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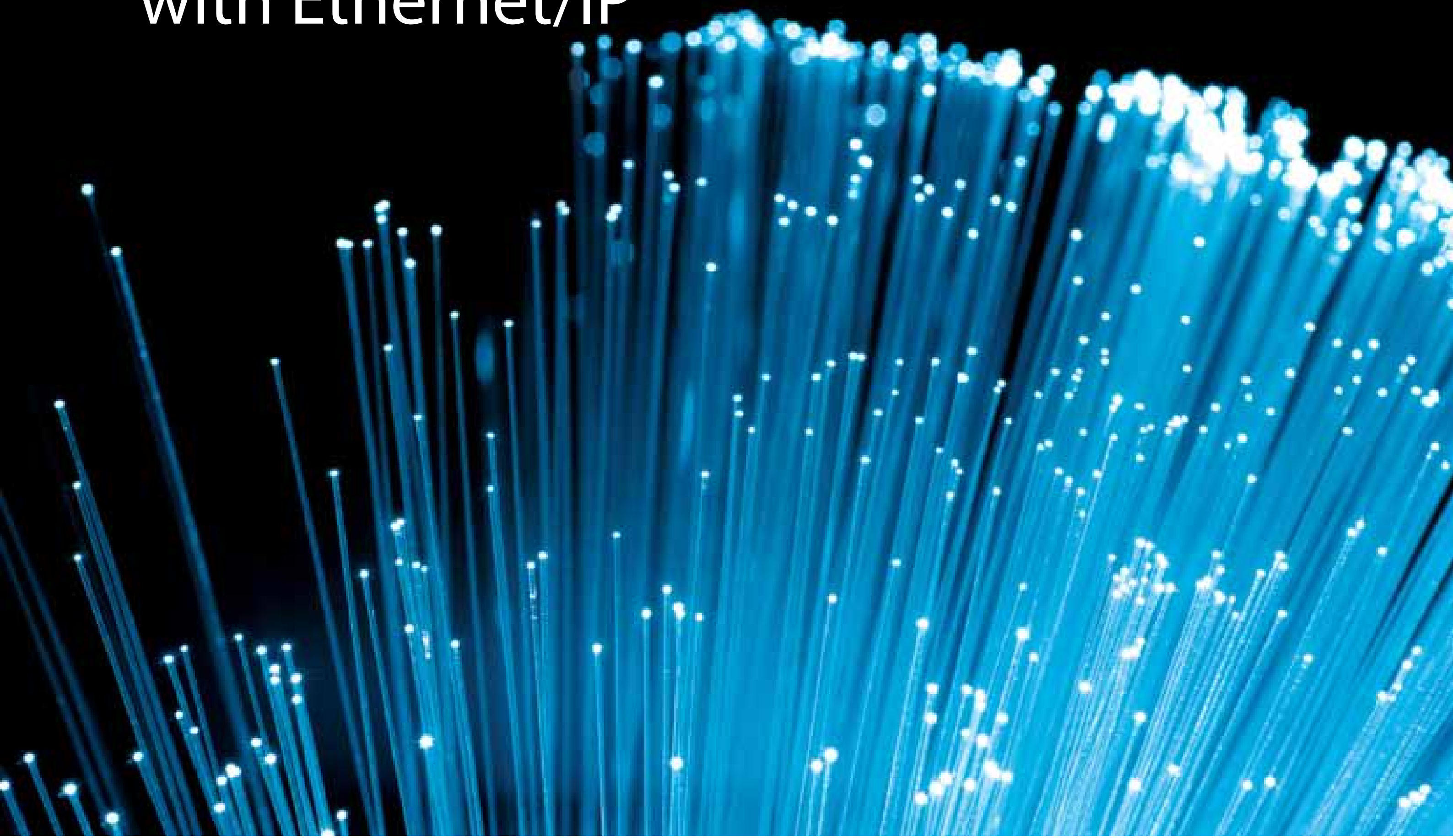
Technical News

INDUSTRIAL SWITCHGEAR & AUTOMATION SPECIALISTS

Industrial networking with Ethernet/IP



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In industrial automation, communication is critically important. The need for data exchange between sensory devices, actuators, human-machine interfaces (HMIs), programmable logic controllers (PLCs), remote input/output (I/O) platforms and supervisory (SCADA) systems has led to the development of a very wide range of electronic communications methods.

Certain protocols and media are better suited for certain types of communication. The simplest communications in a plant are typically simple voltage levels and electrical currents transmitted over copper wire. For high-speed transmission of higher volumes of data, complex multi-layer protocols are typically used over copper or fibre-optic media.

