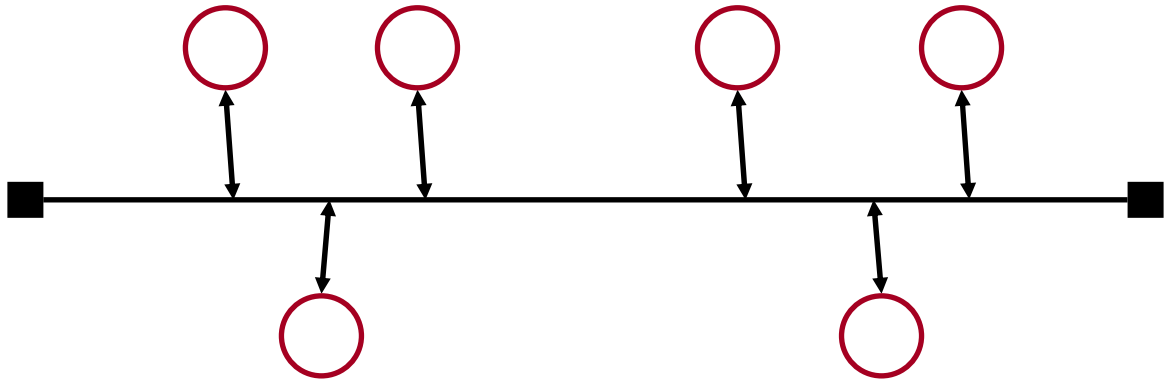
Ethernet

Ethernet [DEC, Intel, Xerox]



- 1-persistent, CSMA-CD with Binary Exponential Backoff.
- Manchester encoding.

Ethernet [operational in 1974]

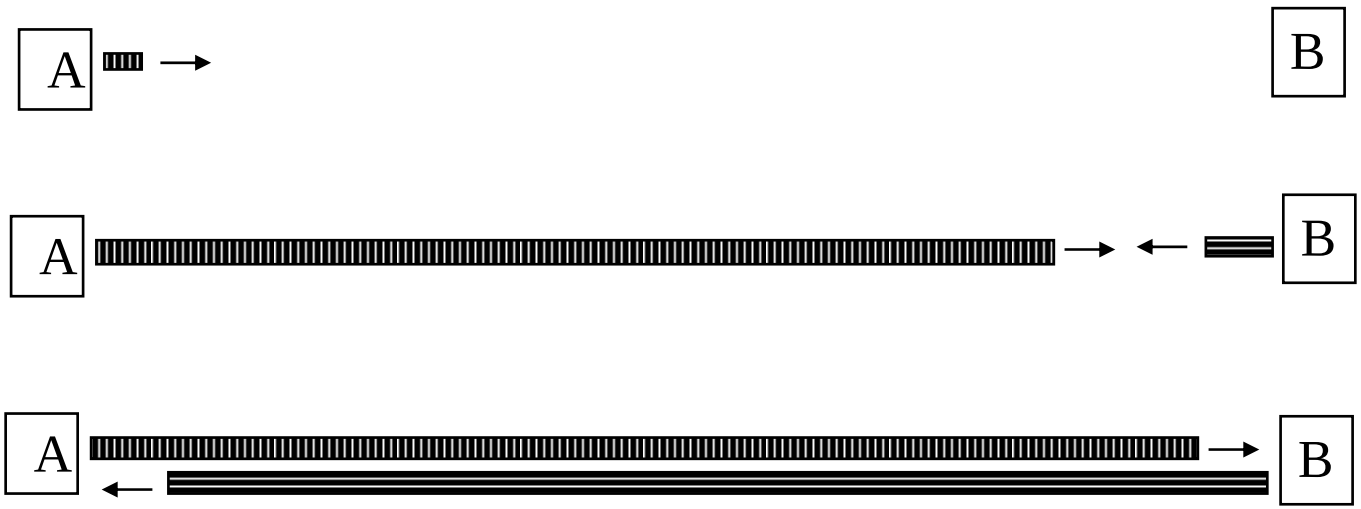
Initially 3 Mbps **baseband** coaxial cable (thick Ethernet).

