIP technology at the application layer.

Connections

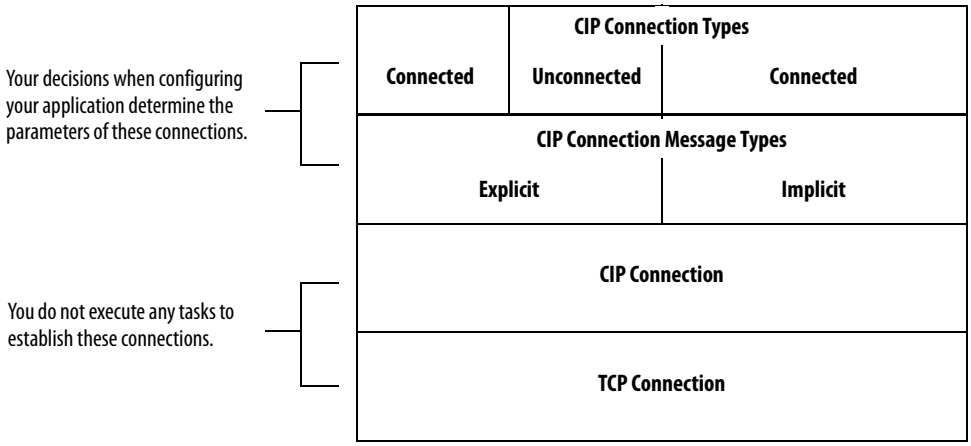
EtherNet/IP communication modules must consider connections and EtherNet nodes to communicate on the EtherNet/IP network. The number of supported nodes applies only to CompactLogix 5370 controllers. See page 65.

A connection is a point-to-point communication mechanism used to transfer data between a transmitter and a receiver. Connections can be logical or physical.

Two connection types--TCP connections and CIP connections--are layered over each other each time data is transferred. The TCP connection is the first connection established. It is used for all EtherNet/IP communication and is required for all CIP connection use. A single TCP connection supports multiple CIP connections and remains open.

Established over TCP connections, EtherNet/IP CIP connections transfer data from an application running on one end-node (transmitter) to an application running on another end-node (receiver). CIP connections are configured to use explicit or implicit message types. The message types support connected and unconnected connection types. Typically, connected CIP messages are used to transfer data. Unconnected CIP messages are used, but they are only temporary.

This graphic shows how connections are layered on each other when data is transferred over the EtherNet/IP network.



Remember these points when configuring your EtherNet/IP network application:

- All of the connections are used each time data is transferred on the EtherNet/IP network.
- You specify CIP connection message types and CIP connection types when configuring your application.

  For example, when a Logix5000 controller sends a MSG instruction to another Logix5000 controller, the transmitter sends the instruction to the receiver over a connection. That connection includes the following:
  - A TCP connection is established.
  - A CIP connection is layered on the TCP connection.
  - An explicit or implicit CIP connection message is delivered via the CIP connection.
  - If an explicit message type is used, it can be connected or unconnected. If an implicit message type is used, it is connected.
- Each EtherNet/IP communication module has TCP and CIP connection limits that you must account for when configuring your application. For more information on connection limits, see Table 12 on page 66.
- Refer to Nodes on an EtherNet/IP Network on page 65 for node count limitations for CompactLogix 5370 controllers.

These example applications describe how connections are used.

EXAMPLE **I/O Connections**

A Logix5000 controller has five CIP I/O connections to modules in a remote chassis and all of these connections are through the same local 1756-EN2T module and the same remote 1756-EN2T module.

The following connections exist:

- One TCP connection
- Five CIP connections

EXAMPLE **RSLinx OPC Test Client**

The following connections exist:

- One TCP connection
- Four CIP connections (four is the default)

Terminology

The terms in this table help you understand connections.

Table 8 - EtherNet/IP Connection Terminology

Term	Definition
Producer and consumer	Producer/consumer refers to implicit connections. With implicit connections, messages are sent cyclically (every RPI). **EXAMPLE:** Assume a ControlLogix controller is controlling a single rack of FLEX I/O with a rack connection. Both the ENBT module that is local to the controller and the FLEX AENT module are consumers and producers of data. The AENT consumes outputs and produces inputs.
Client and server	Client/server refers to explicit connections. A client creates a connection and initiates messages. A server provides a service or data. Clients can send messages continuously or intermittently. **EXAMPLE:** A ControlLogix controller can send a MSG instruction to another controller.
Transports	Each connection has transports. A transport is a uni-directional entity with its own numeric identifier. An implicit connection has 2 transports. An explicit connection has 1 transport. Transports are important because they help you calculate the number of packets per second for each Ethernet interface. **EXAMPLE: I/O** For an I/O connection to a rack of distributed I/O, a connection is configured in the Logix Designer application by adding the communication adapter and I/O modules in the I/O list. When the connection is created, output packets flow from the controller to the I/O rack. In addition, input packets flow from the I/O to the controller. Each direction of flow is a transport. In this example, two transports exist. One transport is from the controller to the adapter. The second transport is from the adapter to the controller. **EXAMPLE: Produced Tag** For a multicast produced tag connection with two consumers, there is a connection to each consumer. Data from the producer is produced to the wire on one transport. Each of the consumers returns a heartbeat. A total of three transports exist in this example. One transport is from the tag producing controller to the 'wire' media. The second transport is from one consumer to the tag producer. The third transport is from the second consumer.
UCMM	In the web servers, you can see references to Unconnected Message Manager (UCMM). This type of messaging is momentary and therefore can be ignored unless you are troubleshooting. Examples of where UCMM messages are used are: • Update of module firmware • Some functions in RSLinx software • CIP Generic MSG instruction • Opening any CIP connection (forward_open command)

TCP Connections

TCP connections are used for all EtherNet/IP communication and are established before one device on the network transmits data to one or more devices on the network. EtherNet/IP communication modules use one TCP connection for each IP address to which the module is connected.

TCP connections are automatically established before CIP connections because you can establish CIP connections only **over** a TCP connection. A single TCP connection supports multiple CIP connections.

IMPORTANT	EtherNet/IP communication modules also have web servers that use TCP connections for non-CIP traffic, such as HTTP. However, TCP connections used for non-CIP traffic do not count against the limits listed above.

CIP Connections

CIP connections are automatically established over a TCP connection and transfer data from one device on the EtherNet/IP network to another. The following are examples of CIP connections:

- Logix5000 controller message transfer to Logix5000 controller
- I/O or produced tag
- Program upload
- RSLinx DDE/OPC client
- PanelView polling of a Logix5000 controller

There are different CIP connections.

Table 9 - CIP Connections

CIP Connection	Description
Bridged	A bridged connection is a connection that passes through the EtherNet/IP communication module. The end point of the connection is a module other than the EtherNet/IP communication module. **EXAMPLE**: An explicit connection from a controller through a 1756-EN2T module to another controller.
End-node	An end-node connection is a connection whose end point is the EtherNet/IP communication module itself. **EXAMPLE**: An explicit connection from RSLinx software to the EtherNet/IP communication module to set the module's IP address.
Rack-optimized	A rack-optimized connections is an implicit message connection to a rack or assembly object in the EtherNet/IP communication module. Data from selected I/O modules is collected and produced on one connection (the rack-optimized connection) rather than on a separate direct connection for each module. This CIP connection is available with only digital I/O modules.
Direct	An implicit message connection from a controller to an specific I/O module (as opposed to a rack-optimized connection). This CIP connection is available with analog and digital I/O modules.

IMPORTANT CIP connections are further defined by these additional connection parameters:

- CIP Connection Message Types
- CIP Connection Types

CIP Connection Message Types

CIP connections use one of the following CIP connection message types:

- Implicit
- Explicit

Implicit connections are time critical in nature. This includes I/O and produced/consumed tags. Implicit refers to information (such as source address, data type, or destination address) that is implied in the message but not contained in the message.

Explicit connections are non-time critical and are request/reply in nature. Executing a MSG instruction or executing a program upload are examples of explicit connections. Explicit refers to basic information (such as source address, data type, or destination address) that is included in every message.

CIP Connection Types

CIP connection types determine how CIP connections transfer data on the network. The CIP connection types determine whether a connection is established between devices. If a connection is established between devices, the connection type determines if that connection remains open after data is transferred.

There are two CIP connection types:

- Connected—Available with both implicit and explicit messages.
- Unconnected—Available with only explicit messages.

Table 10 describes how CIP connections are used with implicit and explicit messages.

Table 10 - CIP Connections with Implicit and Explicit Messages

CIP Connection Type	As Used with Implicit Messages	As Used with Explicit Messages
Connected	The following events occur: 1. A connection is established between devices. 2. Data is transferred between devices. 3. The connection remains open for future data transmission. The following are examples of connected implicit messaging: • I/O data transfer • Produced/consumed tags between Logix5000 controllers Keep in mind the following points for connected implicit messaging: • Execution time is more efficient because the CIP connection between devices does not need to be reopened for each data transfer. • EtherNet/IP communication modules support limited numbers of CIP connections. Because this connection remains open all the time, there is one fewer CIP connection available for other data transfer through the module.	The following events occur: 1. A connection is established between devices. 2. Data is transferred between devices. 3. The connection between the devices is closed. If data needs to be transferred again between these same two device, the connection must be reopened. The following are examples of connected explicit messaging: • MSG instruction • RSLinx Classic software setting the IP address for an EtherNet/IP communication module If you select a cached connection, the connection is not closed at the end of the transaction. Keep in mind the following points for connected explicit messaging: • Execution time is less efficient because the CIP connection between devices must be reopened for each data transfer. • EtherNet/IP communication modules support limited numbers of CIP connections. Because this CIP connection is closed immediately after use, the CIP connection is immediately available for other data transfer through the module.
Unconnected	N/A	In unconnected explicit messaging, no connection is established between devices. Data is sent in a packet that includes destination identifier information in the data structure but does not have a dedicated connection.

Nodes on an EtherNet/IP Network

IMPORTANT This section applies to only CompactLogix 5370 controllers. For most applications, proceed to Table 12 on page 66 for network specifications.

CompactLogix 5370 controllers use the number of Ethernet nodes to stay within their capacity for the number of connections. These controllers have limits on the number of nodes they support in the I/O configuration within your controller project.

