LAN Protocols

Required reading:
Forouzan 13.1 to 13.5
Garcia 6.7, 6.8

CSE 3213, Fall 2015
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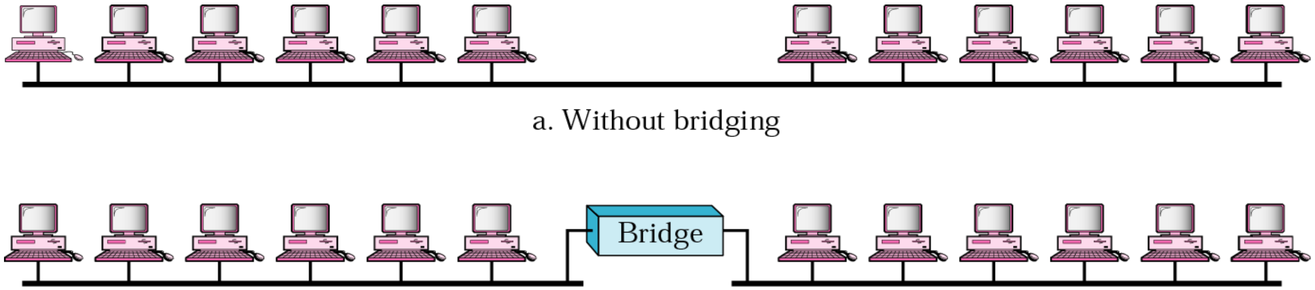
What is LAN?

Local Area Network (LAN) – properties

- **private ownership**
  - freedom to choose/change/upgrade technology
- **low cost**
  - relatively small number of stations ⇒ complex and expensive <u>switching equipment NOT necessary</u>
  - single broadcast medium often sufficient
- **high speed**
  - short distance ~ 1 km between computers ⇒ relatively error free (high-speed) communication possible
  - complex error control unnecessary



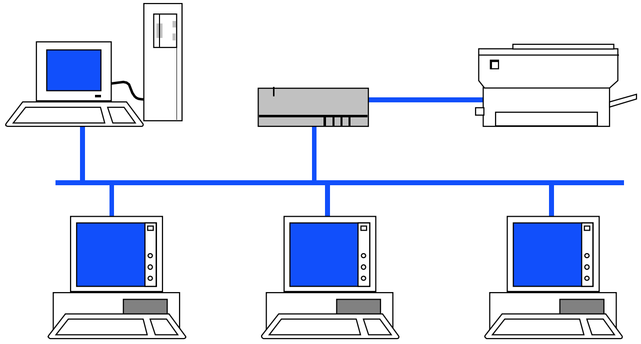
a. Without bridging

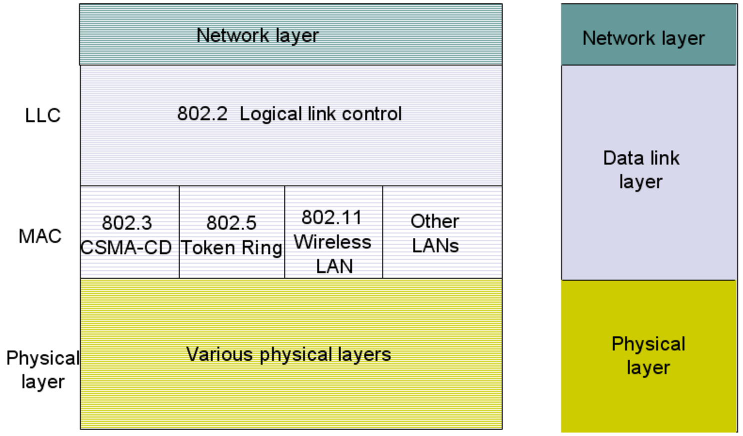
b. With bridging

What is LAN? (cont.)

Typical LAN Structure

- computers and network devices (e.g. printers) connected to broadcast cabling system through network interface card (NIC)
- computers connected via a LAN to the Internet need all 5 layers of the Internet model
  - 3 upper layers (network, transport, application) are common to all LANs
  - physical layer can be considerably different
- data link layer is divided into 2 sublayer:
  - medium access control (MAC) – coordinates access to shared medium; provides <u>connectionless</u> transfer of datagrams – several standards !!!
  - logical link control (LLC) – may be needed to provide extra flow and error control to upper layers (in reality, only IP exists, and IP does not need additional flow and error control) – single IEEE 802.2 standard!



