Chapter 13

course	Computer Networks
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Status	Not started
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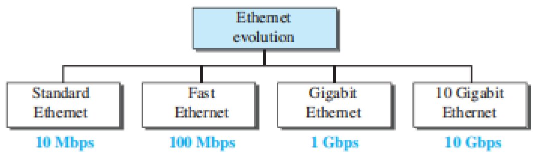
Notes

Wired LANs: Ethernet

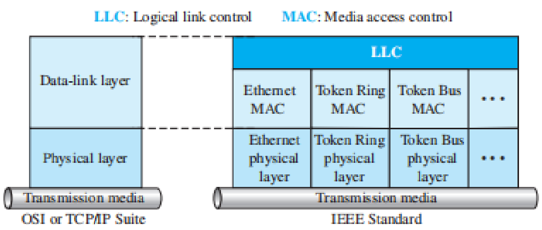
This document summarizes the key points about Ethernet protocol, the dominant technology for wired Local Area Networks (LANs).

Figure 13.2 *Ethernet evolution through four generations*



13.1 Introduction

- TCP/IP doesn't define protocols for data-link and physical layers, leaving them for LAN and WAN technologies.
- This chapter focuses on wired Ethernet, the most widely used LAN technology.



13.1.1 IEEE Project 802

- Established by IEEE to create interoperable networking equipment standards.
- Focuses on data-link and physical layer functionalities (OSI model Layers 2 and 1).
- Subdivides the data-link layer into Logical Link Control (LLC) and Media Access Control (MAC) sublayers.

Relationship between IEEE 802 and TCP/IP:

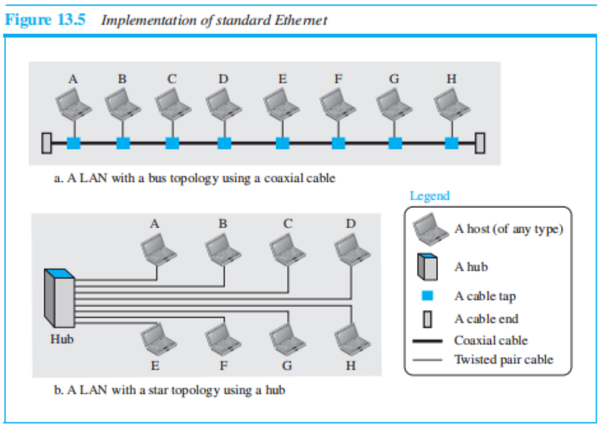
- IEEE 802 standards don't replace TCP/IP but specify functionalities within Layers 1 & 2.
- Illustrated in Figure 13.1 (not shown here).

Sublayers of the Data-Link Layer:

- Logical Link Control (LLC) - Handles flow control, error control, and part of framing.
    - Provides a unified protocol for different LANs, enabling interconnectivity.
- Media Access Control (MAC) - Defines the access method for each LAN type.
    - Specifies CSMA/CD for Ethernet and token-passing for Token Ring/Bus.
    - Also handles part of the data framing process.

13.1.2 Ethernet Evolution: Standard Ethernet

This section dives into the origins and characteristics of Standard Ethernet, the initial Ethernet technology with a data rate of 10 Mbps. While most networks have transitioned to newer technologies, understanding Standard Ethernet provides a foundation for comprehending later advancements.



Characteristics

- **Connectionless and Unreliable Service:** Standard Ethernet offers a connectionless service. Each frame is independent, lacking connection establishment or termination phases. The sender transmits frames whenever ready, and the receiver might not be prepared, potentially leading to dropped frames. Additionally, Ethernet itself doesn't guarantee reliable delivery; corrupted frames are silently discarded. Higher-level protocols (like TCP) handle reliability concerns.
- **Frame Format:** A Standard Ethernet frame consists of seven fields:
    - **Preamble:** 7 bytes (56 bits) alternating 0s and 1s to alert receivers and enable clock synchronization.
    - **Start Frame Delimiter (SFD):** 1 byte (10101011) signifying the frame's beginning.
    - **Destination Address (DA):** 6 bytes (48 bits) specifying the recipient station(s).
    - **Source Address (SA):** 6 bytes (48 bits) containing the sender's link-layer address.
    - **Type:** 2 bytes defining the upper-layer protocol encapsulated within the frame (e.g., IP, ARP).
    - **Data:** This field carries encapsulated data from upper-layer protocols, with a minimum size of 46 bytes and a maximum of 1500 bytes. Padding fills the data field if necessary.
    - **CRC (Cyclic Redundancy Check):** 4 bytes for error detection during transmission. Damaged frames are discarded by the receiver.