Any devices you add directly to the local Ethernet node in the I/O configuration are counted toward the controller's node limitation. The following are example devices that are added to the I/O configuration and must be counted:

- Remote communication adapters
- I/O modules directly connected to the EtherNet/IP network, for example the 1732E-IB16M12R ArmorBlock® EtherNet/IP module
- Motion devices, such as drives

You do not count Ethernet devices that exist on the EtherNet/IP network but are not added to the I/O configuration. These devices include the following:

- Computer
- HMI that are not added to the I/O configuration section, for example, PanelView Plus terminals
- MSG instructions that do not use an RPI and are not time-critical
- Devices that communicate via a socket interface, such as CompactLogix 5370 controllers

Table 11 - CompactLogix 5370 Controller Ethernet Node Guidelines

Cat. No.	Ethernet Nodes Supported
1769-L16ER-BB1B	4
1769-L18ER-BB1B	8
1769-L18ERM-BB1B	
1769-L24ER-QB1B	
1769-L24ER-QBFC1B	
1769-L27ERM-QBFC1B	16
1769-L30ER	
1769-L30ERM	
1769-L30ER-NSE	
1769-L33ER	32
1769-L33ERM	
1769-L36ERM	48

For more information, see the CompactLogix 5370 Controllers User Manual, publication 1769-UM021.

EtherNet/IP Network Specifications

Table 12 - EtherNet/IP Network Specifications

Cat. No.	Connections		CIP Unconnected Messages (backplane + Ethernet)	Ethernet Node Count, Max	Packet Rate Capacity (packets/second)(4)		SNMP Support (password required)
	TCP	CIP			I/O	HMI and MSG	
1734-AENT, 1734-AENTR	32	20	32	N/A	5000	900	No
1738-AENT, 1738-AENTR	32	20	32	N/A	5000	900	No
1756-ENBT	64	128(3)	64 + 64	N/A	5000	900	Yes
1756-EN2F	128	256(3)	128 + 128	N/A	**IMPORTANT**: Packet rates for ControlLogix EtherNet/IP communication modules depend on series and firmware revision. See Table 14 on page 68.	2000	Yes
1756-EN2T	128	256(3)	128 + 128	N/A		2000	Yes
1756-EN2TXT	128	256(3)	128 + 128	N/A		2000	Yes
1756-EN2TR	128	256(3)	128 + 128	N/A		2000	Yes
1756-EN2TRXT	128	256(3)	128 + 128	N/A		2000	Yes
1756-EN2TSC	128	256(3)	128 + 128	N/A		930 with encryption 1800 without encryption	Yes
1756-EN3TR	128	256(3)	128 + 128	N/A		2000	Yes
1756-EWEB	64	128(3)	128 + 128	N/A	N/A	900	Yes
1768-ENBT	32(1) 64(2)	64(3) 128	32 + 32	N/A	5000	960	Yes
1769-L23E*x*	8	32(3)	32 + 32	N/A	2000	380	Yes
1769-L3*x*E	64	32(3)	32 + 32	N/A	4000	760	Yes
1769-L16ER-BB1B	120	256	256	4	6000 @ 500 bytes/packet	400 messages/s @ 20% comm. timeslice	Yes
1769-L18ER-BB1B	120	256	256	8	6000 @ 500 bytes/packet		Yes
1769-L18ERM-BB1B	120	256	256	8	6000 @ 500 bytes/packet		Yes
1769-L24ER-QB1B	120	256	256	8	6000 @ 500 bytes/packet		Yes
1769-L24ER-QBFC1B	120	256	256	8	6000 @ 500 bytes/packet		Yes
1769-L27ERM-QBFC1B	120	256	256	16	6000 @ 500 bytes/packet		Yes
1769-L30ER	120	256	256	16	6000 @ 500 bytes/packet		Yes
1769-L30ERM	120	256	256	16	6000 @ 500 bytes/packet		Yes
1769-L30ER-NSE	120	256	256	16	6000 @ 500 bytes/packet		Yes
1769-L33ER	120	256	256	32	6000 @ 500 bytes/packet		Yes
1769-L33ERM	120	256	256	32	6000 @ 500 bytes/packet		Yes
1769-L36ERM	120	256	256	48	6000 @ 500 bytes/packet		Yes
1783-ETAP	64	N/A	N/A	N/A	N/A	900	No
1783-ETAP1F, 1783-ETAP2F	64	N/A	N/A	N/A	N/A	900	No
1794-AENT	64	64	N/A	N/A	9500	N/A	Yes
2*x*-COMM-E	30	16	16	N/A	400	50	No
9300-ENA	N/A	N/A	N/A	N/A	—	—	N/A

(1) The 1768-ENBT communication module supports 32 TCP connections with firmware revision 1.*x*.

(2) The 1768-ENBT communication module supports 64 TCP connections with firmware revision 2.*x* or later.

(3) CIP connections can be used for all explicit or all implicit applications. For example, a 1756-ENBT module has a total of 128 CIP connections that can be used for any combination of connections.

(4) Total packet rate capacity = I/O Produced Tag, max + HMI/MSG, max. Packet rates vary depending on packet size. For more detailed specifications, see the EDS file for a specific catalog number.

Table 13 - EtherNet/IP Network Specifications

Cat. No.	Media Support		Produced/Consumed Tags		Socket Services	Integrated Motion on the EtherNet/IP Network Axes	Duplicate IP Detection (starting revision)
	Twisted Pair[1]	Fiber	Number of Multicast Tags, Max	Unicast Available in RSLogix 5000 Software			
1734-AENT, 1734-AENTR	Yes[2]	No	N/A	Version 18.02.00 or later	No	N/A	Revision 2.x - 1734-AENT Revision 3.x - 1734-AENTR
1738-AENT, 1738-AENTR	Yes[2]	No	N/A	Version 18.02.00 or later	No	N/A	Revision 2.x - 1738-AENT Revision 3.x - 1738-AENTR
1756-ENBT	Yes[2]	No	32[3]	Version 16.03.00 or later	No	See Table 14 on page 68.	Revision 3.3
1756-EN2F	No	Yes	32[3]	Version 16.03.00 or later	Yes		Revision 1.*x*
1756-EN2T	Yes[2]	No	32[3]	Version 16.03.00 or later	Yes		Revision 1.*x*
1756-EN2TXT	Yes[2]	No	32[3]	Version 16.03.00 or later	Yes		Revision 1.*x*
1756-EN2TR	Yes[2]	No	32[3]	Version 17.01.02 or later	Yes		Revision 1.*x*
1756-EN2TRXT	Yes[2]	No	32[3]	Version 20.01.00 or later	Yes		Revision 1.*x*
1756-EN2TSC	Yes[2]	No	32[3]	Version 20.01.00 or later	Yes		Revision 1.*x*
1756-EN3TR	Yes[2]	No	32[3]	Version 18.02.00 or later	No		Revision 3.*x*
1756-EWEB	Yes[2]	No	N/A	N/A	Yes	N/A	Revision 2.2
1768-ENBT	Yes[2]	No	32[3]	Version 16.03.00 or later	No	N/A	Revision 1.*x*
1768-EWEB	Yes[2]	No	N/A	N/A	Yes	N/A	Revision 1.*x*
1769-L23E*x*	Yes[2]	No	32[3]	Version 17.01.02 or later	No	N/A	Revision 16
1769-L3*x*E	Yes[2]	No	32[3]	Version 16.03.00 or later	No	N/A	Revision 15
1769-L16ER-BB1B	Yes[2]	No	32 multicast produced tags[3] 128 unicast produced tags	Yes	Yes	N/A	Revision 20.*x*
1769-L18ER-BB1B	Yes[2]	No		Yes	Yes	N/A	Revision 20.*x*
1769-L18ERM-BB1B	Yes[2]	No		Yes	Yes	Up to 2 axes	Revision 20.*x*
1769-L24ER-QB1B	Yes[2]	No		Yes	Yes	N/A	Revision 20.*x*
1769-L24ER-QBFC1B	Yes[2]	No		Yes	Yes	N/A	Revision 20.*x*
1769-L27ERM-QBFC1B	Yes[2]	No		Yes	Yes	Up to 4 axes	Revision 20.*x*
1769-L30ER	Yes[2]	No		Yes	Yes	N/A	Revision 20.*x*
1769-L30ERM	Yes[2]	No		Yes	Yes	Up to 4 axes	Revision 20.*x*
1769-L30ER-NSE	Yes[2]	No		Yes	Yes	N/A	Revision 20.*x*
1769-L33ER	Yes[2]	No		Yes	Yes	N/A	Revision 20.*x*
1769-L33ERM	Yes[2]	No		Yes	Yes	Up to 8 axes	Revision 20.*x*
1769-L36ERM	Yes[2]	No		Yes	Yes	Up to 16 axes	Revision 20.*x*
1783-ETAP	Yes[2]	No	N/A	N/A	No	N/A	Revision 1.*x*
1783-ETAP1F, 1783-ETAP2F	Yes[2]	Yes	N/A	N/A	No	N/A	Revision 2.*x*
1794-AENT	Yes[2]	No	N/A	N/A	No	N/A	Revision 3.*x*
2*x*-COMM-E	Yes[2]	No	N/A	N/A	No	N/A	Revision 1.1
9300-ENA	Yes[2]	No	N/A	N/A	N/A	N/A	N/A

(1) Most modules listed, with the exception of three fiber modules, support a speed duplex of 10/100. The 1756-EN2F, 1783-ETAP1F, and 1783-ETAP2F modules have a speed duplex of 100.

(2) Module has two ports instead of one. With the second port, you can wire the module directly into a linear or device-level ring topology instead of connecting the network devices with an external managed switch. For more information on Embedded Switch Technology, see the EtherNet/IP Embedded Switch Technology Application Guide, publication ENET-AP005.

(3) Each controller can send a maximum of 32 produced tags to one single consuming controller. If these same tags are sent to multiple consumers, the maximum number is 31.

