Introduction to Ethernet

Technical Tutorial

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1. Introduction

In today's business world, reliable and efficient access to information has become an important asset in the quest to achieve a competitive advantage. File cabinets and mountains of papers have given way to computers that store and manage information electronically.

Computer networking technologies are the glue that binds these elements together. Networking allows one computer to send information to and receive information from another. We can classify network technologies as belonging to one of two basic groups. Local area network (LAN) technologies connect many devices that are relatively close to each other, usually in the same building. The library terminals that display book information would connect over a local area network. Wide area network (WAN) technologies connect a smaller number of devices that can be many kilometers apart.

In comparison to WANs, LANs are faster and more reliable, but improvements in technology continue to blur the line of demarcation. Fiber optic cables have allowed LAN technologies to connect devices tens of kilometers apart, while at the same time greatly improving the speed and reliability of WANs.

2. Ethernet

Ethernet has been a relatively inexpensive, reasonably fast, and very popular LAN technology for several decades. Two individuals at Xerox PARC -- Bob Metcalfe and D.R. Boggs -- developed Ethernet beginning in 1972 and specifications based on this work appeared in IEEE 802.3 in 1980. Ethernet has since become the most popular and most widely deployed network technology in the world. Many of the issues involved with Ethernet are common to many network technologies, and understanding how Ethernet addressed these issues can provide a foundation that will improve your understanding of networking in general.

The Ethernet standard has grown to encompass new technologies as computer networking has matured. Specified in a standard, IEEE 802.3, an Ethernet LAN typically uses coaxial cable or special grades of twisted pair wires. Ethernet is also used in wireless LANs. Ethernet uses the CSMA/CD access method to handle simultaneous demands. The most commonly installed Ethernet systems are called 10BASE-T and provide transmission speeds up to 10 Mbps. Devices are connected to the cable and compete for access using a Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol. Fast Ethernet or 100BASE-T provides transmission speeds up to 100 megabits per second and is typically used for LAN backbone systems, supporting workstations with 10BASE-T cards. Gigabit Ethernet provides an even higher level of backbone support at 1000 megabits per second (1 gigabit or 1 billion bits per second). 10-Gigabit Ethernet provides up to 10 billion bits per second.

This comprehensive tutorial includes a wide range of information on IEEE 802.3 standards, Topologies, CSMA/CD access methods, Wireless-LAN, and transmission speeds.

3. IEEE standards

IEEE developed a set of network standards. They include:

- **IEEE 802.1**: Standards related to network management.
- **IEEE 802.2**: General standard for the data link layer in the OSI Reference Model. The IEEE divides this layer into two sub-layers -- the logical link control (LLC) layer and the media access control (MAC) layer. The MAC layer varies for different network types and is defined by standards IEEE 802.3 through IEEE 802.5.
- **IEEE 802.3**: Defines the MAC layer for bus networks that use CSMA/CD. This is the basis of the Ethernet standard.
- **IEEE 802.4**: Defines the MAC layer for bus networks that use a token-passing mechanism (token bus networks).
- **IEEE 802.5**: Defines the MAC layer for token-ring networks.
- **IEEE 802.6**: Standard for Metropolitan Area Networks (MANs).

4. Topology

Topology is the shape of a local-area network (LAN) or other communications system. In other words, a topology describes pictorially the configuration or arrangement of a (usually conceptual) network, including its nodes and connecting lines. Topologies are either physical or logical. Ethernet uses topology to transfer the data.

There are four principal topologies used in LANs.

4.1. Bus topology
4.2. Ring topology
4.3. Star topology
4.4. Tree topology

4.1. Bus topology:

All devices are connected to a central cable, called the bus or backbone. Bus networks are relatively inexpensive and easy to install for small networks. Ethernet systems use a bus topology.

4.2. Ring topology:

All devices are connected to one another in the shape of a closed loop, so that each device is connected directly to two other devices, one on either side of it. Ring topologies are relatively expensive and difficult to install, but they offer high bandwidth and can span large distances.

4.3. Star topology:

All devices are connected to a central hub. Star networks are relatively easy to install and manage, but bottlenecks can occur because all data must pass through the hub.

4.4. Tree topology:

A tree topology combines characteristics of linear bus and star topologies. It consists of groups of star-configured workstations connected to a linear bus backbone cable.

These topologies can also be mixed. For example, a bus-star network consists of a high-bandwidth bus, called the backbone, which connects collections of slower-bandwidth star segments.

5. CSMA/CD

The acronym CSMA/CD signifies carrier-sense multiple access with collision detection and describes how the Ethernet protocol regulates communication among nodes. In other words, CSMA/CD is a set of rules determining how network devices respond when two devices attempt to use a data channel simultaneously (called a collision). Standard Ethernet networks use CSMA/CD. This standard enables devices to detect a collision. After detecting a collision, a device waits a random delay time and then attempts to re-transmit the message. If the device detects a collision again, it waits twice as long to try to re-transmit the message.

