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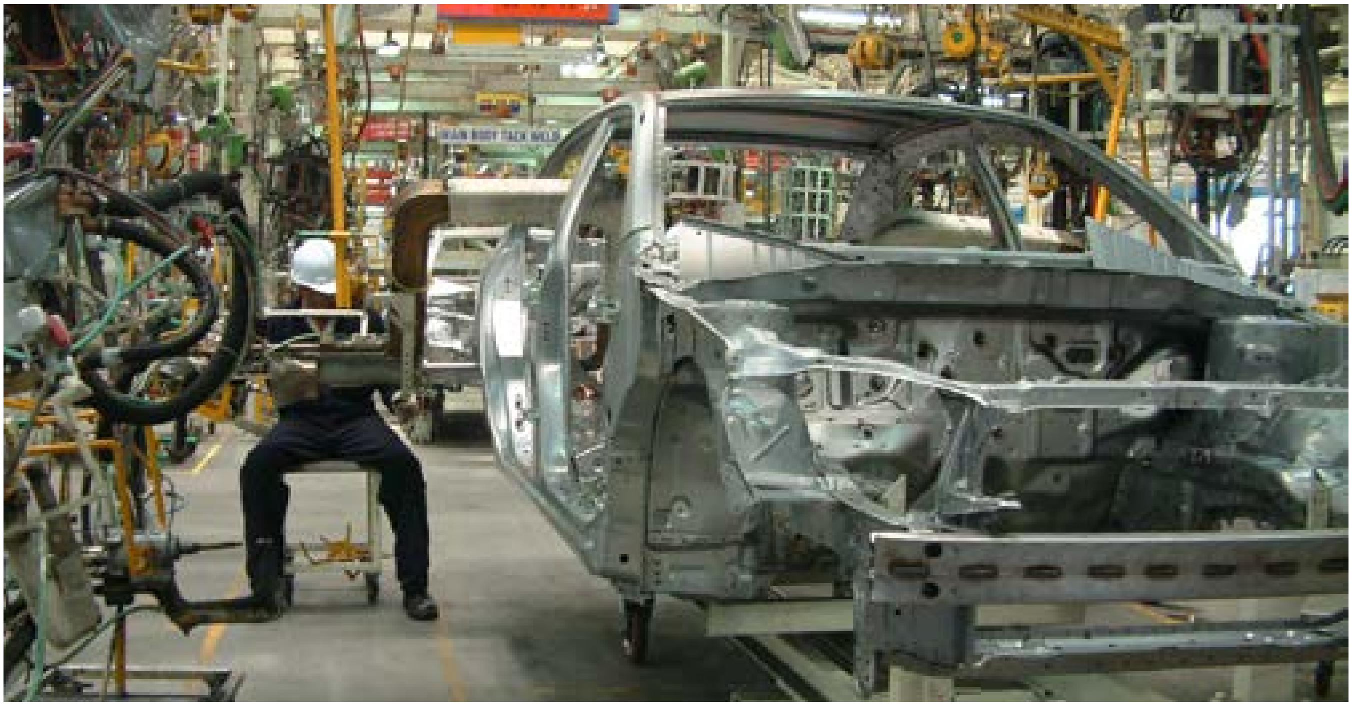
Elevating Ethernet Intelligence: Implementing Ethernet Technology in Industrial Applications

White Paper - W1004



Manufacturers are faced with the constant demand to increase productivity and reduce operating costs. A powerful industrial tool being implemented today to streamline production is reliable, enterprise-wide connectivity, providing the highest level of visibility, control and flexibility. To accommodate evolving networking requirements, such as decentralization of control, integrated diagnostics and simplified maintenance, network protocols integrate with industrial equipment and control systems to communicate crucial status updates and production data.

As practices migrate away from point-to-point topology, advanced architectures ensure connectivity, collaboration and integration from the device level to enterprise business systems.

With protocols available, each offering diverse features, benefits and performance capabilities, this white paper will assist users in selecting the ideal communication solution to suit individual application needs. Used to connect various machines, devices and office equipment, networks enable manufacturers to visually manage all production parameters for continuous and complete control over data—streamlining efficiency and minimizing production downtime. By understanding the need for enterprise connectivity, the various challenges and considerations associated with implementing network protocols, users can maximize data acquisition and management capabilities.

WHAT IS INDUSTRIAL ETHERNET?

Industrial Ethernet (IE) applies the Ethernet and Internet Protocol (IP) suite of standards developed for data communication to manufacturing control networks. It is based on the IEEE 802.3 standard, which is similar to Ethernet found in an office environment but adapted to an industrial environment for automation. This adaptation is not only an adaptation of the IEEE standard to industrial/automation environments, but also the adaptation of the hardware contained within the devices to withstand harsh environments that may have extreme temperature ranges, humidity and/or vibration that traditional office environment/IT equipment are not designed to withstand.