Table 14 - Additional ControlLogix EtherNet/IP Communication Module Specifications

Cat. No.	Series	Firmware Revision	RSLogix 5000 Software Version	RSLinx Software Version	Packet Rate Capacity (packets/ second)[2]		Support for Extended Environment[4]	Integrated Motion on the EtherNet/IP Network Axes
					I/O	HMI/MSG		
1756-ENBT	Any	Any	8.02.00 or later	2.30 or later	5000	900	No	N/A
1756-EN2F	A	2.*x*	15.02.00 or later	2.51 or later	10,000	2000	No	N/A
		3.6 or later	18.02.00 or later[1]		25,000[3]			Up to 4 axes supported[5]
	B							Up to 8 axes supported[5]
1756-EN2T	A	2.*x* or earlier	15.02.00 or later	2.51 or later	10,000	2000	No	N/A
		3.6 or later	18.02.00 or later[1]		25,000[3]			Up to 4 axes supported[5]
	B	2.*x*	15.02.00 or later		10,000			N/A
		3.6 or later	18.02.00 or later[1]		25,000[3]			Up to 4 axes supported[5]
	C							Up to 8 axes supported[5]
1756-EN2TXT	B	2.*x*	15.02.00 or later	2.51 or later	10,000	2000	Yes	N/A
		3.6 or later	18.02.00 or later[1]		25,000[3]			Up to 4 axes supported[5]
	C							Up to 8 axes supported[5]
1756-ENT2TR	A	2.*x*	17.01.02 or later	2.55 or later	10,000	2000	No	N/A
		3.6 or later	18.02.00 or later[1]	2.56 or later	25,000[3]			Up to 4 axes supported[5]
	B							Up to 8 axes supported[5]
1756-EN2TRXT	A	5.028 or later	20.01.00 or later	2.56 or later	25,000[3]	2000	Yes	N/A
1756-EN2TSC	A	5.028 or later	20.01.00 or later	2.56 or later	25,000[3]	930 with encryption 1800 without encryption	No	N/A
1756-EN3TR	A	3.6 or later	18.02.00 or later[1]	2.56 or later	25,000[3]	2000	No	Up to 255 axes supported[5]
9300-ENA	A	1.12 or later	N/A	N/A	N/A	—	No	N/A

(1) This version is required to use CIP Sync technology, Integrated Motion on the EtherNet/IP Network, or Exact Match keying.

(2) For more information on Packet Rate Capacity, see Packets Rate Capacity on page 69.

(3) The packet rate capacity can change slightly depending on the firmware revision of your EtherNet/IP communication module. For more information, see Packets Rate Capacity on page 69.

(4) Module operates in a broad temperature spectrum, -20…70 °C (-4…158 °F), and meets ANSI/ISA-S71.04-1985 Class G1, G2 and G3, as well as cULus, Class 1 Div 2, C-Tick, CE, ATEX Zone 2 and SIL 2 requirements for increased protection against salts, corrosives, moisture/condensation, humidity, and fungal growth.

(5) This value assumes the use of a 1756-L7*x* ControlLogix controller. For a 1756-L6*x* ControlLogix controller, see ControlLogix Controllers User Manual, publication 1756-UM001.

Packets Rate Capacity

Beginning with firmware revision 3.*x* for ControlLogix EtherNet/IP communication modules, packet rate capacity is increased.

IMPORTANT Connection size impacts a module's increased packet rate capacity gained with firmware revision 3.*x* or later.

Smaller connections are processed faster than larger connections. Larger connections can affect the increased packet rate capacity obtained with firmware revision 3.*x* or later. These type of applications use larger connections:

- Applications with rack-optimized connections
- Applications with Integrated Motion on the EtherNet/IP network
- Applications with large produce/consume tag arrays

Modules with **firmware revision 3.*x*** or later always have **greater packet rate capacity** than modules with firmware revision 2.*x* or earlier in the same application. Larger connections impact only how much greater the packet rate capacity is with firmware revision 3.*x* or later.

EtherNet/IP Capacity Tool

The EtherNet/IP Capacity Tool is intended to help you in the initial layout of your EtherNet/IP network by calculating resources, for example, connections, packet rate capacity, used by a proposed network.

Download the EtherNet/IP Capacity Tool at the Integrated Architecture Tools website. http://www.rockwellautomation.com/solutions/integratedarchitecture/resources3.html#enetpredict

IMPORTANT The EtherNet/IP Capacity Tool calculates a **rough estimate** of the packet rate capacity. Packet rate capacity varies depending on the specific conditions of each application.

For a more detailed analysis of a proposed network, use RSNetWorx™ for EtherNet/IP software.

Upgrade to Latest Firmware Revision

All ControlLogix EtherNet/IP communication modules must be upgraded to firmware revision 3.*x* or later to increase their packet rate capacity. You can upgrade your module's firmware regardless of series.

Download the latest firmware revisions at the Rockwell Automation technical support website. http://support.rockwellautomation.com/ControlFlash/

Monitor Packet Sizes in Current Application

Some EtherNet/IP communication modules offer web pages that show module and application information. To view your module's information, type the module's IP address into your web browser.

For more information on packet rate capacity on ControlLogix EtherNet/IP communication modules, see Article ID 66326, ControlLogix 1756-EN*xxx* V3.*x* performance increase FAQ, available from the Rockwell Automation Knowledgebase at http://www.rockwellautomation.com/support/americas/index_en.html.

Requested Packet Interval (RPI)

The RPI is the update rate specified for a particular piece of data on the network. The RPI can be specified for an entire rack via a rack-optimized connection or for a particular module via a direct connection.

When adding a module to the I/O configuration of a controller, you must configure the RPI. This value specifies how often to produce the data for that module. For example, if you specify an RPI of 50 ms, every 50 ms the I/O module sends its data to the controller or that the controller sends its data to the I/O module.

RPIs are used for only implicit connections, such as produced/consumed tags and I/O. For example, a local EtherNet/IP communication module does not require an RPI because it does not produce data for the system but acts as a bridge to remote modules.

Set the RPI only as fast as needed by the application. The CompactLogix 5370 controllers always attempt to scan an I/O module at the configured RPI rate. For guidelines on setting the RPI for the CompactLogix 5370 controllers, see the CompactLogix 5370 Controllers User Manual, publication 1769-UM021.

The RPI also determines the number of packets per second that the module produces on a connection. Each module has a limit on the total number of implicit packets per second. The total includes the sum of sent and received implicit packets. The packet rate capacity for implicit messages is for only implicit packets and neither matches nor includes the explicit packet rate capacity.

Messaging

The EtherNet/IP network supports both time-critical (implicit) and non time-critical (explicit) message transfer services of CIP. Exchange of time-critical messages is based on the producer/consumer model where a transmitting device produces data on the network and many receiving devices can consume this data simultaneously.

Implicit Messages

Implicit messages are time critical in nature. This includes I/O and produced/consumed tags. Implicit refers to information (source address, data type, and destination address) that is implied in the message, but not contained in the message. Examples of implicit applications include the following:

- Real-time I/O data
- Functional safety data
- Motion control data

Implicit messages use the User Datagram Protocol (UDP) and can be unicast or multicast. Implicit messages transport data via transport class 0/1 (Class 1):

- The data source/destination is an application object (assembly object).
- There is no protocol in the message data—it is all I/O data.
- Data transfer is more efficient because the meaning of the data is known ahead of time.
- Transfer is initiated on a time basis (cyclic trigger) or requested packet interval (RPI).
- There is a connection timing mechanism to alert the application if the other side has stopped communicating.
- Messaging is always connected—there are is unconnected implicit messaging.

An implicit message times out in *controller_multiplier* x RPI. The multiplier is selected by the controller firmware so that the timeout is greater than or equal to 100 ms. The minimum multiplier is 4.

These are examples:

- RPI = 2 ms; controller multiplier = 64. The timeout is 128 ms.
- RPI = 10 ms; controller multiplier = 16. The timeout is 160 ms.

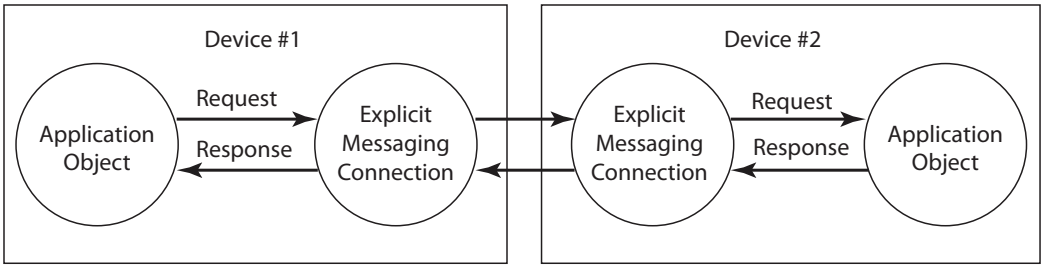
Explicit Messages

Explicit connections are non-time critical and are request/reply in nature. Executing a MSG instruction or executing a program upload are examples of explicit connections. Explicit refers to basic information (such as source address, data type, or destination address) that is included in every message. Each request is typically directed at a different data item. Examples of explicit applications include the following:

- HMI
- RSLinx connections
- Message (MSG) instructions
- Program upload/download

Explicit messages use Transmission Control Protocol (TCP). Explicit messages are used for point-to-point, client-server transactions that use transport class 3 (Class 3):

- The server side is bound to the Message Router object and has access to all internal resources.
- The client side is bound to a client application object and must generate requests to the server.
- Explicit messages use an explicit messaging protocol in the data portion of the message packet.
- Explicit messages can be connected or unconnected.

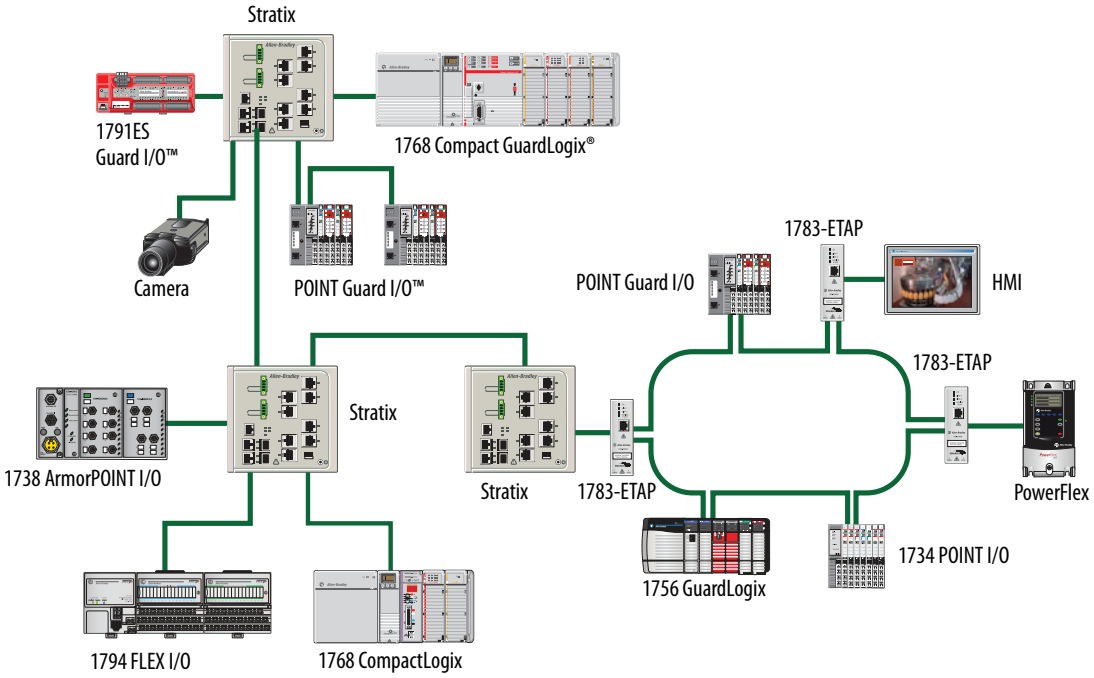


An explicit message times out in 30 seconds. This is user-changeable in the Message (MSG) instruction structure.

