

## 1.0—What Is Industrial Ethernet?

---

### 1.1 Introduction

*Industrial Ethernet is the successful application of IEEE 802.3 standards with wiring, connectors, and hardware that meet the electrical noise, vibration, temperature, and durability requirements of factory equipment, and network protocols that provide interoperability and time-critical control of smart devices and machines.*

Industrial Ethernet is a specialized, rigorous application of standard “office Ethernet” technology that adds any or all of the following requirements:

- *Mission critical:* Downtime is much less tolerable in the factory than the office. When an office network goes down, you go get a cup of coffee and check your e-mail later. When a factory goes down, you choke down your last mouthful of coffee, run into the plant, and fix the problem as fast as possible! The effects of downtime are less isolated in a manufacturing facility.
- *Harsh environment:* Factory equipment is not usually installed in air-conditioned hall closets. It’s more likely to be bolted to a robotic welder or oil rig. Temperature extremes and vibration threaten garden-variety hardware, cables, and connectors. Device selection, installation, and proper wiring practices are crucial.
- *Electrical noise:* Ordinary 110 VAC circuits are not the norm in factories. Industrial Ethernet devices are often used with high-current 480 VAC power lines, reactive loads, radios, motor drives, and high-voltage switchgear. Network communication must continue reliably despite these hazards.
- *Vibration:* Industrial Ethernet “smart devices” are, by definition, mounted on machines. Machines move and shake. Velcro and “telephone connectors” may not be up to the task.
- *Powered devices:* Some devices must be powered by the network cable itself. Many automation devices operate at 24 VDC. New methods are in the works for powering these devices with Ethernet.
- *Security:* The data in your factory is not necessarily more worthy of protection than the data in your office, but the threats are different. Factory equipment is vulnerable to hackers, of course, but accidental disruptions created by yourself or your staff are much more likely. Specific precautions must be taken.

- *Legacy devices:* Real automation systems are a mix of new, nearly new, old, older, and pre-Mesozoic Era equipment from incompatible vendors. Industrial Ethernet must link serial protocols, legacy networks, and fieldbuses.
- *Interoperability:* Ethernet devices must communicate with each other, with PCs, and possibly with Internet/Web applications. The existence of an Ethernet jack is no guarantee of openness, interoperability, or compatibility. You must ask the right questions when making purchases.
- *Levels of priority:* Some machine-control information requires real-time, deterministic responses. Other data is much less urgent. It's important to recognize different priority levels for different kinds of data.
- *Performance:* Beyond physical robustness are subtle characteristics of software drivers, routers, and switches, such as hidden latencies, jitter, limited numbers of connections, and behavior under erratic conditions.
- *Connectivity to other local area networks (LANs):* Most Industrial Ethernet systems must be bridged to business intranets and the Internet. Serious problems can be introduced on both sides if this is not done with care.
- *The IT Department vs. the Automation Department:* Ethernet is precisely the place where two equally valid but conflicting views of “systems” and “data” come together. You must proceed with care to avoid a battle between company fiefdoms, all-out mutiny, or even a brand new pair of cement shoes.
- *Mastery of the basics:* No matter how good your equipment is, if you don't apply proper knowledge of Ethernet, Transmission Control Protocol/Internet Protocol (TCP/IP), and sound installation practices, your system will never work right.

*Industrial Ethernet* is a reference book that addresses each of these concerns and lays down the basic nuts and bolts of Ethernet and TCP/IP. After reading this book, you'll know the basics of the world's most popular network, you'll be able to plan Ethernet projects, and you'll know the right questions to ask when you talk to vendors.

*Ethernet* is the worldwide de facto standard for linking computers together. Ethernet connects hundreds of millions of computers and

smart devices across buildings, campuses, cities, and countries. Cables and hardware are widely available and inexpensive (“dirt cheap” in the case of ordinary office-grade products), and software is written for almost every computing platform.

Ethernet is now a hot topic in automation, where industry-specific networks have dominated: Profibus, DeviceNet, Modbus, Modbus Plus, Remote I/O, Genius I/O, Data Highway Plus, Foundation Fieldbus, and numerous serial protocols over the electrical standards of EIA RS-232, RS-422, and RS-485.

In some cases, Ethernet is displacing these networks. In nearly all cases, Ethernet is being used in demanding installations alongside them. This book gives a basic understanding of Ethernet’s strengths, weaknesses, fundamental design rules, and application guidelines. It addresses the unique demands of the factory environment, intelligent devices, and the most common automation applications and protocols. *Industrial Ethernet* provides basic installation and troubleshooting recommendations to help your projects work right the first time.

## **1.2 A Very, Very Short History of Ethernet and TCP/IP**

Ethernet originated at Xerox Palo Alto Research Center (PARC) in the mid-1970s. The basic philosophy was that any station could send a message at any time, and the recipient had to acknowledge successful receipt of the message. It was successful and in 1980 the DIX Consortium (Digital Equipment Corp., Intel, and Xerox) was formed, issuing a specification, *Ethernet Blue Book 1*, followed by *Ethernet Blue Book 2*. This was offered to the Institute of Electrical and Electronics Engineers (IEEE, [www.ieee.org](http://www.ieee.org)), who in 1983 issued the *Carrier Sense, Multiple Access/Collision Detect* (CSMA/CD) specification—their stamp of approval on the technology.

Ethernet has since evolved under IEEE to encompass a variety of standards for copper, fiber, and wireless transmission at multiple data rates.

Ethernet is an excellent transmission medium for data, but by itself falls short of offering a complete solution. A network protocol is also needed to make it truly useful and what has evolved alongside of Ethernet is TCP/IP.

The big push toward TCP/IP came in the mid-1980s when 20 of the largest U.S. government departments, including the U.S. Department of Defense, decreed that all mainframes (read: expensive computers) to be purchased henceforth required a commercially listed and available implementation of UNIX to be offered. The department didn't necessarily need to use UNIX for the project at hand, but after "the project" was completed, the government wanted the ready option to convert this expensive computer into a general-purpose computer.

This soon meant that all serious computer systems in the world had relatively interoperable Ethernet and TCP/IP implementations. So IBM had Systems Network Architecture (SNA), TCP/IP, and Ethernet on *all* of its computers. Digital (DEC) had DECnet, TCP/IP, and Ethernet on all of its computers. Add a few more examples (Cray, Sun, CDC, Unisys, etc.) and you soon see that the only true standard available on all computers was a TCP/IP plus Ethernet combination.

Both from a historical view as well as in today's industrial world, the TCP/IP plus Ethernet marriage is a key combination. Neither would have survived or prospered without the other.