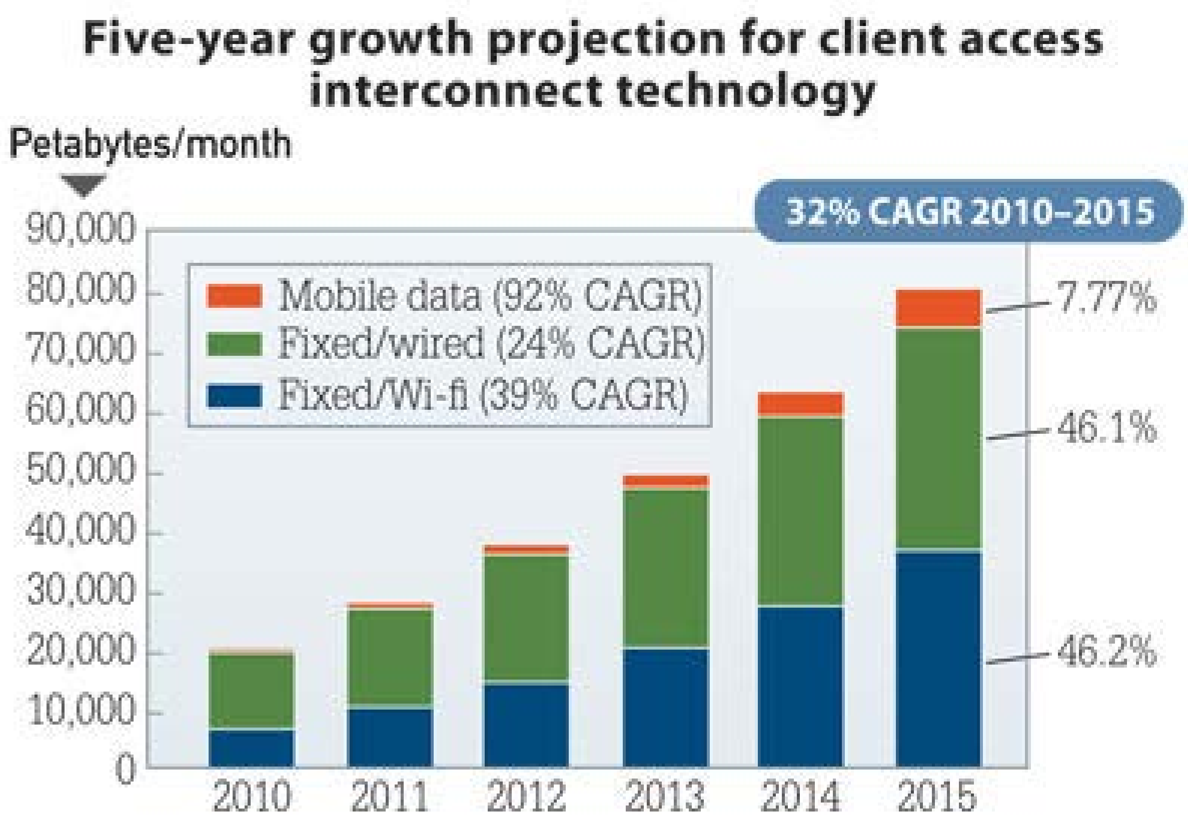


Ethernet
(IEEE 802.3)

Ethernet: Introduction

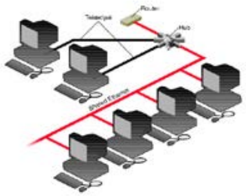
Why do we study Ethernet !?

Isn't WiFi winning, anyway !?



Ethernet: Introduction (cont.)

Ethernet & WiFi: Pros & Cons



Ethernet

- faster - speeds up to 100 Gbps
- more reliable QoS (not impacted by noise or environmental and structural factors)
- more secure (only devices physically connected to the network can intercept signal; jamming attacks very difficult)
- cable has to be stretch to each device
- with every new device added, infrastructure costs go up

WiFi

- speeds up to 150 Mbps
- QoS varies depending on user location, noise, interference, …
- encryption used to protect data $\Rightarrow$ additional processing & delay; jamming attacks still possible
- more convenient - devices can move around and still remain connected
- cheaper & more scalable

Ethernet: Introduction (cont.)

http://www.ethernetalliance.org/wp-content/uploads/2015/03/EthernetAlliance_Roadmap_whitepaper_FINAL-032015-21.pdf