CIP Safety

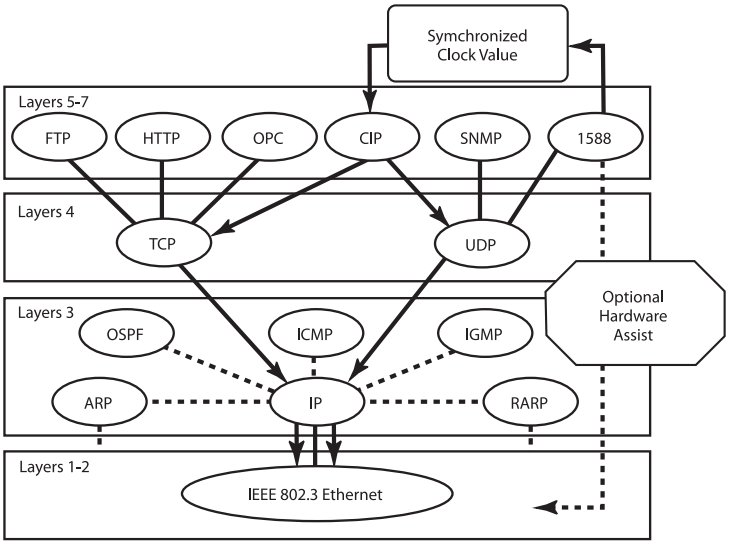
CIP Safety is an extension to the application layer that provides a set of highly integrated safety services that leverage the underlying communication stacks of the standard CIP networks to transport data from a source to a destination. CIP Safety is certified to be compliant with the functional safety standard IEC 61508 up to safety integrity level (SIL) 3.

The CIP Safety end-to-end protocol gives responsibility to ensuring safety to the end nodes—rather than the bridges, routers, or intermediate nodes. CIP Safety cannot prevent communication errors from occurring, but if an error does occur in the transmission of data or in the intermediate router, the end device detects the failure and takes the appropriate action. Because the safety coding and not the underlying communication layers enforce the integrity of the data, the underlying communication layers can be interchanged and intermixed even across subnets. CIP Safety lets you mix standard and safety devices on the same open network.



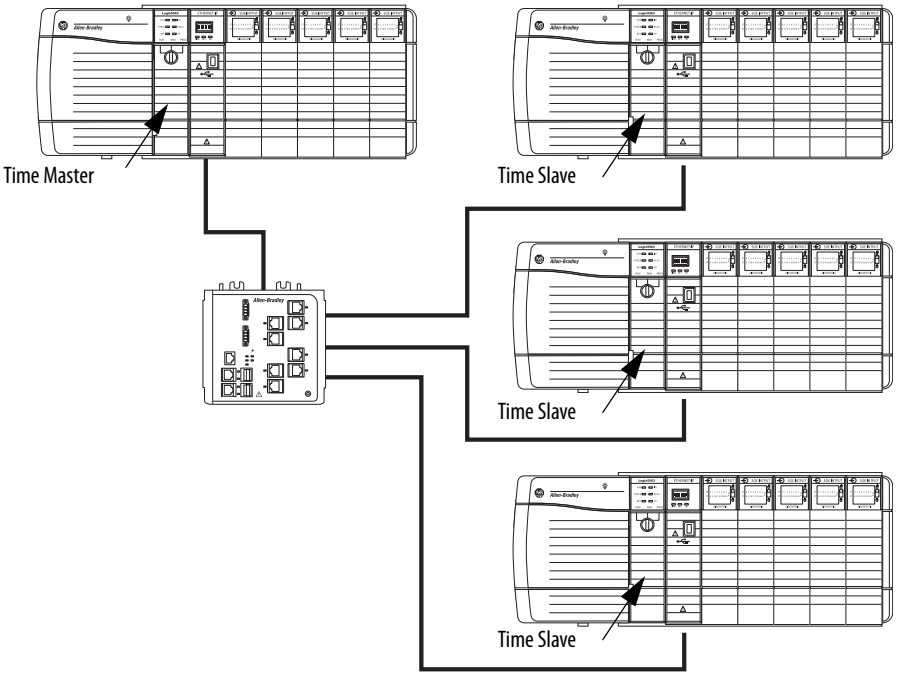
CIP Sync

CIP Sync defines time synchronization services for CIP. Time synchronization on the EtherNet/IP network is a method to synchronize clocks across devices on the network. In a synchronized application, there is a single time master and multiple time slaves. For example, a ControlLogix controller can be configured to act as the time master and other ControlLogix modules, connected via EtherNet/IP communication modules, serve as the time slaves.



You can synchronize the clocks within the following applications:

- Multiple ControlLogix controllers
- ControlLogix redundancy systems
- Real world clocks
- Personal computer-based events



Typical time synchronized applications include the following:

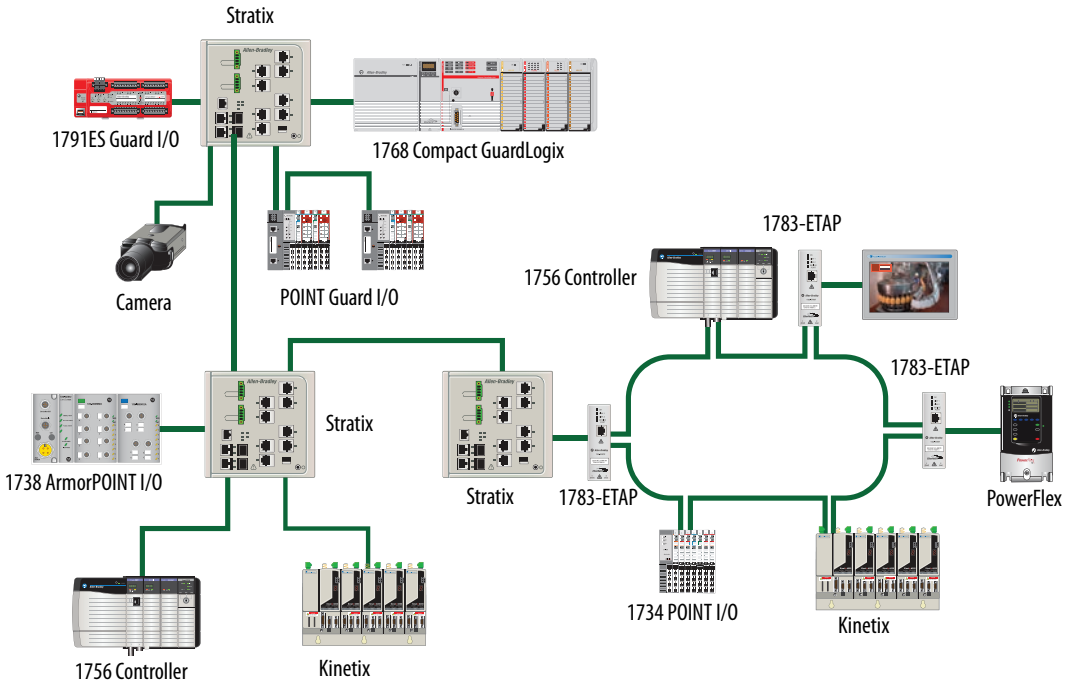
- Input time stamping
  - Events and alarms
  - Sequence of Events recording
  - First fault detection
- Time scheduled outputs
- Integrated motion on EtherNet/IP drive synchronization
- Distributed motion control

CIP Sync a time synchronization extension to the application layer can help solve these application requirements. CIP Sync is based on the IEEE 1588 (IEC 61588) standard—Precision Clock Synchronization Protocol for Networked Measurement and Control Systems, commonly referred to as the Precision Time Protocol (PTP). The protocol provides a standard mechanism to distribute Coordinated Universal Time (UTC) across a standard Ethernet network of distributed devices. By time stamping in UTC events can easily be compared across time zones without having to be adjusted for the geography in which they were generated.

CIP Sync lets users base control on true time synchronization rather than the more limited event synchronization model used historically. In a 100 Mbps switched Ethernet system, advanced testing shows CIP Sync can deliver time synchronization accuracy of less than 500 ns between devices, meeting the requirements of some of the most demanding real-time applications.

Integrated Motion on an EtherNet/IP Network

Integrated motion on an EtherNet/IP network sets the EtherNet/IP networking technology apart from the other industrial Ethernet networks. EtherNet/IP modules with integrated motion on the EtherNet/IP network combine the requirements of deterministic real-time motion control applications with standard unmodified Ethernet that provides full compliance with the Ethernet standards IEEE 802.3 and TCP/IP. This supports the use of standard Ethernet components and infrastructure without the use of special switches or gateways.



Integrated Motion on the EtherNet/IP network accomplishes this by encompassing a set of application profiles that let position, speed, and torque loops to be set in the drive. With the addition of the CIP Sync technology multiple axes can be coordinated for precise, coordinated motion control applications.