Many manufacturing companies maintain separate networks to support their factory floor operations and business operations. For example, the corporate IT network supports traditional administrative functions, the control-level network connects control and monitoring devices and the device-level network links the controllers with the plant floor's I/O devices. Instead of using separate networks, Industrial Ethernet can unite a company's administrative, control-level and device-level networks in a single network infrastructure.

OSI Reference Model

The Open Systems Interconnection (OSI) reference model describes how information from a software application in one computer moves through a network medium to a software application in another computer. The model was developed by the International Organization for Standardization (ISO) in 1984, and is considered the primary architectural model for intercomputer communications.

The OSI reference model divides the tasks involved in moving information between networked computers into seven smaller, more manageable task groups. These tasks are then assigned to seven layers in the OSI model. Each layer is self-contained so that the tasks assigned to it can be implemented independently.

The seven OSI layers include:

- **Application** layer consists of application programs that use the network
- **Presentation** layer standardizes data presentations to the applications
- **Session** layer manages sessions between applications
- **Transport** layer provides end-to-end error detection and correction
- **Network** layer manages connections across the network for the upper layers
- **Data Link** layer provides reliable data delivery across the physical link
- **Physical** layer defines the physical characteristics of the network media

The seven layers are stratified into two layers: upper and lower. The lower layers (physical, data link, network and transport) focus on data-transport functions while the upper layers (session, presentation and application) focus on the applications. While Ethernet technology refers to only the physical and data link layers, Industrial Ethernet encompasses the physical, data link, network and transport layers by using Internet Protocol (IP) addressing in the network layer and Transmission Control Protocol (TCP) in the transport layer. This is also known as the IP suite.

Internet Protocol (IP) Suite

The Internet Protocol (IP) suite is a set of protocols and standards used for the Internet and enterprise networks. It is commonly referred to as TCP/IP because of its most important protocols: Transmission Control Protocol (TCP) and Internet Protocol (IP).

IP is the primary network, defining the address by which the network can transmit the packet from its source to destination. IP provides connectionless delivery of datagrams or packets through a network and provides fragmentation and reassembly of datagrams to support data links with different maximum-transmission unit (MTU) sizes.

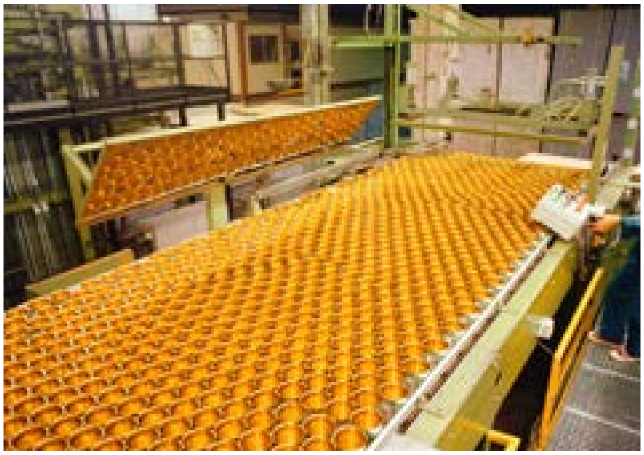
TCP provides reliable delivery of packets between two devices, relying upon IP. TCP establishes connections between applications, allowing them to send packets to each other. It also maintains the state after the packet is sent, ensuring all packets have arrived. Or if a packet is dropped, lost or corrupted during transmission, TCP can also request re-transmission.

TCP/IP has four layers, each with its own protocols:

1. Link layer (Ethernet) contains communication technologies for a local network
2. Internet layer (IP) connects local networks, establishing internetworking
3. Transport layer (TCP) handles host-to-host communication
4. Application layer (HTTP) contains all protocols for specific data communications services on a process-to-process level (I.e. how a web browser communicates with a web server)

SELECTING NETWORKING PROTOCOLS

When choosing a networking solution, users must understand the individual communication requirements as well as any environmental challenges present in each application. Evaluating the performance capabilities, features and characteristics of EtherNet/IP™, Modbus® TCP and PROFINET® assists manufacturers in selecting the ideal networking solution for their critical communication needs.



EtherNet/IP

Ethernet is a relatively new addition to the industrial arena. Developed with the primary purpose of conveying large amounts of information, it was originally relegated to office level networks, where multiple clients use the network to share information. Recently, Ethernet has expanded beyond traditional usage, and with the advent of EtherNet/IP, Ethernet has been implementing on the plant floor. Ethernet is a superior solution for data collection, transmission and monitoring.

EtherNet/IP is a communication protocol supported by the ODVA and is designed for use in industrial automation and process control applications. It takes the Common Industrial Protocol (CIP) and implements it onto the foundation of Ethernet. CIP envelops a wide-ranging suite of messages and services for a variety of applications, including safety, control, configuration and information. EtherNet/IP provides users with tools to deploy standard Ethernet technology for industrial applications.