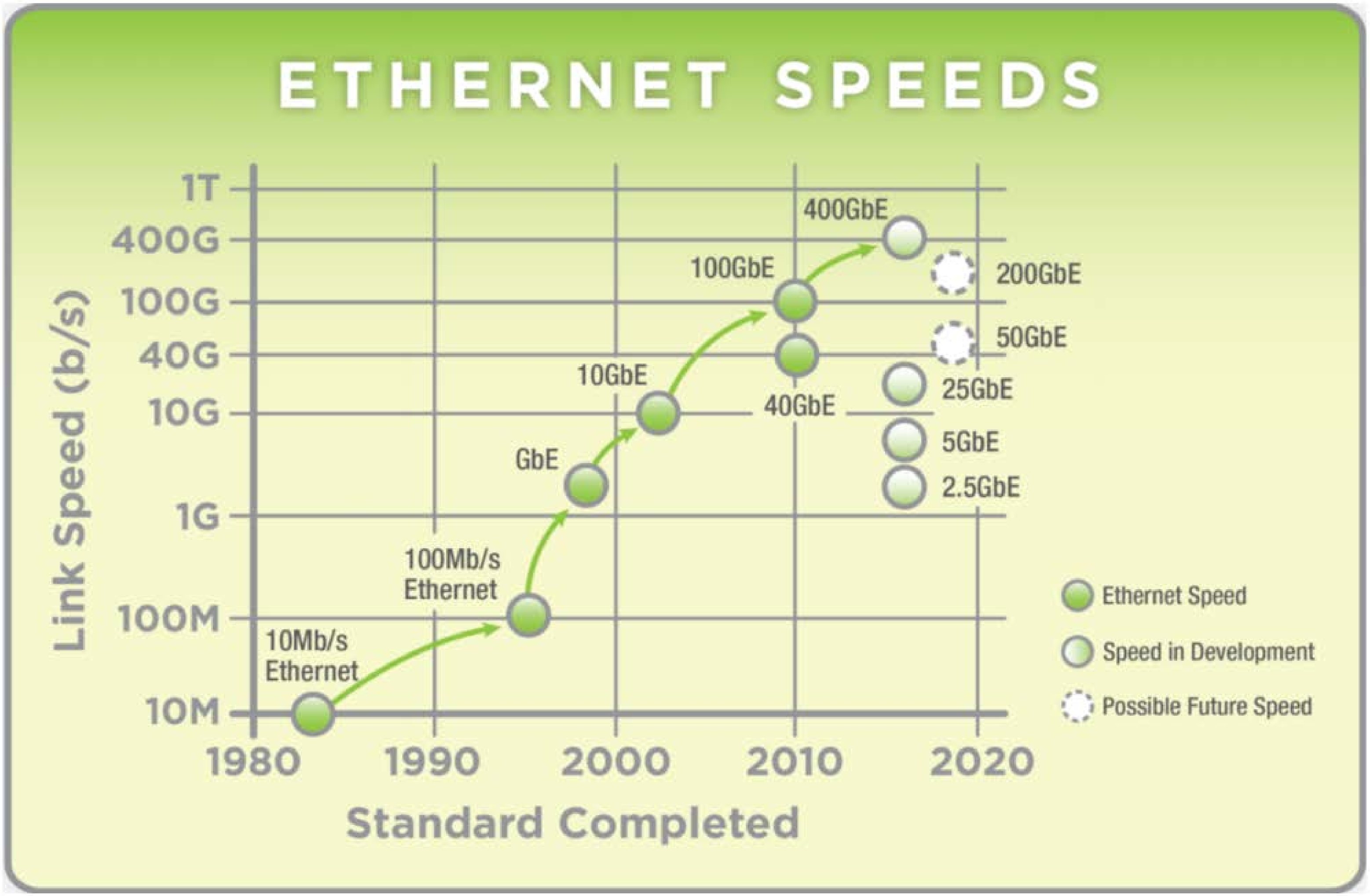


Figure 2: The Speeds of Ethernet

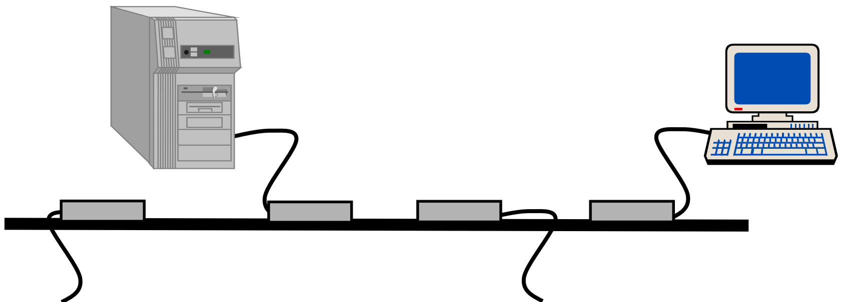
MAC Protocols: Ethernet

Ethernet History

– set of protocols at the physical and data link layer (MAC sublayer)

- developed by Robert Metcalfe, at Xerox, in 1970s
- promoted and used by Dec, IBM and Xerox in 1980s
- 10 Mbps Ethernet became an IEEE standard in 1985 – **IEEE 802.3**
- high-speed versions:
  100 Mbps - Fast Ethernet (1995)
  1000 Mbps - Gigabit Ethernet (1998)
  10 Gbps - 10 Gigabit Ethernet (2002)
  100 Gbps - 100 Gigabit Ethernet (2007 / 2010)
- currently used in about 80-90 % of all LANs

"He chose to base the name on the word 'ether' as a way of describing an essential feature of the system: the physical medium (i.e., a cable) carries bits to all stations, much the same way that the old 'luminiferous ether' was once thought to propagate electromagnetic waves through space. Thus, Ethernet was born"



MAC Protocols: Ethernet (cont.)

IEEE 802.3
(10 Mbps)
MAC Features

- **backoff: 1-persistent CSMA/CD with truncated binary exponential backoff algorithm**
  - **if medium idle – transmit; if medium busy, wait until idle then transmit with p=1;**
  - **in case of retransmission, re-transmission time is determined by selecting an integer in range: $0 < r < 2^k$, where k=min(n,10)**
  - **give up after 16 retransmissions**

- **frame size: original IEEE 802.3 was designed to operate at 10 Mbps over max distance of 2500 [m] with 4 repeaters (plus additional delay!!!)**
  - **$c \approx 2*10^8$ [m/sec] $\Rightarrow$ $2*t_{prop}$ + delays on repeaters $\approx$ 51.2 μ $\Rightarrow$ 512 [bits]**
  - **min frame size = 512 bits = 64 bytes = 46 + 18**
  - **max frame size = 1518 bytes = 1500 + 18 (prevents one station from monopolizing the medium)**

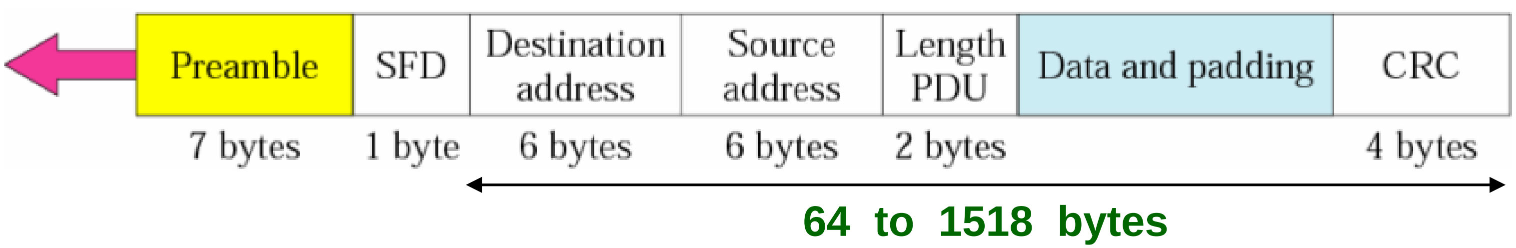
- **for the given min frame size, each 10x increase in bit-rate is accompanied with 10x decrease in max distance**

min frame time = 2*max segment / c = min frame size / data rate

MAC Protocols: Ethernet (cont.)