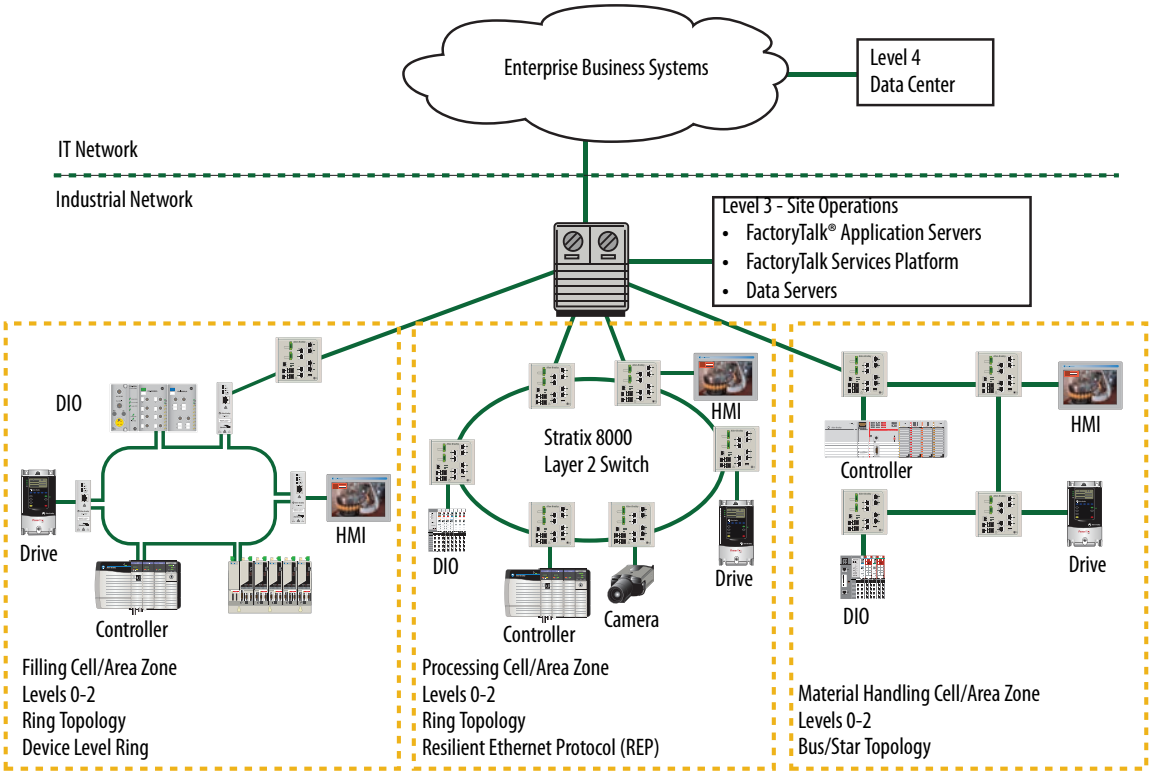
Integrated motion on the EtherNet/IP network uses time-stamped data along with its simple timing model to eliminate hard synchronization constraints between the drive and the controller. Real-time data values are adjusted at the end device at the time the data is applied; no need to hard schedule the network traffic.

In addition, integrated motion on the EtherNet/IP network has the flexibility to handle different types of drives and time synchronization requirements. The same network connection can be used for both a high performance servo drive with precise synchronization requirements, and a low performance Volts/Hertz drive with no time synchronization capability.

Connectivity to IT

While IT and controls engineers are often managed separately and given separate job performance goals, those goals are beginning to align because the availability of information is crucially important in both roles. Some companies are beginning to form hybrid groups and hire individuals with experience in both areas to form policies, guidelines, and procedures for design and maintenance of a common network architecture.

Security Policies	IT Network	Controls Network
Focus	Protect intellectual property and company assets	24/7 operations High overall equipment effectiveness
Priorities	1. Confidentiality 2. Integrity 3. Availability	1. Availability 2. Integrity 3. Confidentiality
Types of data traffic	Converged network of data, voice, and video	Converged network of data, control, information, safety, and motion
Access control	Strict network authentication and access policies	Strict physical access Simple network device access
Implications of a device failure	Continues to operate	Can stop operation
Threat protection	Shut down access to detected threat	Potentially keep operating with a detected threat
Upgrades	As soon as possible During uptime	Scheduled During downtime



Notes:

Predict System Performance

This chapter describes how to predict the performance of your EtherNet/IP network-based control system and how to enhance that performance

IMPORTANT This chapter explains how to calculate system performance with data from your system in specific equations. However, you can also use the EtherNet/IP Capacity Tool, an online tool, to predict system performance.

The EtherNet/IP Capacity Tool and the IAB Tool are intended to help you in the initial layout of your EtherNet/IP network by calculating resources, for example, connections, packet rate capacity, used by a proposed network.

Download the EtherNet/IP Capacity Tool at the Integrated Architecture Tools website: http://www.rockwellautomation.com/solutions/integratedarchitecture/resources3.html#enetpredict.

The EtherNet/IP Capacity Tool calculates a **rough estimate** of the packet rate capacity. Packet rate capacity varies depending on the specific conditions of each application.

For a more detailed analysis of a proposed network, use RSNetWorx for EtherNet/IP software.

System Prediction Goals

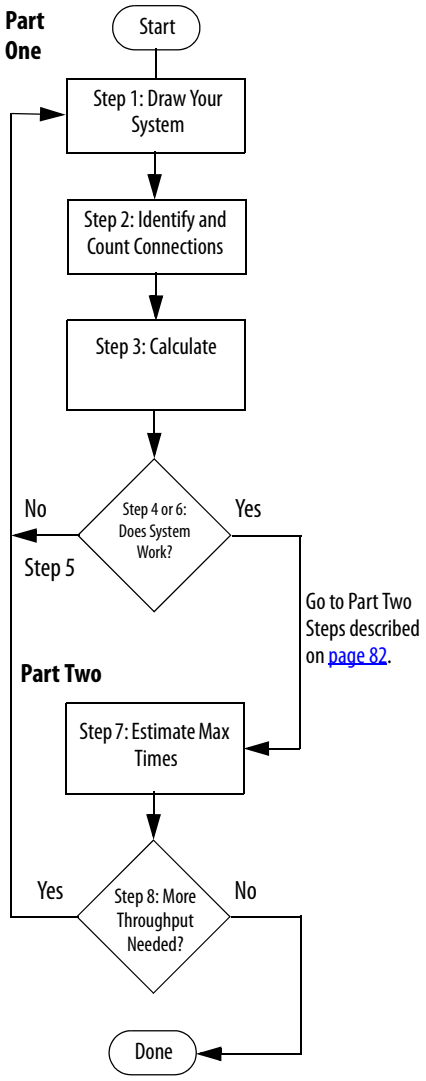
You allocate the bandwidth of your EtherNet/IP communication module between two types of messaging.

Messaging Type	Description
Explicit messaging	Explicit messages are connections that do not use an RPI. Some examples of explicit messaging include the following: • MSG instructions • HMI communication • Studio 5000 uploads and downloads
Implicit messaging	Implicit messages are connections that use an RPI. Implicit messaging is used for I/O data exchanges, including the following: • Rack-optimized connections(1) • Direct connections • Produced/consumed tags

(1) Available with digital I/O modules only.

The performance predictions have two major goals:

- Determine if the system as a whole has sufficient bandwidth and connections to meet application requirements.
- Estimate the maximum input or output times for rack-optimized connections, direct connections, and produced/consumed tags.



Part One: Determine If System Has Sufficient Bandwidth to Meet Application Requirements

To determine if your system has sufficient bandwidth to fulfill the requirements of the application, complete the following steps.

1. Draw an **overall sketch of your system** that includes all of the following:
   - Logix5000 controllers
   - EtherNet/IP communication modules
   - I/O modules
   - All connections to the network

   Include a description of what the controllers are doing, such as messaging with produced tags and any known RPI requirements.
2. **Identify and count** each type of implicit connection for the system and each EtherNet/IP communication module.
3. Use the formulas provided later in this chapter to **calculate the packet rate capacity** loading on each EtherNet/IP communication module and the available bandwidth for any unspecified RPIs.
4. Based on the results of these calculations, decide if your system is sufficient.
5. If necessary, modify your system by doing one or more of the following:
   - For ControlLogix EtherNet/IP communication modules, upgrade to newer series and/or firmware revision.

     For example, the 1756-EN2T/A module, firmware revision 2.*x* or earlier module supports 10,000 pps. However, the 1756-EN2T/A module, firmware revision 3.6 or later module supports 25,000 pps.
   - Increase some RPIs to let other RPIs in the system to decrease.
   - Change connection types, for example, direct to rack-optimized.
   - Change I/O module configurations, such as filter times, trigger types.
   - Add EtherNet/IP communication modules.
   - Add Logix controllers.
   - Verify that the network infrastructure can handle the system traffic.

     TIP We recommend your application's EtherNet/IP links are no more than 60% utilized and QoS is implemented. Typically, these conditions support most EtherNet/IP applications.

   - Verify that the switches support full-duplex operation and IGMP snooping. Port-mirroring is also important for switch and system diagnostic functions.
6. If you have to make modifications, verify that the modified system works by recounting the connections and recalculating the packet rate capacity loading.

Part Two: Predict Maximum input or Output Times for CIP Connections

A CIP connection is an efficient communication path used for high performance. The following are basic types of CIP connections:

- Rack-optimized
- Input or output data
- Produced tag

A CIP connection is bi-directional. During every RPI, each end of a connection initiates a packet of information. A packet of information represents a connection.

The type of data packet produced by each end of the connection depends on the connection type as described below.

Connection Type	Scanner	Adapter	Producer Controller	Consumer Controller
Rack-optimized	Output data	Input data	N/A	N/A
Input data	Heartbeat	Input data	N/A	N/A
Output data	Output data	Output data echo	N/A	N/A
Produced tag	N/A	N/A	Tag data	Heartbeat

To predict the maximum input (I/O to controller) or output (controller to I/O) times for CIP connections, complete the following steps.

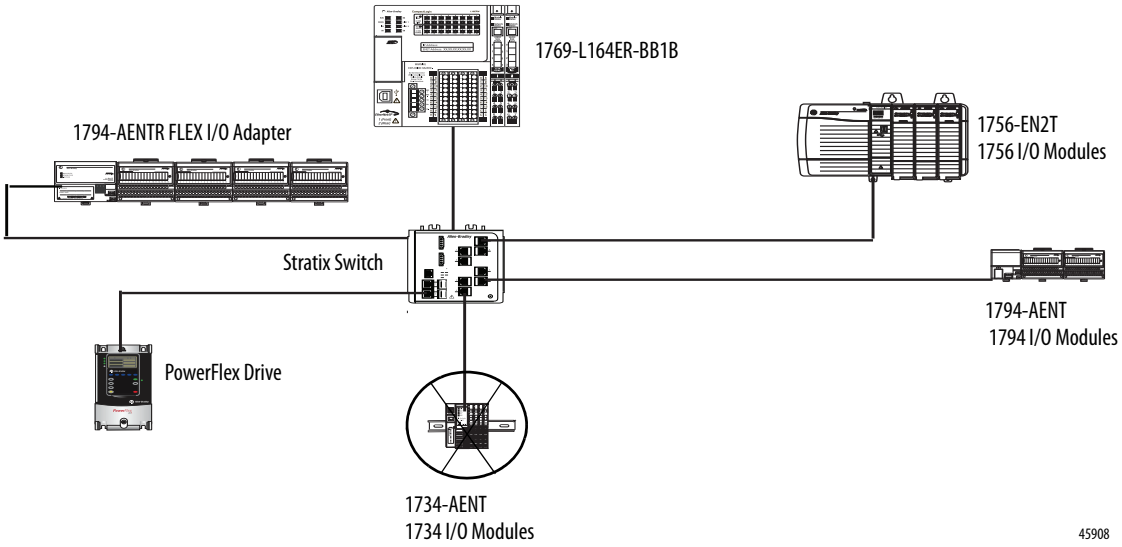
1. Estimate the **maximum time intervals** for each CIP connection types used in the control system.
2. If necessary, modify your system to get more throughput by performing one or more of the adjustments described under step 5 on page 81.
3. If you have made modifications, verify that the modified system works by recounting the connections and recalculating the packet rate capacity loading.