With EtherNet/IP, the exchange of data is based on the producer/consumer model. This means that a transmitting device produces data on the network and multiple receiving devices consume this data simultaneously. Traffic generated during this data exchange can include input/output data and status updates produced by a remote device for consumption by one or more programmable controllers. Data collected and controlled via EtherNet/IP can use an unacknowledged method of sending information between devices on a network, which means that data delivery is not guaranteed. Therefore, to ensure delivery, a higher layer must be implemented prior to data transfer.

For enhanced industrial communication, Transmission Control Protocol/Internet Protocol (TCP/IP) provides a set of services so devices may communicate over an Ethernet network. With the increased prevalence of internet and intranets for internal information distribution, TCP/IP has grown, and has been transported to all major computer operating systems. A typical example of when a manufacturer would implement an Ethernet TCP/IP network is to extend communication plant-wide to connect to a corporation's worldwide network via the internet. Ethernet TCP/IP can take advantage of Ethernet's high capacity for data management to perform a wide variety of tasks, without requiring a high level of determinism or repeatability for message response time. Common TCP/IP applications include program maintenance, data transfer, web page retrieval, supervisory control, connectivity for operator interfaces and events and alarm recording.

Modbus TCP

Modbus TCP is a variant of the Modbus family of simple communication protocols intended for use with automation equipment. It covers the use of Modbus messaging in an environment using the TCP/IP protocols. Although it can be used in a variety of applications, the most common use of these protocols is for Ethernet attachment of PLCs, I/O modules and gateways to other field buses or I/O networks.

As stated in the previous section, TCP and IP protocols are used together and are the transport protocol for the Internet. When Modbus information is sent using these protocols, the data is passed to TCP where additional information is attached and given to the IP; the data is then placed in a packet and transmits it.

TCP must establish a connection before transferring data, since it is a connection-based protocol. The Master (or Client in Modbus TCP) establishes a connection with the Slave (or Server). The Slave waits for an incoming connection from the Master. Once a connection is established, the Slave then responds to the queries from the Master until the connection is closed.

Modbus TCP offers many advantages, including its openness, simplicity, low-cost development and minimum hardware required to support it. Operators can simply use standard PC Ethernet cards to communicate to implemented devices. Further, interoperability among different vendors' devices and compatibility with a large installed base of Modbus-compatible devices makes it an optimal protocol solution.

PROFINET

PROFINET is the open Industrial Ethernet standard of PROFIBUS and PROFINET International (PI) for automation. It uses TCP/IP and IT standards and complements them with specific protocols and mechanisms to provide real-time performance capabilities. PROFINET enables the integration of existing Fieldbus systems like PROFIBUS, DeviceNet and Interbus, without changes to existing devices. This makes it ideal for multiple industrial applications, including factory and process automation. It is also recognized as a standard in the automotive industry for machine building, food, packaging and logistics applications.

Featuring integrated, Ethernet-based communication, PROFINET satisfies a wide range of requirements, from data-intensive parameter assignment to synchronous I/O signal transmission. Further, PROFINET communication takes place over the same cable in all applications—whether it's a simple control task to highly demanding motion control applications.

PROFINET easily conforms to existing plant settings, eliminating the need for costly custom solutions. As it is based entirely on standard Ethernet, operators can easily combine wired and wireless transmissions. This allows WLAN and Bluetooth communication to be integrated into the solution, including for real-time data.

PROFINET offers several advantages in comparison to other protocols, including more flexibility to control automation devices, high-speed operation through real-time communication, simple network structure for easy implementation and cost-efficient technology.

PROFINET uses three different communication channels to exchange data with Programmable Controllers and other devices. The standard TCP/IP channel is used for parameterization, configuration and acyclic read/write operations. The Real Time (RT) channel is used for standard

cyclic data transfer and alarms. RT communications bypass the standard TCP/IP interface to expedite the data exchange with Programmable Controllers. The third channel, Isochronous Real Time (IRT) is the high-speed channel used for motion control applications.

THREE PROTOCOLS, ONE DEVICE

For a reliable solution across hardware platforms, these three protocols—EtherNet/IP, Modbus TCP and PROFINET—can be deployed in one device to create easier integration with host control systems. This can be applied in any application that uses a host system with Modbus TCP (client), EtherNet/IP (scanner) or PROFINET (master). Upon network power-up, the Ethernet device recognizes the network protocol available to the network, allowing only one Ethernet master to control the outputs while the input and diagnostic data is available to the other two protocols.

This technology eliminates the need to configure a device based on the Ethernet host system that will be deployed, ensuring easy device application, minimal maintenance and simplified product specification.

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