NHP offers connectivity to every commonly used industrial protocol in our market. This can be important, as existing installations have a wide range of protocols in use on-site.

This article focuses on the implementation of one such multi-layer protocol, Ethernet/Industrial Protocol (IP). This protocol is well suited to enabling communication between PLCs, remote I/O platforms, HMIs and SCADA systems, over category 5e (CAT5e) copper media and fibre optic media.

WHAT IS ETHERNET/IP?

Ethernet/IP is one of three network adaptations of the Common Industrial Protocol (CIP) that NHP offers. The other two are DeviceNet, which is a CAN-based network typically used for PLC to device communication, and ControlNet, which is a deterministic network often used for time-critical data. Within CIP, the upper layers are identical – differences exist in the lower layers, from transport layer down to physical media layer.

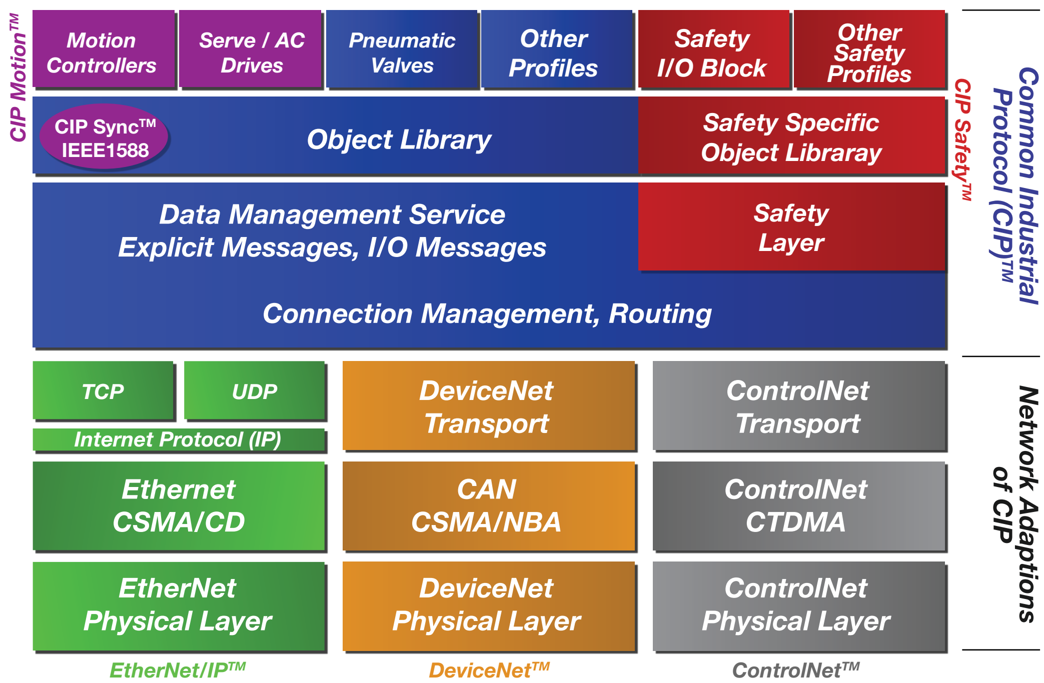

Fig. 1 - Structure of Common Industrial Protocol (CIP) networks

COPPER PHYSICAL MEDIA

Copper media (twisted pair cable) terminating in RJ45 connectors is the most common physical media selection for Ethernet networks. This is the standard connector used in IT environments, and is used as the connection system in the vast majority of cases on Rockwell Automation products with Ethernet/IP connectivity.

Where using copper media, it is recommended that the designer use CAT5e Ethernet cables designed for industrial environments. While it is possible to use standard blue CAT5e cable as you would find in a commercial setting, this media is not physically robust, and is typically ill-suited to industrial environments. Options including UV-resistance, noise shielding and weld-spatter resistance are available on request. Some important limitations of copper media to note are:

- **IP20 rated:** An IP67 rating is possible using M12 connectors, but standard RJ45 connectors need to be protected from dust and water ingress. If high IP ratings on the Ethernet media are required for connection to I/O in the field, the ArmorPoint system will suit the task.
- **Distance limitation:** Ethernet/IP over CAT5e copper media will work in environments with low electrical noise to a distance of up to 100m. Beyond this distance, the signal may not be reliable. Fibre optic media resolves this issue, and will allow connections without repeaters of up to 10 km depending on switch and media selection.
- **Noise susceptibility:** Unshielded copper cable carrying data at high speed is susceptible to electrical noise. If high current carrying cables (for example power cables to drives) or electrically noisy processes are near copper media, communication speed will be compromised due to lost packets, and effective communication distances will be reduced. In some particularly noisy environments, copper media will simply not work at all. The solution to this issue is fibre-optic media, which is not susceptible to electrical noise.
- **Outdoor installations:** As with any copper communications cable, if laid in the ground between buildings lightning strikes near the cable run can induce high spike currents that may destroy equipment at both ends. The solution is fibre optic cable, which cannot carry induced currents.