Performance Calculations

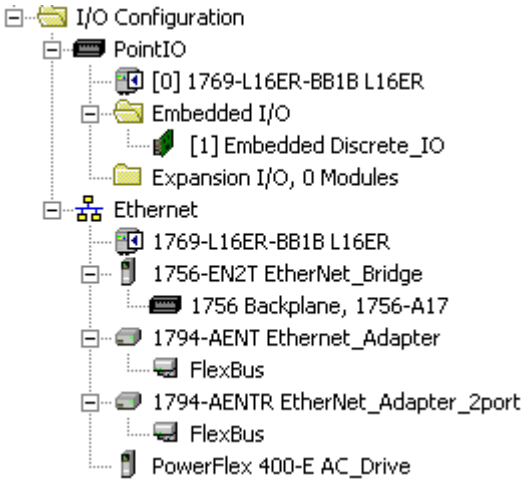
Logix5000 controllers use packets per second and the number of connections for predicting system performance. However, CompactLogix 5370 controllers use the number of Ethernet nodes to stay within their capacity for the number of connections.

CompactLogix 5370 Controller Example

As shown in the illustration below, the 1769-L16ER-BB1B controller supports a maximum of four nodes. Therefore, any additional node, such as a 1734 Ethernet adapter, cannot be added to our example EtherNet/IP network. Use the supported node chart on page 65 and the EtherNet/IP Capacity Tool to simplify calculating system resources for your CompactLogix 5370 network.



The devices you add directly to the local Ethernet node in the I/O configuration section of your controller project are counted toward the 1769-L16ER-BB1B controller's node limitation.



While you can use the EtherNet/IP node count to select a CompactLogix 5370 controller for your network requirements, most applications use three sets of calculations to determine performance:

- Identify and Count Connections
- Calculate Packets/Second
- Estimate Maximum Input or Output Times for CIP Connections

ControlLogix Controller Example

This example control system includes these connections:

- The 1756-L73 controller in the local chassis producing one tag that the 1756-L73 controller in the remote chassis consumes

  The produced/consumed tags between the local and remote 1756-L73 controllers use an RPI = 20 ms

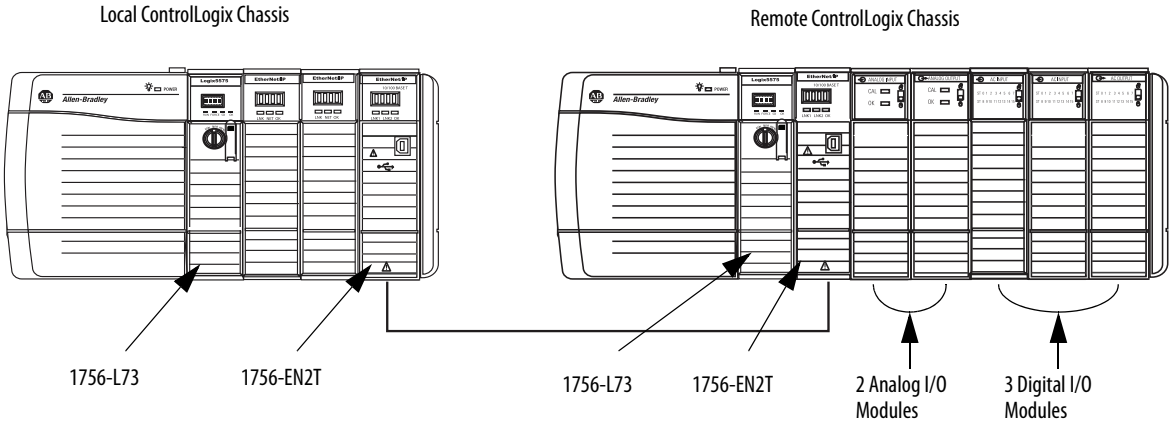
- One rack-optimized connection between the local controller and the remote digital I/O modules at an RPI = 20 ms

- One direct connection to each remote analog I/O module at an RPI = 50 ms.

IMPORTANT Each 1756-EN2T communication module in the example control system is series A, firmware revision 2.003.

For 1756 communication modules, series level and firmware revision determine the maximum packet rate capacity. For more information, see Table 13 on page 67.

Figure 8 - Example ControlLogix System over an EtherNet/IP Network



You also can use the EtherNet/IP Capacity Tool described on page 69 to make performance predictions.

Identify and Count Connections

Use your design to identify and count the total number of these connections for each EtherNet/IP communication module in your system. Performance prediction is done on a CIP connection basis.

This table describes how to count connections for an **EtherNet/IP communication module**, regardless of whether it is in a local or remote chassis.

Connection Type	Count Calculation Method
Produced tag between controllers	Number of consumers
Consumed tag between controllers	Number of tags consumed
Rack-optimized connections	Number of chassis to which the controller is making a rack-optimized connection
Direct connections	Number of devices to which the controller is making a direct connection, such as drives or I/O modules

IMPORTANT The table above is used to calculate connections used by an EtherNet/IP communication module.

To calculate connections used on a Logix5000 controller, see Logix5000 Controllers Produced and Consumed Tags Programming Manual, publication 1756-PM011.

Use this table to count the connections for the EtherNet/IP communication module in the example system shown on page 84.

Communication Module	Connection Type	Total
Local 1756-EN2T communication module	Produced tag between controllers	1 (Number of consumers)
	Rack-optimized connections to digital I/O modules	1 x 1 = 1 (Number of chassis to which a rack-optimized connection is made x Number of rack-optimized connections made to the chassis)
	Direct connections to analog I/O modules	2 x 1 = 2 (Number of remote analog modules to which a direction connection is made x Number of connections per remote analog module)
Remote 1756-EN2T communication module	Consumed tag between controllers	1 (Number of tags consumed)
	Rack-optimized connections to digital I/O modules	1 x 1 = 1 (Number of chassis to which a rack-optimized connection is made x Number of rack-optimized connections made to the chassis)
	Direct connections to analog I/O modules	2 x 1= 2 (Number of remote analog modules to which a direction connection is made x Number of connections per remote analog module)

Each 1756-EN2T communication module in the example system uses four connections.

Calculate Packets/Second

All EtherNet/IP communication modules have a packet rate capacity, that is, maximum number of packets/second it can send. You must calculate the number of packets/second that each EtherNet/IP communication module in the control system is sending when predicting system performance.

The number of packets/second an EtherNet/IP communication module sends in a control system depends on the number of each CIP connection type being sent and the RPI for that connection.

CIP Connection Type[1]	Packets/Second Calculation Method
Produced/consumed tags[2]	At producer: (1 + number of connections)/RPI for each produced tag
	At consumer: 2/RPI for each consumed tag
Rack-optimized connection	(2 x number of connections)/RPI
Direct connection	(2 x number of connections)/RPI

(1) This method applies when application conditions are configured such that the heartbeat connection RPI equals the produced tag RPI. With the Studio 5000 environment, version 16.03.00 and later, the heartbeat RPI can be configured to a value different from the produced tag RPI. This option decreases the bandwidth utilization on resources, such as the EtherNet/IP communication module or controller. For more information see Knowledge For more information, see Rockwell Automation Knowledgebase answer ID 38535. You can access the Knowledgebase at http://www.rockwellautomation.com/knowledgebase/.

(2) Producer and all consumers are in different chassis and operate at a uniform RPI.

For each EtherNet/IP communication module, the total is the sum of the above calculations. This total must not exceed the recommended 90% limit.

We recommend you allocate bandwidth as follows:

- Reserve 10% of each EtherNet/IP communication module's packet rate capacity for the processing of explicit messages.

IMPORTANT	Not reserving at least 10% of each EtherNet/IP communication module's bandwidth can prevent you from going online with the Logix Designer application or be able to access the EtherNet/IP communication module's embedded web server. To remedy this situation, remove the EtherNet/IP communication modules from one or more chassis to reduce the EtherNet/IP network traffic in the overloaded EtherNet/IP communication modules. Then go online with the Logix Designer application to reconfigure the RPIs to a less frequent (slower) rate.

- The total for implicit messaging must not exceed 90% of capacity for each EtherNet/IP communication module.

Use this table to count the total packets/second sent for each EtherNet/IP communication module in the example system shown on page 84.

Communication Module	Connection Type	Packets/Second
Local 1756-EN2T communication module	Produced tag between controllers	(1 + 1)/20ms = **100**
	Rack-optimized connections	(2 x 1)/20ms = **100**
	Direct connections	(2 x 2)/50ms = **80**
		Module total packets/second = **280**(1)
Remote 1756-EN2T communication module	Consumed tag between controllers	2/20ms = **100**
	Rack-optimized connections	(2 x 1)/20ms = **100**
	Direct connections	(2 x 2)/50ms = **80**
		Module total packets/second = **280**(1)

(1) A 1756-EN2T/ A module, firmware revision 2.003 has a packet rate capacity = 10000 packets/second. When sending 280 packets/second, the module in the example system uses approximately 3% of its packet rate capacity, well below the recommended maximum of 90% of the module's packet rate capacity.

In addition to the configurable RPI parameter, you control system includes the Actual Packet Interval (API). The API is the actual time that requested data is delivered.

The relationship between the RPI and API in your system depends on the controller initiating the communication. In general, these controller types calculate the API as follows:

- ControlLogix: API = RPI
- 1768 CompactLogix: API = RPI
- CompactLogix 5370 controllers, SoftLogix™: API = RPI
- 1769-L23E*x*, 1769-L3*x*E: API = 2^n (where 2^n is a value that is a power of 2, for example, 2, 4, or 8, that is equal to or faster than the RPI you configured)

IMPORTANT In most cases, you can get data faster than the RPI you configured. This increased data transmission rate can increase the number of packets to be more than you expected based on the RPI.

Therefore, the percentage of the EtherNet/IP communication module's packet rate capacity used can be slightly higher than expected.

