# A layman's overview of **Ethernet** and **Ethernet/IP**

Ethernet refers to a particular standardised way of transferring electronic data between computers (devices) to create a network. Networking standards (protocols) are developed, at least conceptually, in terms of a seven layer hierarchical model. The Ethernet standard corresponds to the bottom layers (1 and 2) of this model. Layer 1 is the physical layer of the network and describes such things as electrical characteristics, how *bits* of information (ones and zeroes) are to be represented (usually by different voltage levels), how many bits per second can be transmitted, cable and connector mechanical and electrical properties and maximum cable distances. Layer 2 is the data link layer and describes how the *bits* of information are grouped into *frames* or packets for transmission between devices and how the network can detect and deal with errors resulting from a physical layer problem (eg bad wiring or dodgy connector).

Ethernet was invented in the 1970s (at the Xerox Palo Alto Research Center) and was formalised as a standard (IEEE 802.3) by the Institute of Electrical and Electronics Engineers (IEEE) during the 1980s. An interesting characteristic of Ethernet is that all devices can access the network at any time while, in contrast, the physical network (the piece of wire connecting the devices) can only support one device 'talking' at a time. To handle the possibility of 'collisions' caused by two or more devices trying to 'talk' at the same time, a strategy referred to as *"carrier sense multiple access / collision detection (CSMA/CD)"* is used. Simply this means that each device only talks when the network is idle and if two or more devices happen to start talking at the same time they stop and each wait a small but random time before trying again.

There are alternative standards to Ethernet such as Token Ring and ARCnet. While the technical merits of each of the networking standards are debatable, Ethernet is by far the most commonly used and is now the de facto standard for business and personal computer networks. It is fast, sufficiently reliable for most applications, almost universally supported and the networking hardware is readily available and inexpensive. For these reasons Ethernet is also being increasingly used in industrial applications for factory-level control and information exchange.

Within the Ethernet standard a number of enhancements have been made to the physical layer specifications. Early specifications supported data transfer rates of ten million bits per second (10Mbps) using thick coaxial cable and in later years using telephone-like twisted pair cable. More recent specifications have increased the transfer rate to 100Mbps and higher over twisted pair cable and 1Gbps (1000 Mbps) and higher using fibre optic cable.

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Ethernet specifications have also been expanded to include the use of a radio link where physical network cabling is impossible or undesirable. This is known as wireless Ethernet and is formalised in standard IEEE 802.11b. Wireless Ethernet is simply Ethernet encoded over a radio link and can be used as a direct replacement for physical cable. Data transfer rates for wireless Ethernet are presently limited to about 10Mbps.

The Ethernet standard only covers the physical and data link layers of the communication model and additional specifications are required to achieve a practical network. Layers 3 and 4, the network and transport layers describe such things as how the network data packets are addressed to the destination device, how large blocks of data can be broken up into smaller packets and reliably reassembled by the destination device and how packets are routed across large and complex networks such as the internet. A common layer 3 and 4 specification is Internet Protocol (IP) and Transport Control Protocol (TCP) respectively.

In combination, network layers 1 – 4 describe a reliable method for transporting packets from one device to another over local or large and complex networks. However these layers don't specify the format of the information actually being transported within the packet or how the destination device should interpret this information once it is extracted from the packet (as the saying goes, "just because you can make a phone ring in Beijing doesn't mean you can speak Mandarin"). The information interpretation is described by layer 7, the application layer. Common layer 7 standards are FTP (for transferring data files), Telnet (for connecting remote terminals) and HTTP (an internet transfer protocol).

Each of these layer 7 standards has been developed to suit a particular application. However none of these are suitable for industrial control systems. To meet this growing need, industry developed a new standard known as Control and Information Protocol (CIP). This protocol allows for control of low-level devices on the factory floor and exchange of high-level control system information. Although CIP is actually independent of the underlying network (layers 1 – 4), it can be used with Ethernet networks using IP and TCP. The combination of Ethernet (as the physical layer), IP (as the network layer), TCP (as the transport layer) and CIP (as the applications layer) to form a complete industrial control and information network is referred to as Ethernet/IP. The IP in Ethernet/IP stands for Industrial Protocol which is a little unfortunate given that IP commonly stands for Internet Protocol.