IEEE 802.3
(10 Mbps)
MAC Frame

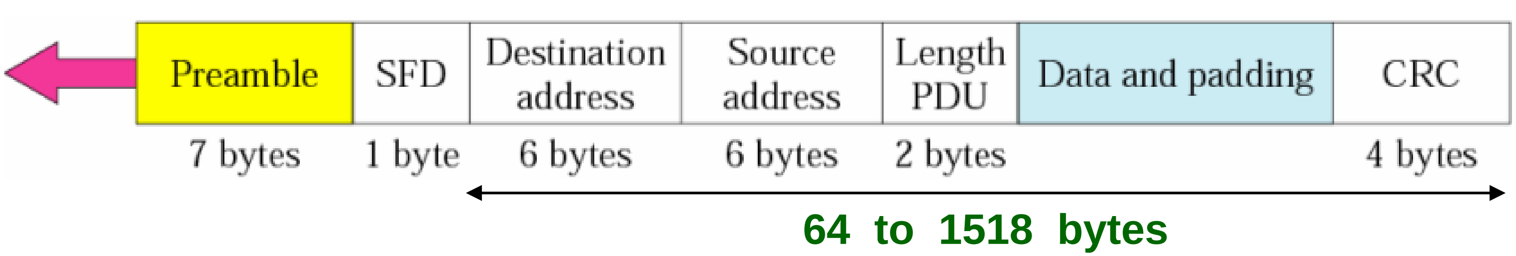
- **Preamble – 7 bytes / 56 bits of alternating 0s and 1s**
  - **alerts receiving stations of the coming frame and enables them to synchronize – 56 bits long , to allow stations to synchronize even if they miss some bits at the beginning**
  - **added at the physical layer, not (formally) part of the frame**
- **Start-Frame Delimiter – 1 byte (10101011)**
  - **signals the beginning of a frame; last chance for synchronization**
  - **two consecutive 1-bits indicate that the next bit is the first bit of the destination address**
- **Destination Address – 6 bytes**
  - **contains the physical address of the station to receive the frame**
- **Source Address – 6 bytes**
  - **contains the physical address of the sending station**



MAC Protocols: Ethernet (cont.)

IEEE 802.3 MAC Frame (cont.)

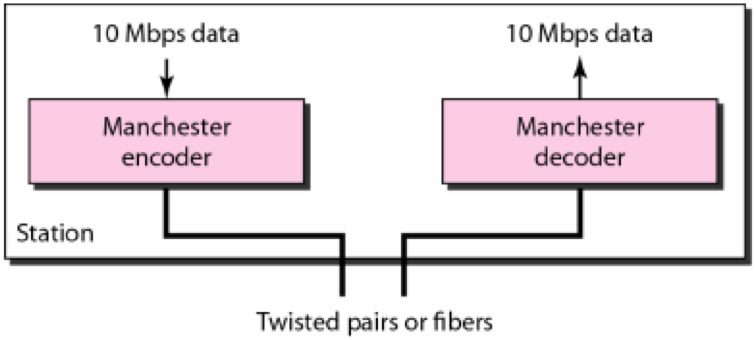
- **Length** – 2 bytes
  - indicates the <u>number of bytes</u> in ‘data’ (information) field
  - min allowable frame size 64 bytes, with 18 bytes of overhead
    $\Rightarrow$ min data length = 46 bytes
  - max allowable frame size 1518 bytes, with 18 bytes of overhead
    $\Rightarrow$ max data length = 1500 bytes
- **Data** – 46 to 1500 bytes
  - data from upper-layer protocols
- **Padding** –
  - ensures that the frame size is always at least 64 bytes
- **CRC** – 4 bytes
  - CCITT 32-bit CRC check that <u>covers addresses, length and data</u>



MAC Protocols: Ethernet (cont.)

IEEE 802.3 10 Mbps Physical Layer

- **10 Mbps Mthernet uses Manchester signaling – additional bandwidth to achieve better synchronization, not a big issue**



IEEE 802.3 10 Mbps Network Implementations

- **thick (10 mm) coaxial cable Ethernet – awkward to handle and install**
- **thin (5 mm) coaxial cable Ethernet – cheaper and easier to handle, but the length of each segment cannot exceed 200 m, due to high level of attenuation in thin coaxial cable**
- **unshielded twisted pair Ethernet – low-cost and prevalent in offices, but due to poor transmission qualities of twisted pair the length of individual links is limited to 100 m**