Operational Description

- *Ethernet stations **sense** the channel.*
- *When the channel is free, the station **transmits** a frame.*
- *The stations **monitor** the 'ether' during the transmission.*
- *If a **collision is detected** by any station, the transmission is terminated immediately and a **jam signal** is sent.*
- *Upon collision, transmitting stations **backoff** using a local counter and then retransmit.*

Collision Detection [worst case]

A begins to transmit at t=0



B begins to transmit at $t = t_{prop} - \delta$;
B detects collision at $t = t_{prop}$

A detects collision at $t = 2\ t_{prop} - \delta$

It takes **2 t_{prop}** to find out if channel has been captured

Ethernet

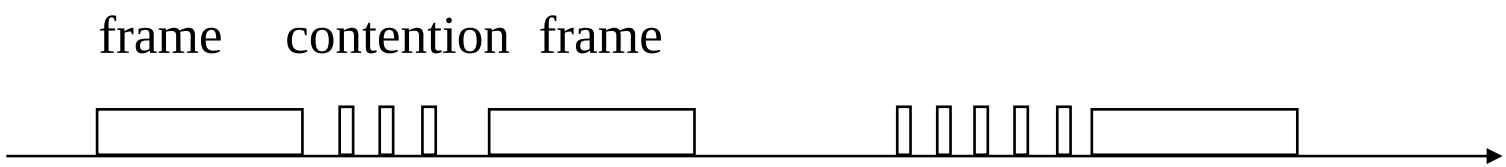


Figure 6.23

- A frame *seizes the channel after 2* t_{prop}
- On 1 km Ethernet, t_{prop} is approximately 5 microseconds.
- Contention interval = ***2*** $\boldsymbol{t_{prop}}$
- ***Interframe gap = 9.6 microseconds***
- Modeled as *slotted scheme* with slot = ***2*** $\boldsymbol{t_{prop}}$

Binary Exponental Backoff

- Upon a collision, the **sending stations** increment a local counter K. The backoff interval is randomly selected using a uniform distribution over the $L = 2^K$ slots.
- K is initially set to 0.
- Thus upon collision, the value of L is doubled locally for each **sending station**.

Binary Exponential Backoff (BEB)