Bearing in mind these limitations, copper media with RJ45 connectors is by far the easiest of the Ethernet media to implement, and should be considered before moving on to other options.

FIBRE OPTIC PHYSICAL MEDIA

Where connectivity is required over long distance, through electrically noisy environments, or between buildings, fibre optic media is the logical choice. Transmission is this media works by flashing light down glass or plastic fibres, and receipt is achieved with a photoelectric sensor. For each connection there are two cables, one for traffic in each direction. The fibre media connection system used with all of the switches and modules NHP offers are LC connectors, which is an industry standard.

The key options when selecting fibre optic media components are the choices between single mode fibre and multimode fibre as the media, and the choice of maximum bandwidth of either 100Mb/s or 1Gb/s. With multimode fibre, hardware costs are lower, and achievable distances are shorter. With single mode, costs are higher, and achievable distances are higher. The same rationale applies to bandwidth, lower speed connections are less expensive.

UNMANAGED SWITCHES

When any architecture is needed that is more complex than one node connecting to one other node, a switch or switches will be needed. Switches are devices with multiple Ethernet ports that allow connections between nodes to be electronically made and broken, permitting communication as required between nodes on the network.

Unmanaged switches provide simple functionality, and are suited to small jobs with limited required data flow. They are also suitable for sections of networks segmented by managed switches. The key limitation of unmanaged switches as compared to managed is that they provide no constraint of multicast traffic. What one node transmits, all connected nodes receive, regardless of whether they are the intended recipient or not. This can mean that if one node broadcasts an excessive amount of information (known as broadcast storming) a network based solely on unmanaged switches can fail. Most Rockwell Automation products are multicast tolerant, up to a certain level – if in doubt, consult technical data for the specific product concerned. Another important feature of unmanaged switches is a lack of programming and diagnostic tools. They are simply plug and play, which is good for rapid set up times and low cost implementations, but not useful if network analysis is required.

MANAGED SWITCHES

Managed switches include a range of features designed to overcome the multicast issue and to provide a wide range of diagnostic capabilities. These features include Port mirroring, IGMP Snooping, Port diagnostics, Web browser support, Forced speed and duplex, SNMP support, Rate limiting, Trunking, Portfast and support for VLANs. Managed switches should be used wherever a connection to an IT environment is needed, wherever connection to hardware that is not multicast tolerant is required, and wherever any architecture is required that goes beyond a handful of devices.

RJ45 connector, the termination typically used for copper physical media.

Unmanaged switch, from the Stratix 2000 range

Managed switch hardware, from the Stratix 8000 range

NETWORK ARCHITECTURES

Three basic topologies are supported; star, linear and ring.

Star topology

Star topology is the simplest - this is a switch in the centre of a collection of hardware, with patch cords connecting each device to the switch. In simple applications, an unmanaged switch will serve this purpose –networking a MicroLogix 1400 PLC, a PanelView Component HMI, and a PowerFlex 40 drives ***(Fig. 2)*** could be done with a simple unmanaged switch, such as the 1783-US05T.

In more complex applications, a managed switch should be used in a star configuration ***(Fig. 3)*** with a managed switch (1783-MS10T), connections to two HMIs, a PLC, some remote I/O, a radio, a power monitoring unit, two drives and an unmanaged switch.

