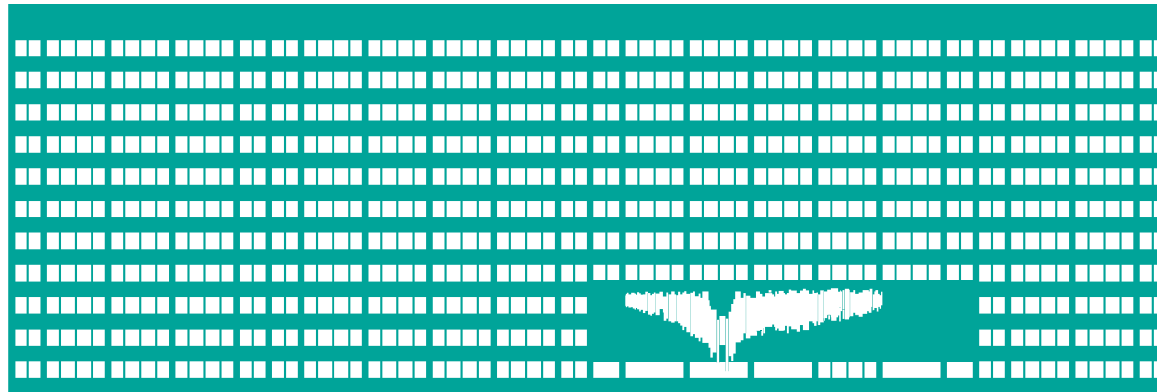


Ethernet



Computer Networks Lecture 4

The History of Ethernet

- Originally: DIX Ethernet (DEC-Intel-Xerox, Ethernet II) - 10Mbps.
 - No LLC sublayer
- Later standardized as: IEEE 802.3
 - Frame format has changed:
 - (type/length field interpretation).
- Both frame formats are being used today
 - even on the same medium

Naming of Ethernet Family Members According to IEEE 802.3

Today, Ethernet is a whole technology suite with a common frame format

- (both LAN and WAN technologies)

{Mbps|Gbps**G**}{Base|Broad}{seg_len/100[m]|-medium}

Medium: T/TX – Twisted Pair,
 F/LX/SX/... – Fiber optic, ...

Examples:

10Base5, 10Base-T, 100Base-LX10,
10GBase-T

Half-duplex Ethernet MAC Access Protocol: CSMA/CD

- p-persistent
 - Maximum signal delay in the Ethernet network is defined to be 51,2 microseconds
 - 2x maximum time of signal propagation + delays incurred by repeaters/hubs
 - Corresponds to 512 bit intervals (64B) at 10Mb/s
 - Implies the maximum network reach and maximum number of repeaters/hubs with a standardized maximum signal delay (5-4-3 rule)
- A station that detects collision sends a jam signal
 - which helps other stations to detect the collision to limit the duration of a collision
- Exponential backoff is applied after a collision