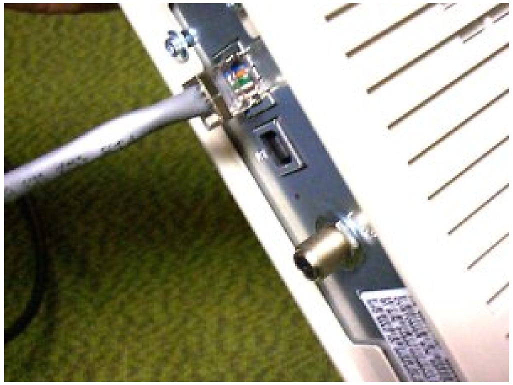
baseband

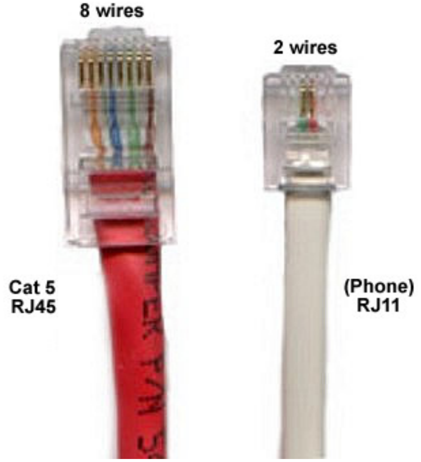
Characteristics	*10Base5*	*10Base2*	*10Base-T*	*10Base-F*
Media	Thick coaxial cable	Thin coaxial cable	2 UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m
Line encoding	Manchester	Manchester	Manchester	Manchester

MAC Protocols: Ethernet (cont.)