6. Wireless-LAN

A wireless LAN (WLAN) is a flexible data communication system implemented as an extension to, or as an alternative for, a wired LAN within a building or campus. Using electromagnetic waves, WLANs transmit and receive data over the air, minimizing the need for wired connections. Thus, WLANs combine data connectivity with user mobility, and, through simplified configuration, enable movable LANs.

In a typical WLAN configuration, a transmitter/receiver (transceiver) device, called an access point, connects to the wired network from a fixed location using standard Ethernet cable. At a minimum, the access point receives, buffers, and transmits data between the WLAN and the wired network infrastructure. A single access point can support a small group of users and can function within a range of less than one hundred to several hundred feet. The access point (or the antenna attached to the access point) is usually mounted high but may be mounted essentially anywhere that is practical as long as the desired radio coverage is obtained.

Users of traditional Ethernet LANs generally experience little difference in performance when using a wireless LAN and can expect similar latency behavior. Wireless LANs provide throughput sufficient for the most common LAN-based office applications, including electronic mail exchange, access to shared peripherals, and access to multi-user databases and applications.

7. Transmission Speed

7.1. 10Base-T

The most commonly installed Ethernet systems are called 10BASE-T and provide transmission speeds up to 10 Mbps. Devices are connected to the cable and compete for access using a Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol.

7.2. 100BASE-T

Fast Ethernet or 100BASE-T provides transmission speeds up to 100 megabits per second and is typically used for LAN backbone systems, supporting workstations with 10BASE-T cards. The 100BASE-T standard consists of five different component specifications. These include the Media Access Control (MAC) layer, the Media Independent Interface (MII), and the three physical layers, (100 BASE-TX, 100BASET4, and 100BASE-FX).

7.3. Gigabit Ethernet

Gigabit Ethernet provides an even higher level of backbone support at 1000 megabits per second (1 gigabit or 1 billion bits per second). Used mostly for backbones, the first IEEE standard (802.3z) for Gigabit Ethernet (GigE) was defined in 1997 for use over multimode optical fiber. 802.3z provides full-duplex operation from switch to end station or to another switch and half-duplex using CSMA/CD in a shared environment.

7.4. 10 Gigabit Ethernet

10 Gigabit Ethernet is an upcoming Ethernet technology that transmits at 10 Gbps. 10 Gigabit Ethernet enables a familiar network technology to be used in LAN, MAN and WAN architectures. However the CSMA/CD method for gaining access to the physical medium is not employed, and half duplex operation is not supported. 10 Gigabit Ethernet uses multimode optical fiber up to 300 meters and single mode fiber up to 40 kilometers.

8. Limitations of Ethernet

There are practical limits to the size of our Ethernet network. A primary concern is the length of the shared cable.

Electrical signals propagate along a cable very quickly, but they weaken as they travel, and electrical interference from neighboring devices (fluorescent lights, for example) can scramble the signal. A network cable must be short enough that devices at opposite ends can receive each other's signals clearly and with minimal delay. This places a distance limitation on the maximum separation between two devices on an Ethernet network.

Additionally, since in CSMA/CD only a single device can transmit at a given time, there are practical limits to the number of devices that can coexist in a single network.

Ethernet networks face congestion problems as they increased in size. If a large number of stations connected to the same segment and each generated a sizable amount of traffic, many stations may attempt to transmit whenever there was an opportunity. Under these circumstances, collisions would become more frequent and could begin to choke out successful transmissions, which could take inordinately large amounts of time to complete. One way to reduce congestion would be to split a single segment into multiple segments, thus creating multiple collision domains. This solution creates a different problem, as now these now separate segments are not able to share information with each other.

To alleviate these problems, Ethernet networks implemented bridges. Bridges connect two or more network segments, increasing the network diameter as a repeater does, but bridges also help regulate traffic. They can send and receive transmissions just like any other node, but they do not function the same as a normal node. The bridge does not originate any traffic of its own; like a repeater, it only echoes what it hears from other stations.

9. Sena Products and Ethernet

Sena Products supports rich network standards that have been designed by IEEE. All the Sena products support static and dynamic IP addresses.

Sena Product	Network Interface
HelloDevice Lite Series	10 Base-T Ethernet
HelloDevice Pro Series	10 Base-T Ethernet
HelloDevice Super Series	10 Base-T /100 Base-T Fast Ethernet
POSLink	10 Base-T Ethernet
IALink	10 Base-T Ethernet
UPSLink	10 Base-T /100 Base-T Fast Ethernet
VTS	10 Base-T /100 Base-T Fast Ethernet