Estimate the Fastest RPI

The fastest RPI for an EtherNet/IP communication module is calculated with this formula:

$$RPI_{(Fastest)} = (2 \times connections)/pps$$

IMPORTANT It is not necessary to operate at the fastest RPI.

Example One

A 1756-EN2T module, firmware revision 3.6 or later, supports 25,000 pps. If there are only 40 connections that are all at the same RPI, the fastest RPI is the following:

$$RPI_{(Fastest)} = (2 \times 40)/25{,}000 = 3.2 \text{ ms}$$

Example Two

Assume there are 23 connections running at an RPI of 2 ms on a 1756-EN2T module, firmware revision 3.6 or later, that supports 25,000 pps. These connections are already using some of the communication packets:

$$pps = (2 \times 23)/0.002 = 23{,}000 \text{ pps}$$

The fastest RPI possible for a fourth connection is the following:

$$RPI_{(Fastest)} \text{ for } 4^{th} \text{ connection} = (2 \times 1)/(25{,}000\text{-}23{,}000) = 1 \text{ ms}$$

The same concept can be used for produced tags and consumed tags by replacing the (2 x connections) with (1 + connections) for produced tags or (2/RPI) for consumed tags.

Estimate Maximum Input or Output Times for CIP Connections

System response is dependent on several factors. These are the dominant factors:

- RPI value
- Number of implicit CIP connections.

To simplify, the response time of a connection can be approximated with only the RPI.

The maximum input (I/O to controller) or output (controller to I/O) times for implicit CIP connections can be estimated as follows:

- Rack-optimized: 1 RPI
- Direct Connect:
  - Digital = 1 RPI
  - Analog (nonisolated) = 2 RTS (Real Time Sampling rate)
  - Analog (isolated) = 1 RTS
- Produced/Consumed Tag = 1 RPI

The above response times are estimates. For more accurate numbers, include system delays, as described in Refine Estimates on page 99.

Example: Predict System Performance

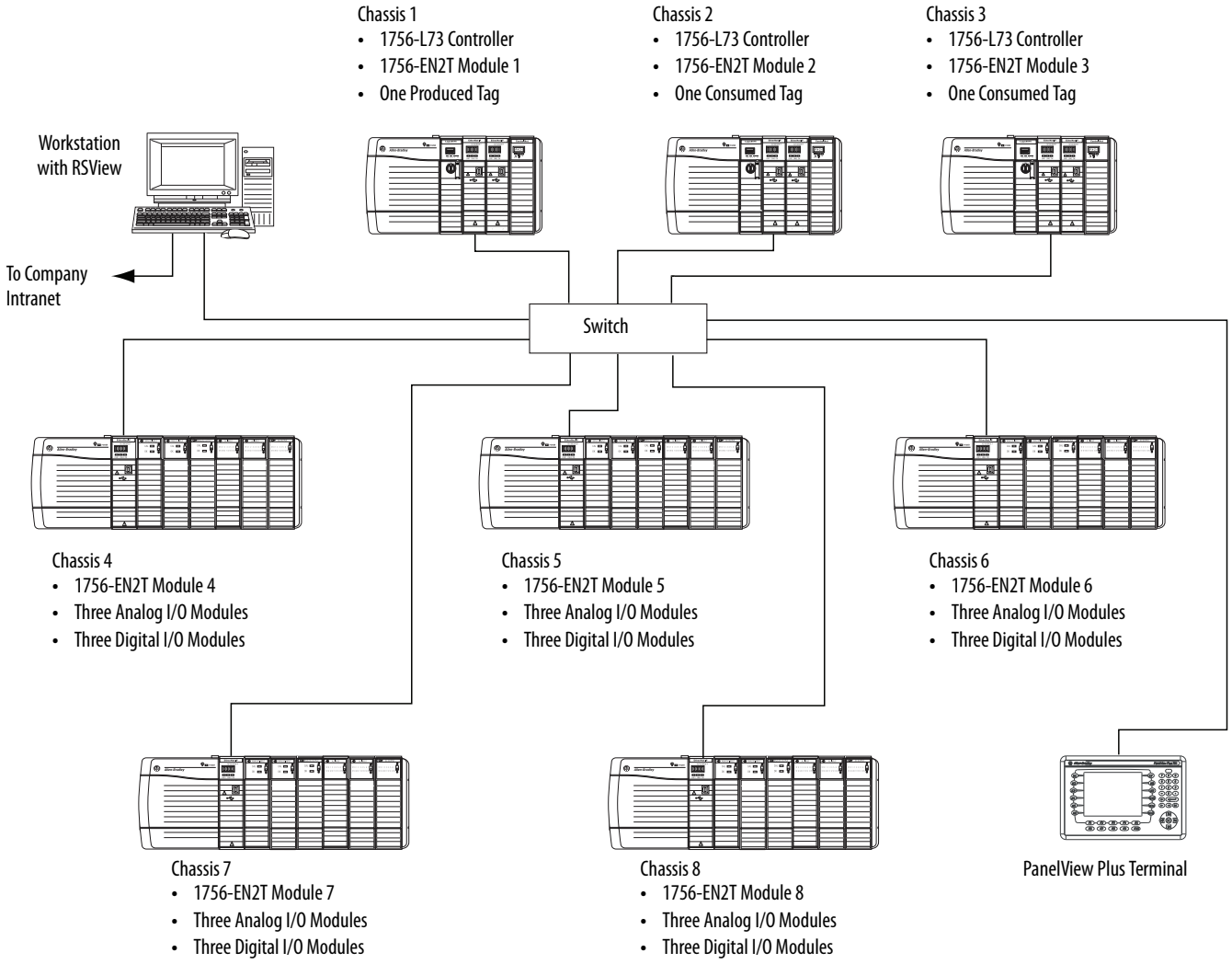
This example ControlLogix system has the following components:

IMPORTANT The information in the remainder of this section shows how to compute system performance with ControlLogix controllers.

- 1756-L73 controller in chassis 1 that executes these tasks:
  - Produces a tag that 1756-L73 controllers, in chassis 2 and 3 respectively, consume at an RPI = 20 ms
  - Controls remote I/O in chassis 4...8
- 1756-L73 controllers in chassis 2 and 3 consuming a tag from the controller in chassis 1
- Eight 1756-EN2T/A communication modules, firmware revision 2.003, one module in each chassis
- Fifteen digital I/O modules with rack-optimized connections at an RPI = 20 ms, 3 modules in each chassis 4...8
- Fifteen analog I/O modules across five remote chassis with direct connections at an RPI = 50 ms, three modules in each chassis 4...8
- PanelView Plus terminal with a direct connection to an array of 40 tags at an RPI = 100 ms and an explicit connection to an array of 100 tags sent every 300 ms
- Workstation running FactoryTalk View SE software, requiring explicit messaging of an array of 1500 tags every 100 ms. This workstation also connects to the company Intranet

Determine If System Has Sufficient Bandwidth to Meet Application Requirements

Based on the system requirements, the initial network diagram is shown below:



IMPORTANT: Each chassis with three analog and three digital I/O modules, that is, chassis 4…8, uses these connections:

- Three direct connections (one for each analog I/O module in the chassis)
- One rack connection (one for all digital I/O modules in the chassis)

Explicit Messaging

The RSView® and PanelView Plus messages are explicit messages. Reserve 10% of the bandwidth of the EtherNet/IP communication module for explicit messaging.

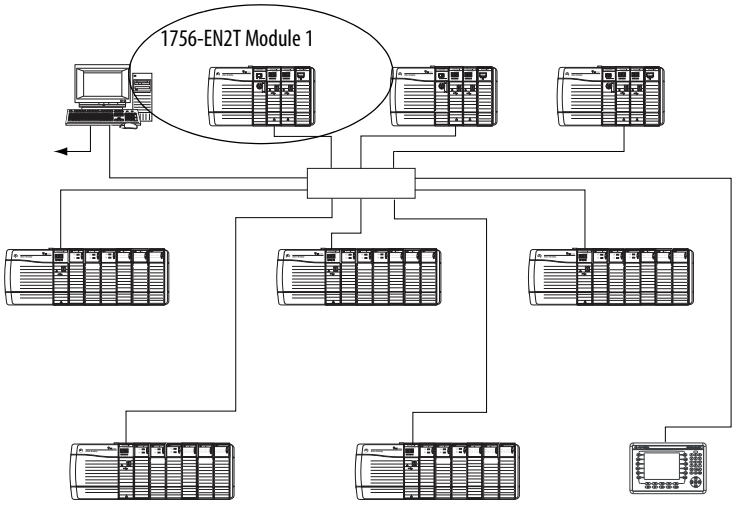
EtherNet/IP Interface	Total Bandwidth	10% Reserve for Explicit Messaging
1756-ENBT	5000 pps	500 pps
1756-EN2F 1756-EN2T 1756-EN2TR 1756-EN2TXT 1756-EN3TR	The pps for these modules depends on the module's series and firmware revision. The modules support this pps: • Series A, firmware revision 2.*x* or earlier = 10,000 pps • Series A or later, firmware revision 3.6 or later= 25,000 pps For more information on the pps supported by these modules, see Table 12 on page 66.	One of the following: • Series A, firmware revision 2.*x* or earlier = 1000 pps • Series A or later, firmware revision 3.6 or later= 2500 pps
1768-ENBT	5000 pps	500 pps
1769-L23E*x*	2000 pps	200 pps
1769-L32E 1769-L35E	4000 pps	400 pps
1769-L30ER	6000 pps	600 pps
1769-L30ERM		
1769-L30ER-NSE		
1769-L33ER		
1769-L33ERM		
1769-L36ERM		
1769-L24ER-QB1B		
1769-L24ER-QBFC1B		
1769-L27ERM-QBFC1B		
1769-L16ER-BB1B		
1769-L18ER-BB1B		
1769-L18ERM-BB1B		
1788-ENBT	5000 pps	500 pps
1734-AENT	5000 pps	500 pps
1794-AENT	9500 pps	950 pps

Explicit messaging throughput is also dependent upon network availability and target availability. Therefore, reserving 10% of the total bandwidth does not guarantee throughput.

Next determine if each EtherNet/IP communication module has enough bandwidth to handle the implicit messaging.

EtherNet/IP Module Serving as a Scanner

EtherNet/IP module 1 functions as a scanner.