Slotted ALOHA has been shown to be **unstable** *when*

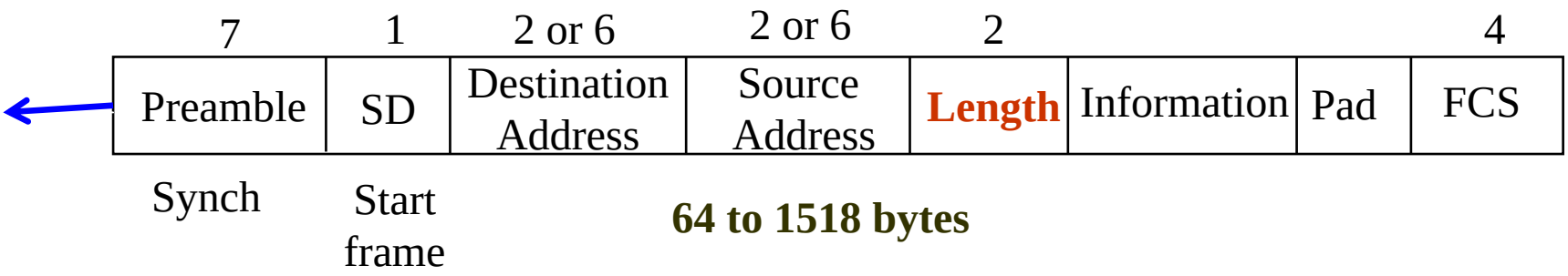
$$p > 1/n$$

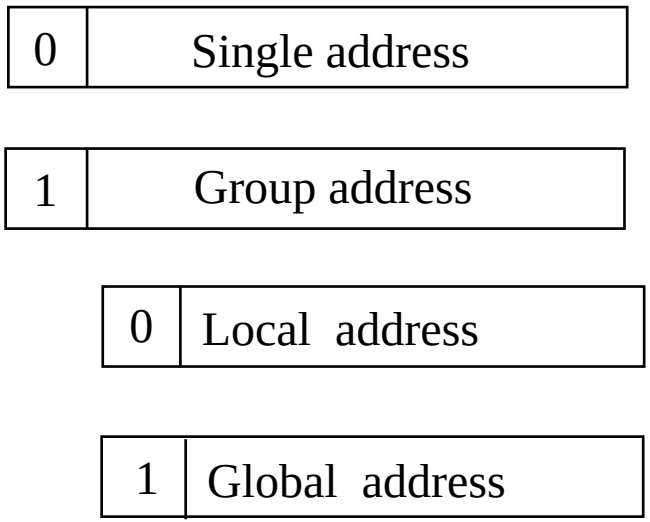
Since Ethernet permits up to 1024 stations, backoff continues until $K = 10$, $L = 2^{10}$, and $p = 1/2^{10}$

Normally K is incremented up to 10, but BEB is set for 16 retries. After 16 retries, MAC gives up trying to send the frame.

{The IP packet is now considered lost}.

802.3 MAC Frame





- Destination address is either single address or group address (broadcast = 111...111)

- Addresses are defined on local or universal basis
- 2^{46} possible global addresses