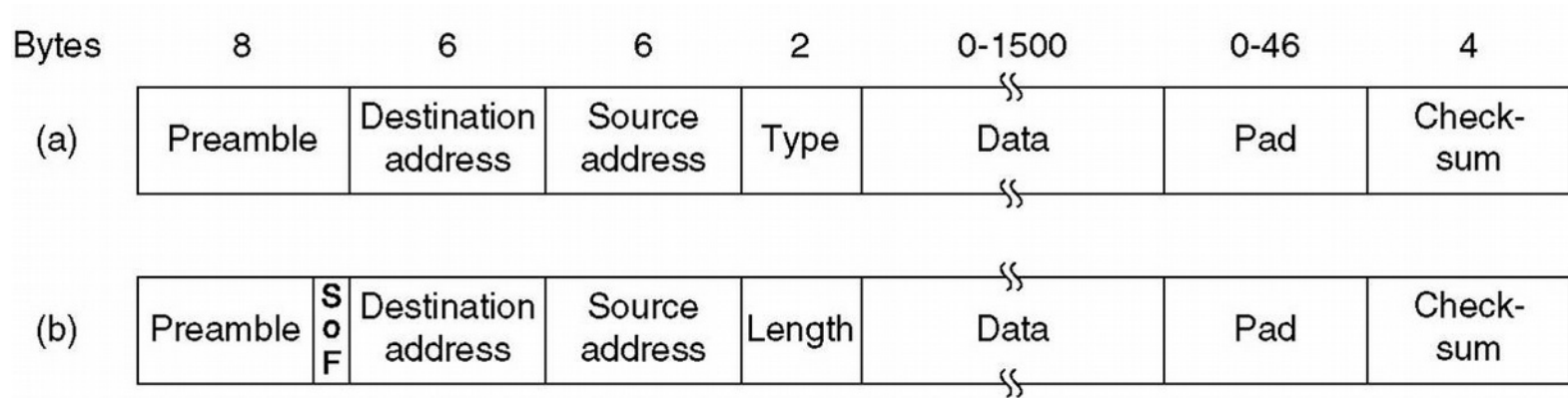
Half-duplex and Full-duplex Ethernet

- Half duplex – collision environment (CSMA/CD)
 - In half-duplex mode we have to adhere CSMA/CD timing that implies the maximum cable lengths
- Full duplex – collision-free (switched) environment
 - For compatibility with half-duplex NICs, P2P links may also operate in half-duplex mode

Duplex and Speed Autonegotiation

- Stations may automatically negotiate duplex mode and speed (10/100/1000 Mb/s).
- Implemented using Fast Link Pulses (FLP)
 - Compatible with 10BaseT heartbeat
 - Each side encodes its capabilities by a sequence of pulses that generated instead of the original heartbeat pulse
 - original heartbeat just mandates the maximum and minimum interval between pulses

Ethernet Frame Format



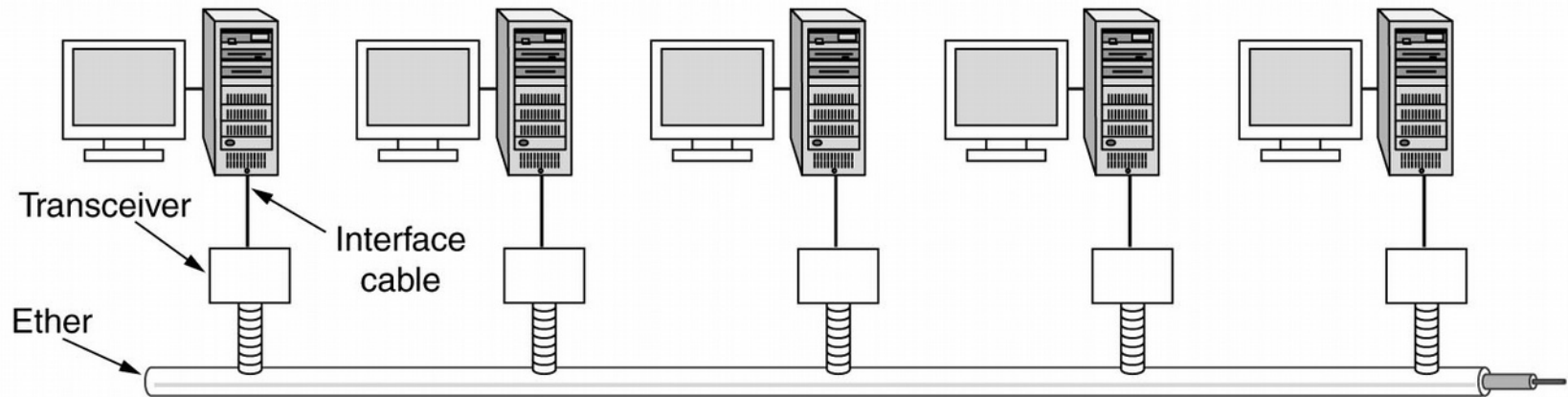
(a) DIX (b) 802.3

- Interpretation of Type/Length field
 - Length (by default up to 1500 B, in reality more – encapsulation, lower than 2000)
 - Upper layer protocol identification
- Interframe gap is 96 bit intervals

Ethernet Standards

10Base5 – Topology

= Thick Ethernet = DIX Ethernet = ETHERNET II



10Base5 - Capabilities

- Bus (coaxial) „Yellow Cable“
 - 50ohm, diameter of 10 mm
- Max segment length 500m, terminated
 - At most 5 segments interconnected by 4 repeaters, stations may be placed only on 3 segments (5-4-3 rule)
 - At most 100 stations per segment, minimum distance of 2.5 m
- Manchester encoding
- Utilizes external transceivers (AUI interface)
 - Attached to bus by T-connector or vampire tap

