# Ethernet Technologies

CCNA 1 v3 – Module 7

# 10 Mbps Ethernet

Legacy Ethernet means:

- **10BASE5**
- **10BASE2**
- **10BASE-T**

| Ethernet Frame | | | | | | |
|---|---|---|---|---|---|---|
| Preamble | SFD | Destination | Source | Length Type | Data ⋮ Pad | FCS |
| 7 | 1 | 6 | 6 | 2 | 46 to 1500 | 4 |

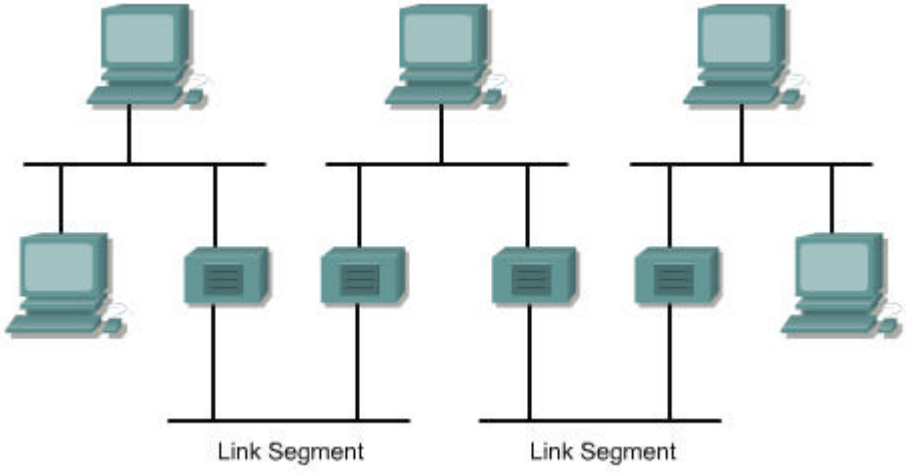
Common features are:

- frame format
- timing parameters
- transmission process
- basic design rule

| | |
|---|---|
| Bit Time | 100 nsec |
| Slot Time | 512 bit times |
| Interframe Spacing | 96 bits |
| Collision Attempt Limit | 16 |
| Collision Backoff Limit | 10 |
| Collision Jam Size | 32 bits |
| Maximum Untagged Frame Size | 1518 octets |
| Minimum Frame Size | 512 bits (64 octets) |

The timing limits are based on:

- Cable length and its propagation delay
- Delay of repeaters
- Delay of transceivers
- Interframe gap shrinkage
- Delays within the station

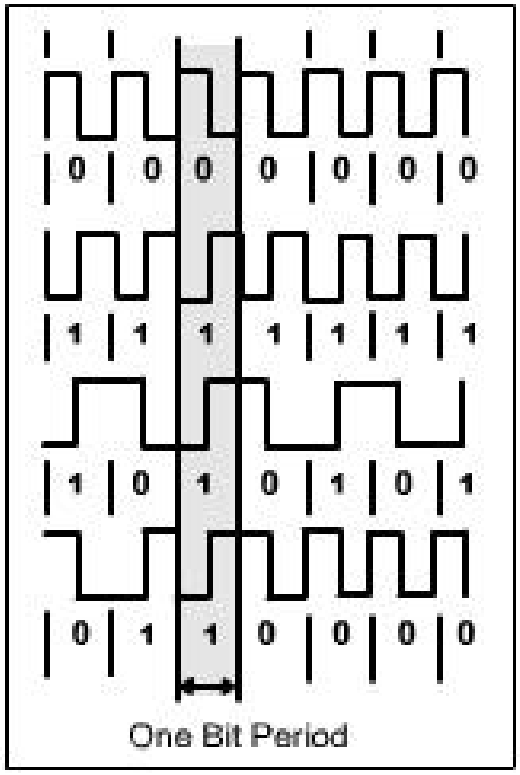


| | 10Base2 | 10Base5 | 10BaseT |
|---|---|---|---|
| Encoding | Manchester | | |
| Duplex | Half | | Half/Full |
| Installation | Easy | Difficult | Easiest |
| Speed | 10 Mbps | 10 Mbps | 10/20 Mbps |
| Length | 185m | 500m | 100m |
| Cable | Thin Coax | Thick Coax | Cat 3/5 UTP |
| Cable Cost | Cheaper | Cheap | Cheapest |
| NICs | Rare | | Common |
| Topology | Bus | | Star |
| Connector | BNC | | RJ 45 |

# 10 Mbps Ethernet

**Line encoding** describes how the bits are actually signalled on the wire.

Encoding used in 10 Mbps systems is called "**Manchester**."