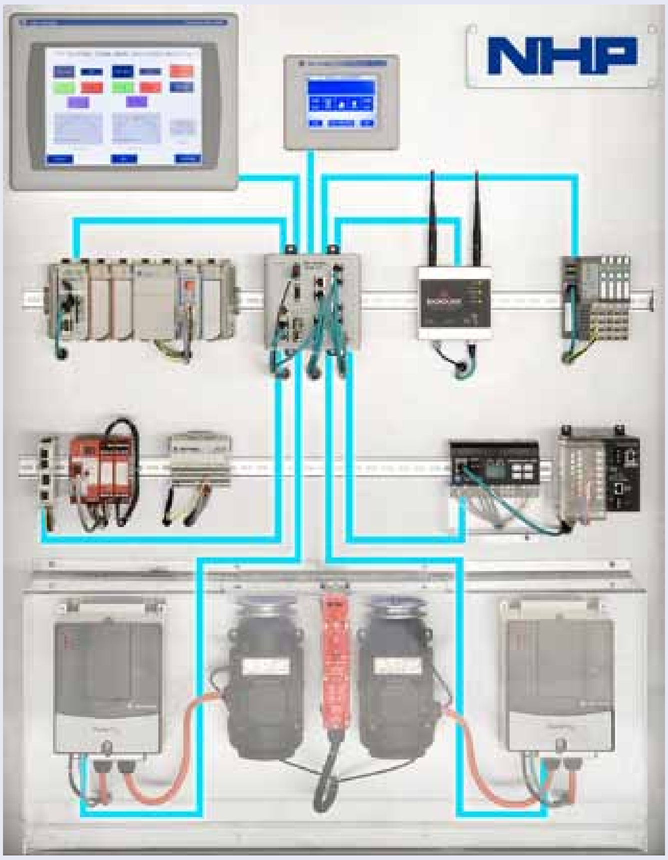

Figure 3:
Star topology; managed switch

Figure 2:
Star topology; unmanaged switch

NETWORK ARCHITECTURES

Linear and ring topology

Linear topologies allow switches to be used like taps in a more traditional network. This permits connection from one location to the next, which avoids the need to wire everything all the way back to one switch. This also allows networks on copper to extend to greater distances. The distance between each switch must be less than 100 metres, but the total distance is not restricted in this manner. In this layout, each switch in the linear arrangement acts like a booster for the signal.

If the linear topology requires redundancy, then each switch or device needs two ports. This can be achieved by using a managed switch at each location or by using devices that have embedded switch technology ***(Fig. 5)***. If the device doesn't have embedded switch technology it may be interfaced using an EtherNet/IP Tap ***(Fig. 5)***. In the event that this approach is being taken, a logical step is to close the linear topology by providing a link from the end of the linear run back to the start. This creates a ring, which is the next topology type.

Ring topologies are used where redundancy is required. The concept is that if one link (i.e., one of the connections between devices) of the ring is lost, all elements on the ring can still communicate with each other. In the event of a cable breakage, the communications automatically re-negotiate an alternative path around the ring. It is also possible to alert operators to the fact that a link has been lost so that corrective action can be taken before another link is lost, which would result in some loss of communication.

A simple device level ring can be implemented by creating a ring using devices that have embedded switch technology and EtherNet/IP taps. The ring can be created using fibre or copper medium, different models of the EtherNet/IP Taps have multiple combinations of fibre and copper ports.

This example uses three EtherNet/IP Taps (1783-ETAP2F), two ControlLogix EtherNet/IP cards with embedded switch technology (1756-EN2TR), one Point I/O EtherNet/IP Adapter with embedded switch technology (1734-AENTR) and an Armor Point I/O EtherNet/IP Adapter with embedded switch technology (1738-AENTR).

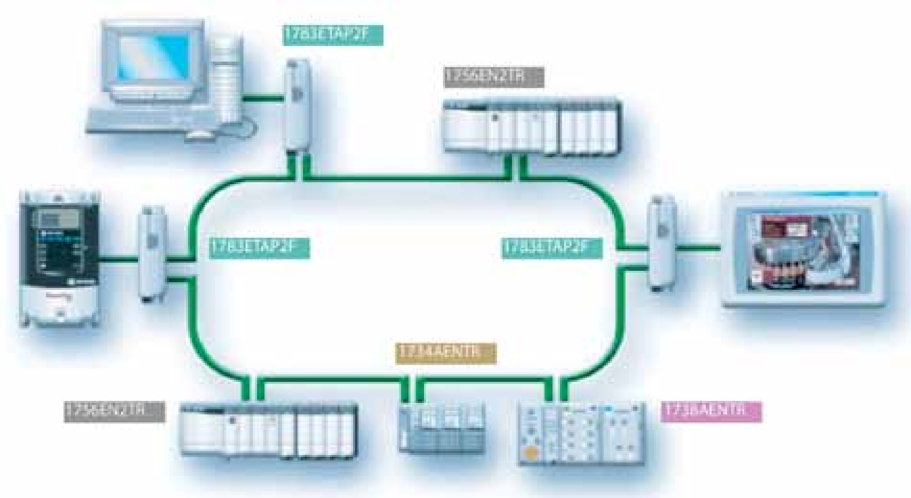

Figure 5:
Ring topology using Ethernet/IP taps, and devices incorporating embedded switch technology

CONCLUSION:

Ethernet networking is becoming the pre-eminent means of achieving connectivity between elements of industrial automation systems. Ethernet/IP is a leading implementation of Ethernet networking for industry, and is supported by over 150 vendors. NHP stands ready to meet your Ethernet networking needs, and looks forward to working with you.

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