10Base2

= Thin Ethernet = CheaperNet

- bus, coax RG58
 - 50ohm, diameter of 5 mm
- Max segment length 185m, terminated
 - 5-4-3 rule
 - At most 30 stations per segment
 - minimum distance between stations is 0.5m
- Interconnection: BNC and T connectors
 - Transceiver is integrated on the NIC

10Base-T

- Star (tree) topology
 - 2 twisted pairs (UTP3) + RJ-45 connectors
 - May operate in full-duplex mode when switches are applied
- Stations interconnected with hubs
 - 5-4-(3) rule
 - max. 512 stations in the whole tree
- Max 100m between hub and NIC
 - min 0.6m
- Crossing of transmitter and receiver cable pairs

Fast Ethernet (100Mbps)

- IEEE 802.3u
- Based on 10BaseT
 - the same MAC address protocol and frame format
 - NICs are obviously backward compatible with 10BaseT
 - Speed auto-negotiation capability
- Uses UTP5, limited to at most 100m between network devices

Physical Layer of Fast Ethernet

- 100Base-TX
 - UTP5, STP – UTP5, max 100m
 - 4B5B + MLT3, 125 MHz
- 100Base-FX: FO, max. distance is 400 m half duplex (because of CSMA/CD timing), 2 km in full duplex
 - 100Base-LX10: Single-mode long-wave FO, max. distance up to 10 km in full duplex mode
 - 100BASE-SX: Multi-mode optical fiber, reach up to 550 m full duplex
- Other sparsely used options
 - Developed for compatibility with older cablings - 100BaseT2, 100BaseT4

Fast Ethernet Topologies (half-duplex)

- 2 directly connected NICs (also PC & switch)
- Star with Class I hub
- Two Class II hubs interconnected by line of maximum 10 m in length

Hub class I and II differ in

- Maximum allowed signal delay
- Capability of encoding transformation, i.e. the ability of using different media in a single collision domain
 - e.g. transformation of 100BaseTX to 100BaseT4

Gigabit Ethernet (802.3z)

- Developed since 1995, originally supposed to require fiber optic or coax cable, standard later extended for twisted pair
 - 802.3ab – compatible with existing wirings (Cat5e)
- Makes the standard Ethernet faster again
 - CSMA or switching, IEEE 802.3 frame, star topology
- Problems with minimum frame length in collision-mode when trying to keep the same maximum cable lengths as with 10BaseT
 - Appends a padding to 512B into a frame if necessary or applies packet bursting.
- Most commonly used for backbone links

Physical Layer of the Gigabit Ethernet

- 1000Base-T: UTP5e
 - All 4 pairs used simultaneously in both directions (PAM5, echo cancellation), max. 100m
 - Problems with reflections connectors (the cabling system may start to resonate)
- 1000Base-SX (short wavelength-850 nm)
 - used more often, 8B10B encoding
 - 62.5 μ m MMF 440m, 50 μ m MMF 550m
- 1000Base-LX (long wavelength-1300 nm)
 - 8B10B encoding, SMF 3 km, 62.5 μ m MMF 440m, 50 μ m MMF 550m.
 - Usage of „offsets“ to limit transversal modes on MMF (decreases dispersion)
- ANSI Fibre Channel
 - Supports bandwidths of 133Mbps to 1Gbps on various cable types (MMF, STP, coaxial cable)

10 Gigabit Ethernet

- Full-duplex mode only
- Supposed to operate on fiber optic at the beginning
- Operates on UTP6 today (10GBaseT)
- Used also as WAN link technology
- No PoE until recent 802.3bz definition

Gigabit+ Ethernet Improvements

- 40G, 100G Ethernet
 - SMF, MMF (802.3bm)
 - UTP Cat.8 , Backplane (802.3ba)
- 200G – single-mode fiber (802.3bs)
- 400G – future standard on multi-mode fiber (802.3cm)
- Single pair – 1000BASE-T1 (802.3bp) – automotive and industrial
- 2.5GBASE-T/5GBASE-T – 2.5 Gigabit and 5 Gigabit Ethernet over Cat-5/Cat-6 cable (802.3bz)