Frame Length Restrictions

- **Minimum:** 512 bits (64 bytes) - This minimum ensures proper CSMA/CD (Carrier Sense Multiple Access with Collision Detection) operation (discussed later). Part of this length is for headers and trailers. If the data from the upper layer is less than 46 bytes, padding is added.
- **Maximum:** 1518 bytes (without preamble and SFD) - This limit originated from memory limitations and preventing a single station from monopolizing the shared medium. The maximum payload length is 1500 bytes after subtracting headers and trailers.

Addressing

- Each Ethernet station has a unique Network Interface Card (NIC) with a 6-byte (48-bit) link-layer address, typically written in hexadecimal notation with colons separating bytes (e.g., 47:20:1B:2E:08:EE).
- **Transmission Order:** Addresses are transmitted left to right, byte by byte, with the least significant bit sent first within each byte. This prioritizes delivering the unicast/multicast bit for faster processing by the receiver.
- **Unicast, Multicast, and Broadcast Addresses:**
  - **Unicast:** Source address is always unicast (one sender).
  - **Multicast:** Destination address targets a group of stations. The least significant bit of the first byte in a multicast address is 1.
  - **Broadcast:** Destination address of all Fs (FF:FF:FF:FF:FF:FF) sends the frame to all stations on the LAN.

Distinguishing Unicast, Multicast, and Broadcast

While Standard Ethernet utilizes a shared medium (coaxial cable or twisted-pair cables with a hub), all transmissions are essentially broadcasts.

- **Unicast:** All stations receive the frame, but only the intended recipient (based on the destination address) keeps and processes it, while others discard it.
- **Multicast:** Similar to unicast, all stations receive the frame. However, only stations configured as members of the designated multicast group keep and process the frame, discarding it otherwise.
- **Broadcast:** All stations (except the sender) receive and process the broadcast frame.

Access Method: CSMA/CD

Standard Ethernet employs Carrier Sense Multiple Access with Collision Detection (CSMA/CD) to control access to the shared medium. Here's a simplified scenario:

1. **Station A** intends to send a frame to **Station D**.
2. **Carrier Sense:** Station A first checks for ongoing transmissions (carrier sense). If no signal is detected (idle medium), it starts sending the frame.
3. **Collision Detection:** If a signal is present, another station is transmitting. Station A continuously monitors the medium until it becomes idle for a short period.
4. **Collision:** During transmission, Station A keeps monitoring for collisions. If a collision is detected (energy level exceeds normal levels), both stations involved stop transmitting and send a jam signal to notify other stations.
5. **Backoff and Retransmission:** After a while the system retransmits the signal that was being held up in the data link layer.

Standard Ethernet Implementations and Technologies

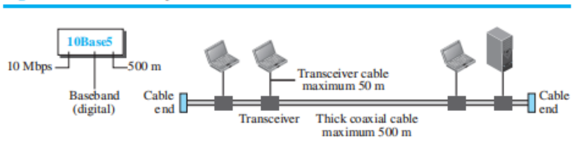
This summary focuses on essential details of Standard Ethernet implementations and technological advancements that led to faster and more efficient Ethernet.

Standard Ethernet Implementations

Standard Ethernet offered various implementations, but four dominated in the 1980s:

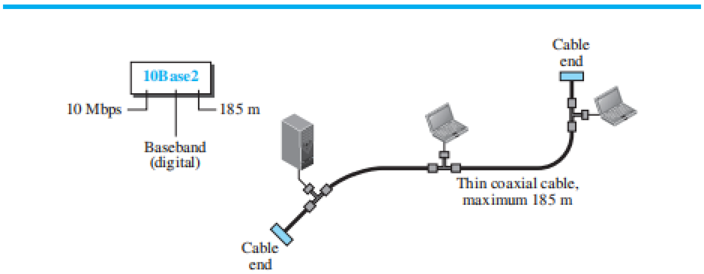
- **10Base5 (Thick Ethernet):**
  - Thick coaxial cable (500m max)
  - Uses external transceivers connected via taps
  - Bus topology
  - Manchester encoding

Figure 13.7 *10Base5 implementation*



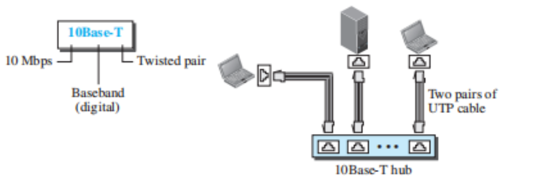
- **10Base2 (Thin Ethernet):**
  - Thin, flexible coaxial cable (185m max)
  - Transceiver integrated into the NIC
  - Bus topology
  - Manchester encoding