EtherNet/IP module 1, in the chassis with the main controller, must perform these tasks:

- Communicate with five remote I/O chassis. The EtherNet/IP module connects to the I/O modules in each chassis this way:
  - One rack-optimized connection to digital I/O modules at an RPI = 20 ms
  - Three direct connections to three analog I/O modules at an RPI = 50 ms
- Communicate with the PanelView Plus terminal via direct connections at an RPI = 100 ms
- Communicate with the two other controllers with a produced tag at an RPI = 20 ms
- Perform explicit messaging

Fill in the worksheet for this module as follows.

EtherNet/IP Module ID: 1	
Rack-optimized Connections 5 @ 20 ms **(for digital I/O modules)**	
= (2 x connections)/RPI	
= (2 x 5)/ 20 ms =	500
Direct Connections 15 @ 50 ms **(for analog I/O modules)**	
= (2 x connections)/RPI	
= (2 x 15)/ 50 ms =	600
Produced Tag Connections 2 @ 20 ms	
= (1 + connections)/RPI for each produced tag	
= (1 + 2)/ 20 ms =	150
Consumed Tags 0	
= 2/RPI for each consumed tag	
=	N/A
Total Packets Per Second	1250

The total of 1250 is well within the 1756-EN2T/A module's, firmware revision 2.003, remaining bandwidth of 9000 pps. The total of 22 CIP connections is well within the 1756-EN2T/ A module's, firmware revision 2.003, capacity of 256 CIP connections.

PanelView Plus/FactoryTalk View Connection Considerations

PanelView Plus terminals and workstation with FactoryTalk View software use RSLinx Enterprise software for communication with a Logix controller. RSLinx Enterprise software can open 2...5 CIP connections to a single Logix-based controller, based on the number of tags currently on scan.

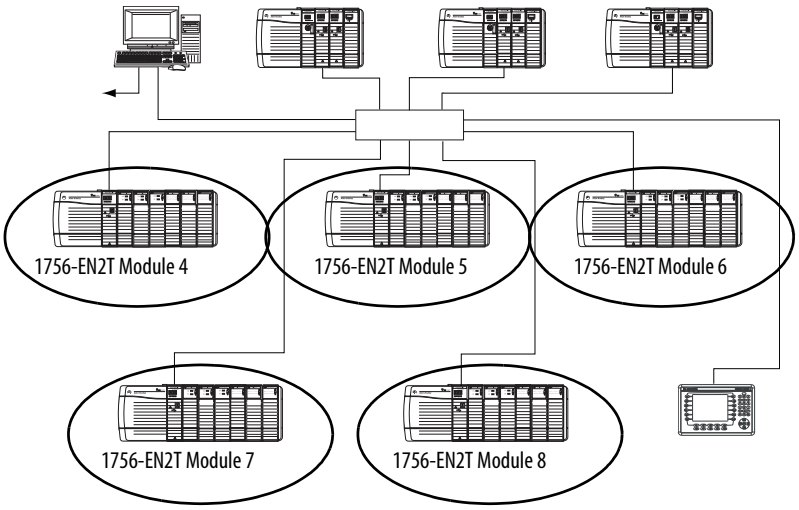
RSLinx Enterprise software opens up to four CIP connections for tag reads, based on the volume of tags requested. If a small number of tags are on scan at one time, for example, 80 DINT tags, only one CIP connection is opened. If a larger number of tags are currently on scan, for example, 320 DINT tags, four CIP connections are opened for reads.

Only a single CIP connection is opened for all tag writes.

For more information on determining the number of CIP connections required by a given application, see Rockwell Automation Knowledgebase article 39366. You can access the Knowledgebase at http://www.rockwellautomation.com/knowledgebase/.

EtherNet/IP Modules Functioning as Adapters

EtherNet/IP modules 4...8 function as adapters.



Each EtherNet/IP module functioning as an adapter in an I/O chassis, that is, 1756-EN2T EtherNet/IP communication modules 4...8 in the example on page 91, has these connections:

- One rack-optimized connection for digital I/O modules in its chassis.

  The digital I/O has a required RPI = 20 ms
- Three direct connections for analog I/O modules in its chassis.

  The analog I/O has a required RPI of 50 ms.

For example, use the worksheet in Appendix A for each of the five EtherNet/IP modules as follows.

EtherNet/IP Module ID: 4 - 8

Rack-optimized Connections 1 @ 20 ms

= (2 x connections)/RPI

= (2 x 1)/ 20 ms = 100

Direct Connections 3 @ 50 ms

= (2 x connections)/RPI

= (2 x 3)/ 50 ms = 120

Produced Tag Connections 0

= (1 + connections)/RPI for each produced tag

= N/A

Consumed Tags 0

= 2/RPI for each consumed tag

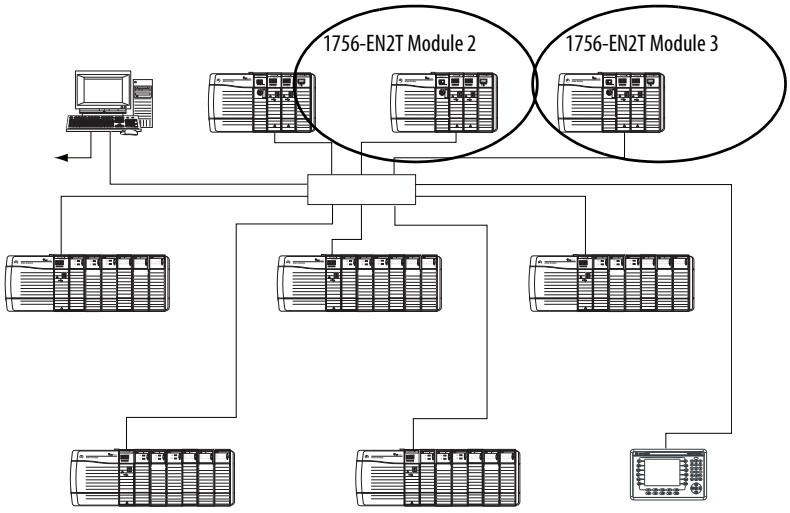
= N/A

Total Packets Per Second 220

The total pps of 220 is well within the 1756-EN2T/A module's, firmware revision 2.003, remaining bandwidth of 9000 pps.

EtherNet/IP Modules 2 and 3 with Consumed Tags

EtherNet/IP modules 2 and 3 interface two consumer controllers to the network.



Each of these controllers consumes one produced tag at an RPI = 20 ms.

Either of these EtherNet/IP modules uses these connections.

	EtherNet/IP Module ID: 2 or 3
Produced Tag Connections 0	
= (1 + connections)/RPI for each produced tag	
=	N/A
Consumed Tags 1 tag @ 20 ms	
= 2/RPI for each consumed tag	
= 2/20 ms =	100
Total Packets Per Second	100

The total of 100 pps is well within the 1756-EN2T/A module's, firmware revision 2.003, remaining bandwidth of 9000 pps.

Recommendations to Achieve More Throughput in an Existing Control System

Unlike the configuration of the last example control system, some control system configurations do not initially have enough bandwidth to achieve the desired throughput.

If you determine your control system does not have the bandwidth to achieve the desired throughput, you need to modify your system. We recommend that you use one of these tasks described in step 5 on page 81, to increase system throughput.

Estimate the Maximum Input or Output Times for CIP Connections

Calculate the worst-case, maximum input (I/O to controller) or output (controller to I/O) times for CIP connections in your system.

For a **Rack-optimized Connection,** the maximum input or output time for a CIP connections is estimated as follows:

$$T_{MAX\ (Rack\text{-}optimized)} = RPI = 20\ ms$$

For the **Direct Connect Analog Modules**, assume non-isolated modules with the real-time sampling (RTS) rate equal to the RPI, that is, 50 ms. Therefore, the maximum input or output time is estimated as follows:

$$T_{MAX\ (Analog\ Non\text{-}Isolated)} = 2RTS$$

$$= 2 \times 50\ ms = 100\ ms$$

Isolated modules have an RTS rate of 1RTS.

For a **Produced or Consumed Tag**, the maximum input or output time is estimated as follows:

$$T_{MAX\ (Produced/Consumed\ Tag)} = 1RPI$$

$$= 1 \times 20\ ms = 20\ ms$$

Assume that these times are acceptable for the example application. If you find that the times for your system are too slow, you can make adjustments to operate at faster RPIs. This can require choosing I/O modules that operate at faster data rates, adding more EtherNet/IP communication modules, and/or other changes as outlined in step 5 on page 81.

No further modifications have been made, so the system is complete.

Refine Estimates

To further increase the accuracy of these times, include considerations for system delays.

For a **Rack-optimized Connection**, to the RPI, add these delays:

$$T_{MAX\ (Rack\text{-}optimized)} = \text{input filter} + \text{RPI} + \text{transmission} + \text{switch} + \text{queue}$$

See the table for descriptions of delay types with a rack-optimized connection.

Type of Delay	Description
Input Filter	Discrete input modules have filters. The default for a 1756 discrete I/O module is 1 ms. For The default for a FLEX discrete I/O module is 0.25 ms. input delay = 1 ms There are no filters for outputs, so there is no additional delay for outputs. Outputs are always sent via an RPI timer.
Transmissions	The transmission delay is the interval of time that it takes a packet to be transmitted at a specific bit rate, for example, 100 Mbps. For example, in a 7-slot ControlLogix chassis, the size of the entire packet is approximately 122 bytes (including header, all protocols, all data, and CRC). At 100 Mbps, this packet takes approximately 10 microseconds. (0.01 ms) on the wire. transmission delay = 0.01 ms x (number of CIP connections)
Switch	Switch latency is the delay between reception of the first bit and transmission of the first bit. This delay depends on the type of switch. It is typically 0.1 ms. switch delay = 0.1 ms
Queue	Input data is sent from the remote rack (adapter), through a switch, through a communication module in the controller rack, and finally to a controller (scanner). If two or more input CIP connections are simultaneously ready to be transmitted, they must be transmitted sequentially. It takes 0.2 ms for a 1756-ENBT to process 1 implicit packet. Note that 0.2 ms is equal to the reciprocal of 5000 (pps). The total queue delay is 0.2ms times the number of CIP connections through the module. queue delay = 0.2 ms X (number of CIP connections)

For the **Direct Connect Analog Modules**, you add the same transmission, switch, and queue delays as for rack-optimized data:

$$T_{MAX\ (Analog\ Non\text{-}Isolated)} = 2RTS + \text{transmission} + \text{switch} + \text{queue}$$

For a **Produced or Consumed Tag**, you add the same transmission, switch, and queue delays as for rack-optimized data:

$$T_{MAX\ (Produced/Consumed\ Tag)} = 1RPI + \text{transmission} + \text{switch} + \text{queue}$$

Notes:

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