Ethernet Coaxial Cable

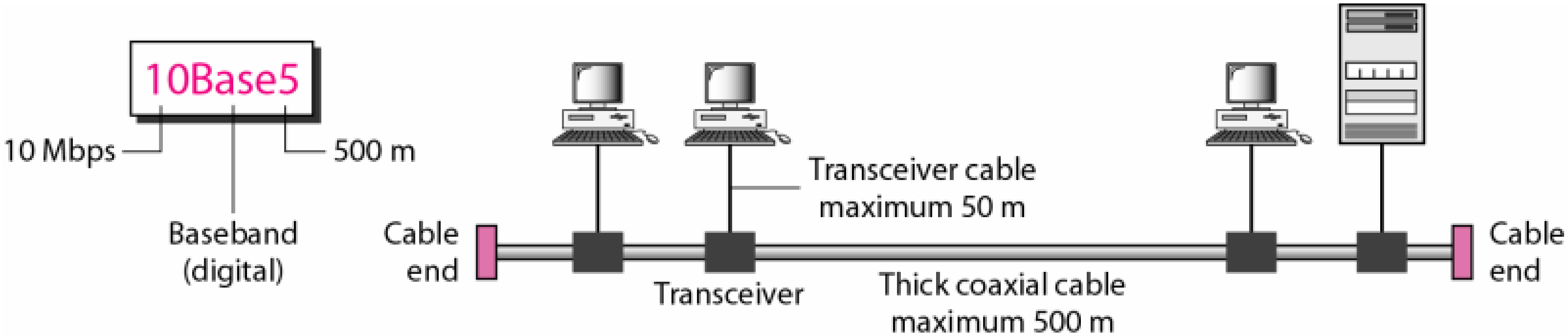
Ethernet Twisted Pair

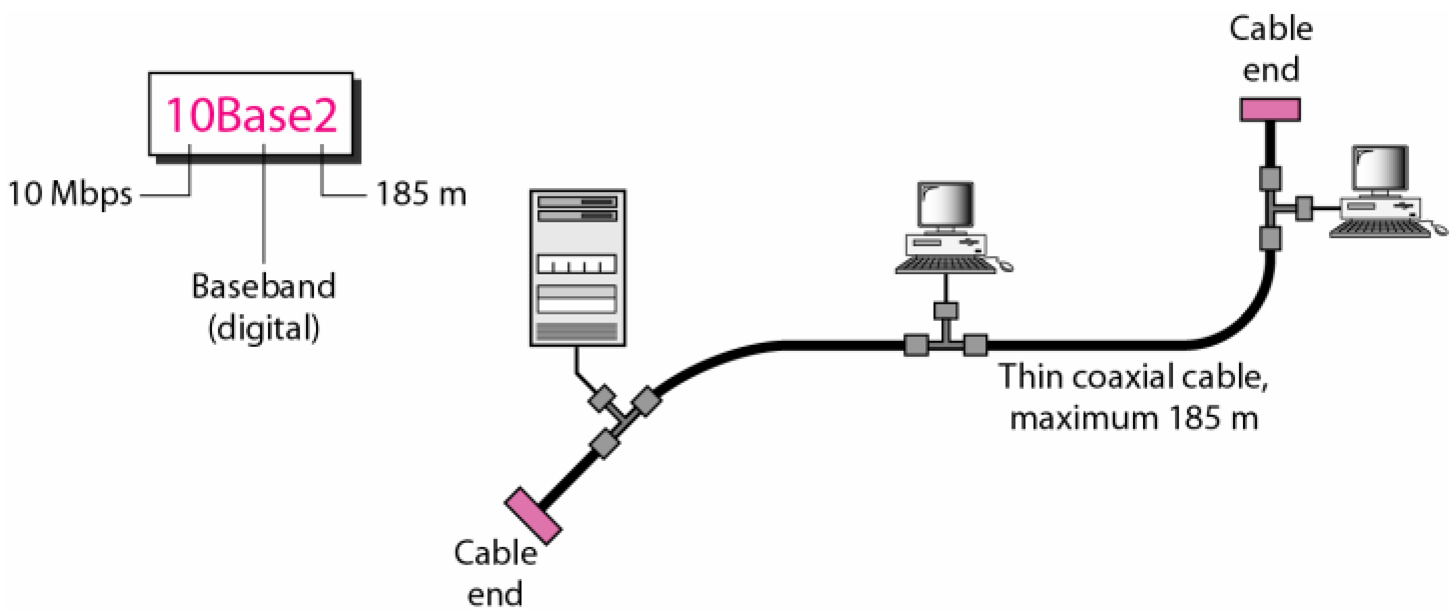




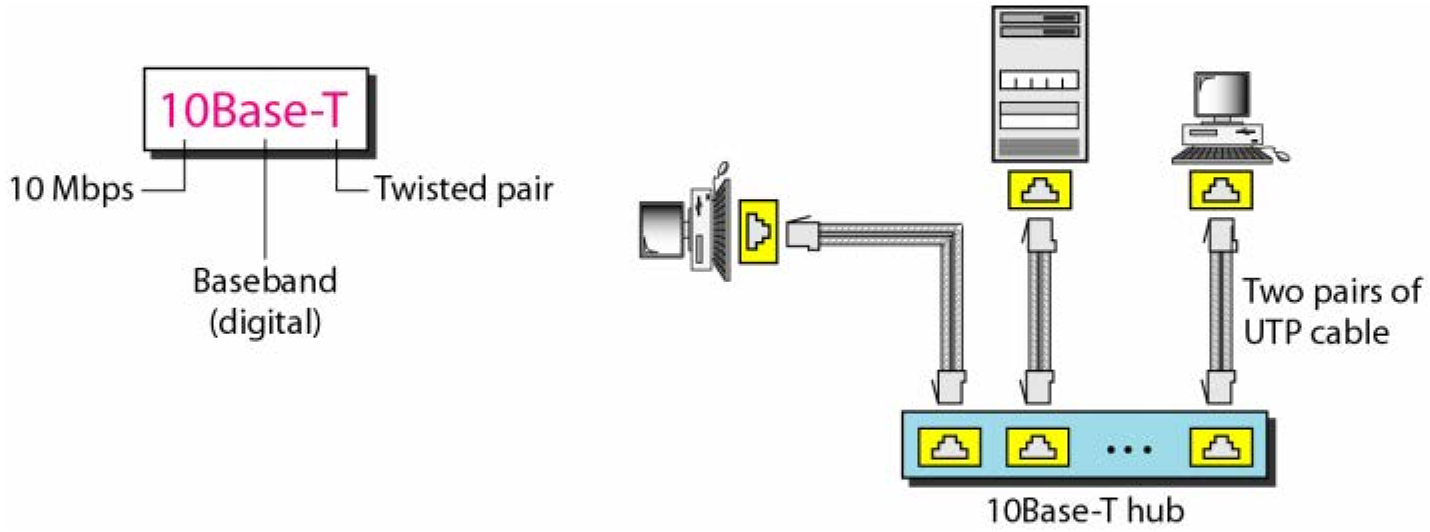
Ethernet vs. Telephone Cable

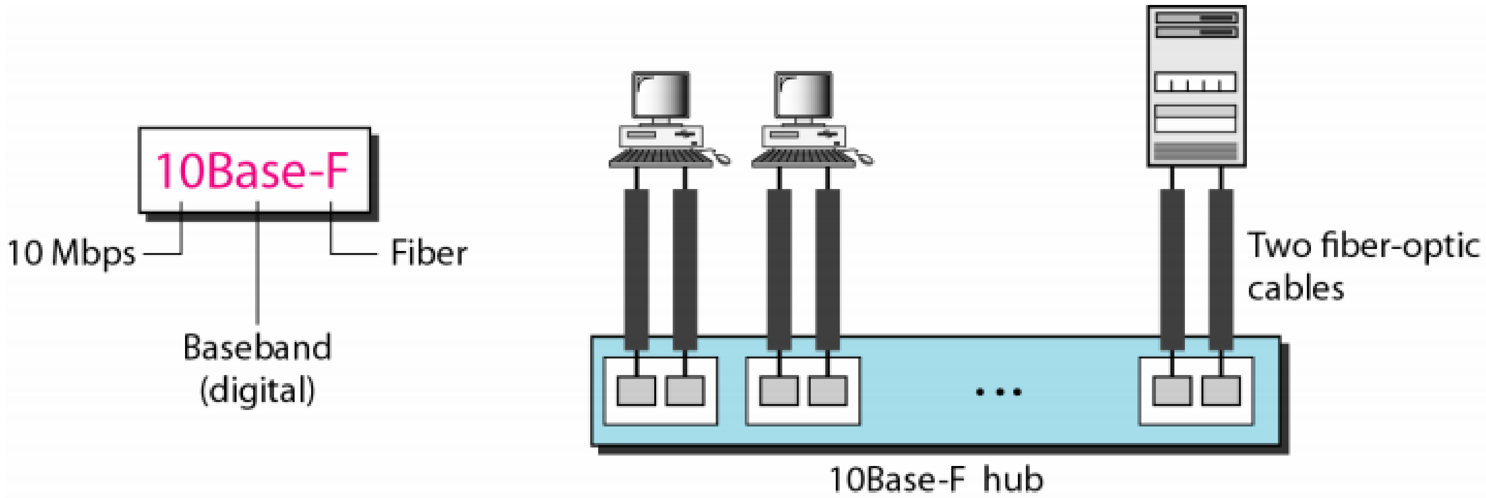
MAC Protocols: Ethernet (cont.)