Figure 13.8 *10Base2 implementation*



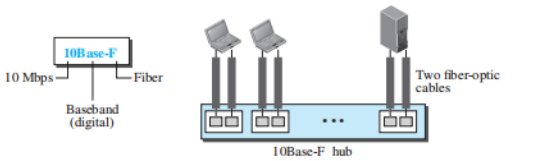
- **10Base-T (Twisted-Pair Ethernet):**
  - Uses twisted-pair cables (100m max) in a star topology
  - Stations connect to a central hub
  - Manchester encoding

Figure 13.9 *10Base-T implementation*



- **10Base-F (Fiber Ethernet):**
  - Uses fiber-optic cables (2000m max) in a star topology
  - Stations connect to a central hub
  - Manchester encoding

Figure 13.10 *10Base-F implementation*



Key Points:

- All implementations use baseband signaling (digital signals on the cable).
- Manchester encoding ensures data transitions at every bit interval for clock synchronization.
- Each implementation offers a different maximum cable length due to signal degradation.

Evolution of Standard Ethernet

Standard Ethernet paved the way for faster and more efficient Ethernet technologies:

- **Bridged Ethernet:**
  - Bridges segment the network, increasing effective bandwidth and reducing collision domains.
  - Stations in separate bridge segments don't contend for the same medium, reducing collisions.
- **Switched Ethernet:**
  - Switches create dedicated point-to-point connections between stations and the switch.
  - Offers full bandwidth to each station simultaneously, eliminating shared medium limitations.
- **Full-Duplex Ethernet:**
  - Enables simultaneous transmission and receiving on separate links.
  - Doubles the effective bandwidth compared to half-duplex (one direction at a time).
  - Eliminates the need for CSMA/CD (Carrier Sense Multiple Access with Collision Detection) as collisions are impossible.
- **MAC Control Layer (Full-Duplex only):**
  - Introduced for flow and error control in full-duplex environments.
  - Standard Ethernet lacked these functionalities at the MAC sublayer.

Key Points:

- Bridging and switching improve network performance by reducing collision domains and offering dedicated bandwidth.
- Full-duplex Ethernet provides significant speed improvements and eliminates the need for CSMA/CD.
- Full-duplex environments leverage the MAC control layer for flow and error control.

Fast Ethernet (100 Mbps) Summary

Key Points:

- Introduced in the 1990s to compete with FDDI and Fiber Channel.
- Maintains compatibility with Standard Ethernet (10 Mbps).
- Increased data rate to 100 Mbps.
- Utilizes the same 48-bit address and frame format.

Access Method:

- Standard Ethernet's CSMA/CD (Carrier Sense Multiple Access with Collision Detection) might not be suitable due to the higher transmission rate.
- Fast Ethernet offers two solutions:
    - **Star topology with passive hubs:** Maintains compatibility with Standard Ethernet but limits cable length to 250 meters.
    - **Star topology with switches:** Uses full-duplex connections, eliminating collisions and the need for CSMA/CD. Stations can transmit and receive simultaneously.

Autonegotiation:

- Allows devices with different capabilities (e.g., 10 Mbps vs 100 Mbps) to connect and negotiate the optimal mode or data rate.

Physical Layer:

- Different encoding schemes are used for various implementations due to data rate and cable type requirements:
    - **100Base-TX (UTP or STP):** Uses MLT-3 encoding with 4B/5B block coding for synchronization.
    - **100Base-FX (Fiber):** Employs NRZ-I encoding with 4B/5B block coding for synchronization.
    - **100Base-T4 (UTP):** Utilizes 8B/6T encoding due to category 3 UTP limitations.

Table Summary:

Implementation	Medium	Length	Wires	Encoding
100Base-TX	UTP/STP	100 meters	2	4B/5B + MLT-3
100Base-FX	Fiber	185 meters	2	4B/5B + NRZ-I
100Base-T4	UTP	100 meters	4	8B/6T**pen_spark**

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1. Propagation Delay (d_prop)

- Formula: `d_prop = distance / speed_of_propagation`

This formula calculates the time it takes for a signal to travel from the sender to the receiver, considering only the physical distance and the speed at which the signal propagates through the medium. In your example,

- Distance (d) = 2500 meters (given)

- Speed of propagation (s) = 2 × 10^8 meters per second (often assumed as the speed of light in a vacuum)

2. Transmission Delay (d_trans)

- Formula: `d_trans = data_size / bandwidth`

This formula calculates the time it takes to transmit a specific amount of data (data_size) over a communication channel with a certain bandwidth. Here,

- Data size = 512 bits (given)
- Bandwidth = 10^7 bits per second (given)

3. Efficiency

- Formula: `Efficiency = (propagation_delay + transmission_delay) / total_time`

Efficiency represents the portion of the total transmission time that's actually used for sending data. In your calculation, it seems the total_time is assumed to be the sum of propagation delay and transmission delay.