# 10BASE-T wiring and architecture

The 100 m distance starts over at a switch.

Bridges and switches divide collision domains.

Hubs count toward the limit on repeaters between distant hosts.

Avoid linking hubs to prevent exceeding maximum delay limit.

100 m maximum is typically 'used up' when wiring a building.

Switches have made the distance limitation less important.

# 100 Mbps Fast Ethernet

Two important FE technologies:

1. **100BASE-TX**, which is a **copper UTP** medium
2. **100BASE-FX**, which is a **multimode optical fiber** medium

These have three characteristics in common:

1. **timing** parameters
2. the frame **format** (same as the 10-Mbps frame)
3. parts of the **transmission process**

Signals are more susceptible to noise because of higher frequency and a shorter bit time of **10nsec**

Therefore two separate encoding steps are used:

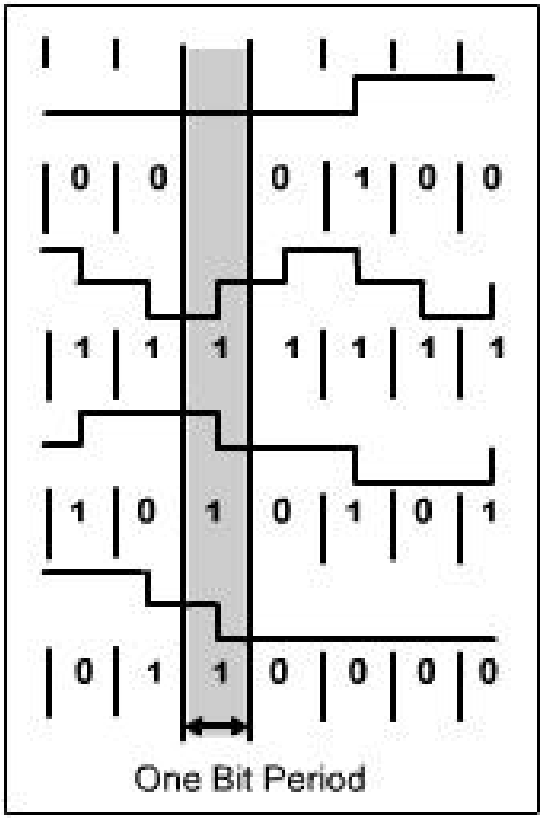
1. **4B/5B**
2. line encoding specific to copper or fiber

**Class I repeaters** change between one type of Ethernet and another.
A Class I repeater <= 140 bit-times of latency
A Class II repeater <= 92 bit-times latency
Because of the reduced latency it is possible to have two Class II repeaters in series, but only if the cable between them does not exceed 5 m.

# 100BASE-TX

100BASE-TX uses **4B/5B** encoding, which is then scrambled and converted to multi-level transmit-3 levels or **MLT-3**.

- No transition indicates a binary 0
- A binary 1 is represented by a transition.




Two separate transmit-receive paths exist.
This is identical to the 10BASE-T configuration.
100BASE-TX carries 100 Mbps in half-duplex mode.
In full-duplex mode, 100BASE-TX can exchange 200 Mbps.

**Pinout for a 100BASE-TX connection**

| Pin | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Signal | TD+ | TD- | RD+ | | | RD- | | |

# 100BASE-FX

- Introduced for backbone applications, connections between floors and buildings where copper is less desirable, and also in high noise environments.
- Never widely adopted due to Gigabit Ethernet copper and fiber.
- 100BASE-FX also uses **4B/5B** encoding

**100BASE-FX Pinouts**

| Fiber | Signal |
|---|---|
| 1 | Tx (LED and laser transmitters) |
| 2 | Rx (high-speed photodiode detectors) |

- Fiber pair with ST or SC connectors most commonly used.
- 200 Mbps transmission using separate  Tx and Rx paths.
- Half duplex is undesirable as signalling scheme is full duplex

# 1000-Mbps Ethernet

1000-Mbps Ethernet or Gigabit Ethernet use both fiber and copper.

**IEEE 802.3z**, specifies 1 Gbps full duplex over optical fiber

**1000BASE-TX**, **1000BASE-SX**, and **1000BASE-LX** use the same timing parameters:

Since the bits are introduced on the medium for a shorter duration and more often, **timing is critical**

| Parameter | Value |
|---|---|
| Bit Time | 1 nsec |
| Slot Time | 4096 bit times |
| Interframe Spacing | 96 bits * |
| Collision Attempt Limit | 16 |
| Collision Backoff Limit | 10 |
| Collision Jam Size | 32 bits |
| Maximum Untagged Frame Size | 1518 octets |
| Minimum Frame Size | 512 bits (64 octets) |
| Burst Limit | 65,536 bits |

On **copper media** bits are more susceptible to noise.