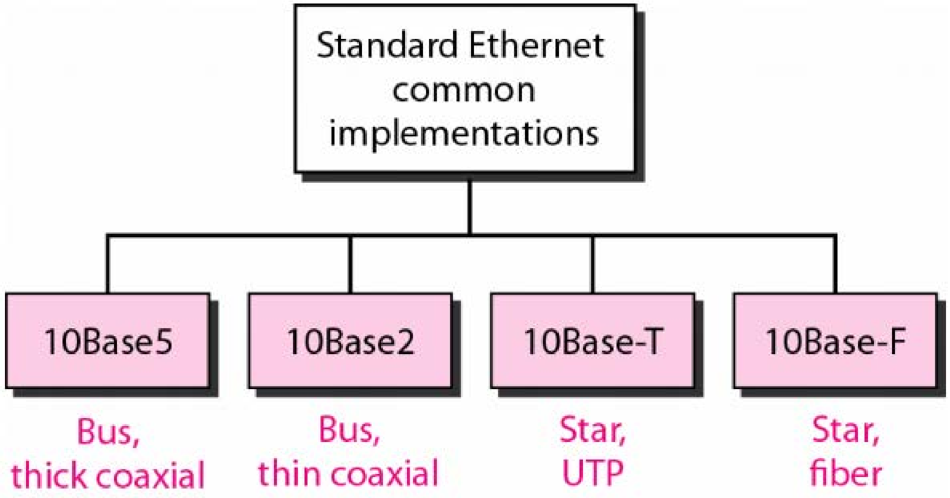


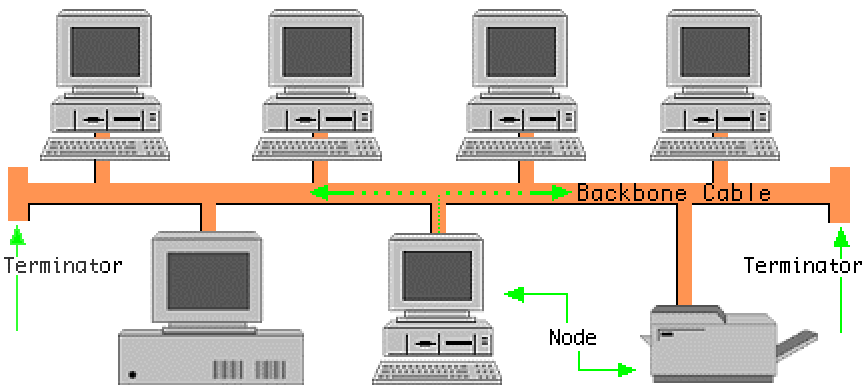
MAC Protocols: Ethernet (cont.)

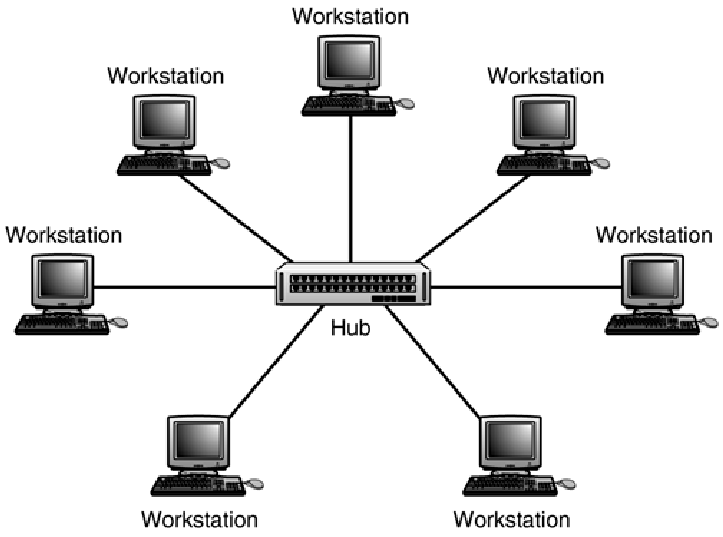




MAC Protocols: Ethernet (cont.)



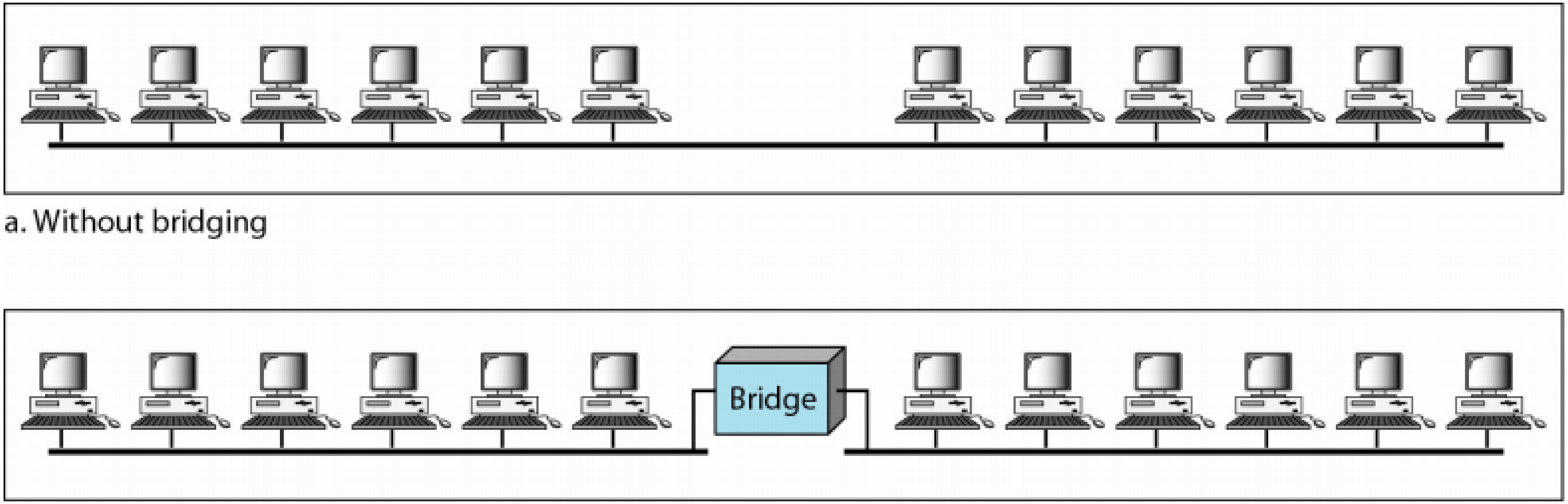




MAC Protocols: Ethernet (cont.)