- Data transmission optimised by using codes to represent bit stream.
- Encoded data provides synchronization, efficient use of bandwidth, and improved Signal-to-Noise Ratio characteristics.
- Frame is coded into **control** and **data symbols** to increase throughput.

**Fiber-based** Gigabit Ethernet uses **8B/10B** encoding (similar to the 4B/5B) and **NRZ line encoding**

# 1000BASE-T

1. 1000BASE-T standard is IEEE **802.3ab**
2. Provided more "speed" for **intra-building backbones**, inter-switch links, server farms, wiring closet applications and high-end workstations.
3. Cable for Fast Ethernet should pass the **Cat 5e** test.
4. Uses all four pairs of wires with **full duplex** transmissions on each
5. **250 Mbps per pair x 4 pairs = 1Gb**
6. This results in a **permanent collision** on the wire pairs.
7. These collisions result in complex **voltage patterns**.
8. **Complex integrated circuits** use techniques such as echo cancellation, Layer 1 Forward Error Correction (FEC), and prudent selection of voltage levels.
9. Uses 1000BASE-T encoding with **4D-PAM5** line encoding
10. In idle periods there are **nine** voltage levels found on the cable.
11. During data transmission periods there are **17** voltage levels
12. The system is more susceptible to **noise** due to cable and termination problems.

# 1000BASE-SX and LX

SX - **Short-wavelength** uses an **850 nm** laser or **LED**.

- **lower-cost** of the options but **shorter distances**.

LX - **Long-wavelength** uses **1310 nm laser** source.

- Either single-mode or multimode optical fiber
- Single-mode fiber can achieve distances of up to **5000 m**.

Light is pulsed using low and high power:

- **low power =0** **high power =1**

**Separate fibers** are used for Tx and Rx on a point-to-point, full duplex link.

Gigabit Ethernet permits only **one repeater** between two stations.

**NRZ signals** are pulsed into the fiber.

# 10 Gigabit Ethernet

- **IEEE 802.3ae** now includes 10 Gbps full-duplex over fiber.
- 10GbE is being developed for **LANs**, **MANs**, and **WANs**.
- Frame format and other Ethernet Layer 2 specifications **compatible** with previous standards
- **Bit time** is now **0.1 ns**, CSMA/CD not necessary.
- Flexible, efficient, reliable, relatively low cost end-to-end Ethernet networks become possible.

| | |
|---|---|
| **10GBASE-SR** | Short distances 26 m to 82 m on existing multimode |
| **10GBASE-LX4** | Uses WWDM, supports 240 m to 300 m on multimode, 10 km over single-mode fiber |
| **10GBASE-LR**<br>**10GBASE-ER** | 10 km and 40 km over single-mode fiber |
| **10GBASE-SW**<br>**10GBASE-LW**<br>**10GBASE-EW** | Work with OC-192 STM SONET/SDH WAN equipment |

# 10-Gigabit Ethernet Architectures

- 10-Gigabit Ethernet uses **two separate encoding steps**.
- Uses **codes** to **represent** the user **data**.
- Encoded data **provides synchronization**, **efficient** usage of bandwidth, and **improved Signal-to-Noise Ratio** characteristics.
- **Complex serial bit streams are used** for all versions of 10GbE except for 10GBASE-LX4
- **10GBASE-LX4** uses **WWDM**
- **No repeater** is defined for 10-Gigabit Ethernet
- **Half duplex** is explicitly **not supported**.

# Future of Ethernet

Ethernet has evolved:

Legacy ? Fast ? Gigabit ? **MultiGigabit** technologies.

- Ethernet **dominates** new **LAN** installations.
- **Standard** for horizontal, vertical, and inter-building connections.
- Blurring the distinction between **LANs**, **MANs**, and **WANs**.
- Working on **40**, **100**, or even **160 Gbps** standards.
- Proposals for arbitration schemes other than CSMA/CD.

The future of networking media is three-fold:

1. Copper (up to 1000 Mbps, perhaps more)
2. Wireless (approaching 100 Mbps, perhaps more)
3. Optical fiber (currently at 10,000 Mbps and soon to be more)

**Bandwidth** limitations on fiber are **extremely large**.

Speed is **limited by** electronic technology such as **emitters** and **detectors** and **fiber manufacturing processes**.