Bridged Ethernet

- **bridge = device that divides network into 2 or more segments**
  - **separates collision domains**
  - **results in increased 'total' bandwidth**



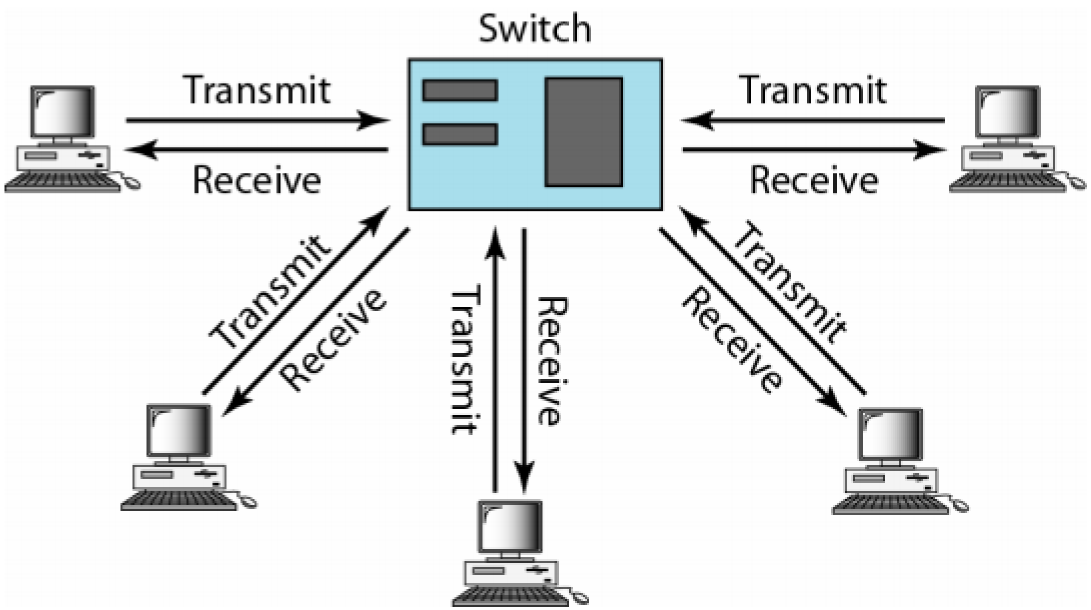
a. Without bridging

b. With bridging

MAC Protocols: Ethernet (cont.)

Full-Duplex Switched Ethernet

- **layer-2 switch = multiport bridge**
- **full-duplex = each station has one link to transmit, one to receive**
  - **each link is a dedicated point-to-point path between the station and the switch**
  - **carrier sensing and collision detection can be <u>turned off</u>**



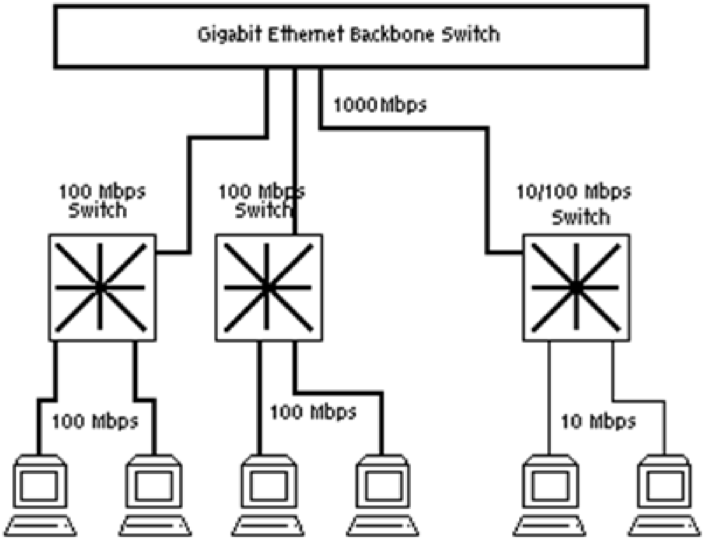
MAC Protocols: Ethernet (cont.)

IEEE 802.3
100 Mbps
(Fast Ethernet)

- **if we want to keep the minimum size of the frame, while increasing Ethernet bit-rate, the maximum length of the network should be changed**

min frame time = 2*max segment / c = min frame size / data rate

- **in 100 Mbps the maximum segment size drops to 250m – impractical for bus topology !!!**
- **solutions: star-topology with 250 segments, or switched Ethernet**



MAC Protocols: Ethernet (cont.)

IEEE 802.3
100 Mbps
(Fast Ethernet)

- **100 Mbps Ethernet uses a combination of 4B/5B block coding** (good for synchronization and to prevent long sequences of 0s & 1s) **and MLT-3 multi-level line coding** (to minimize the demand on bandwidth)