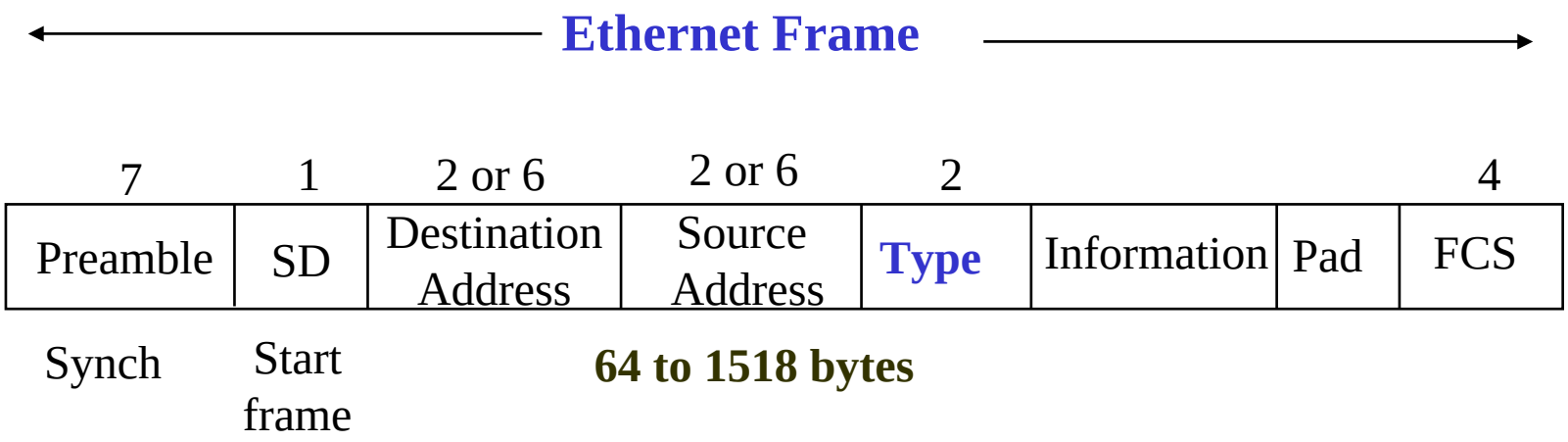
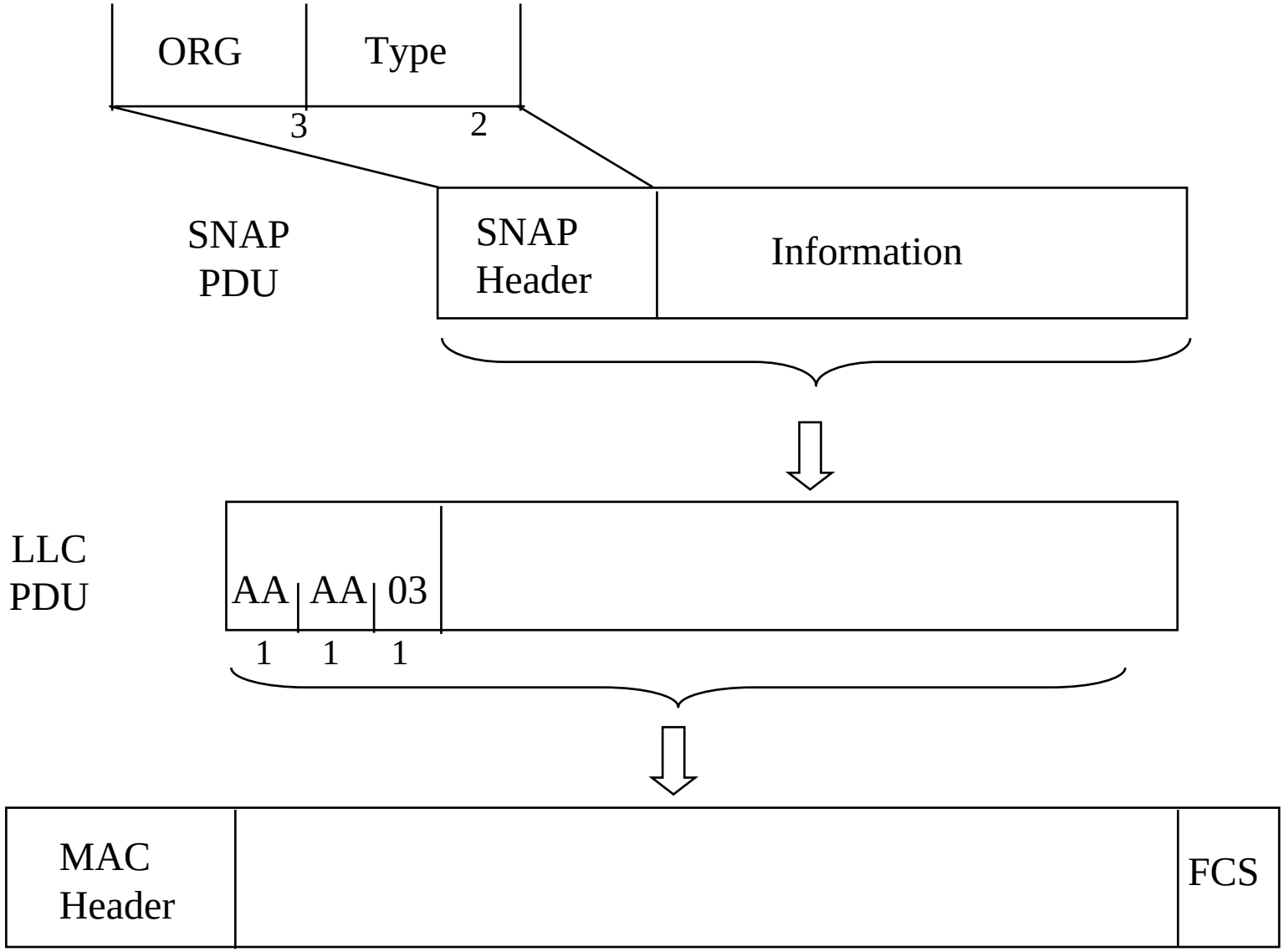


Figure 6.54



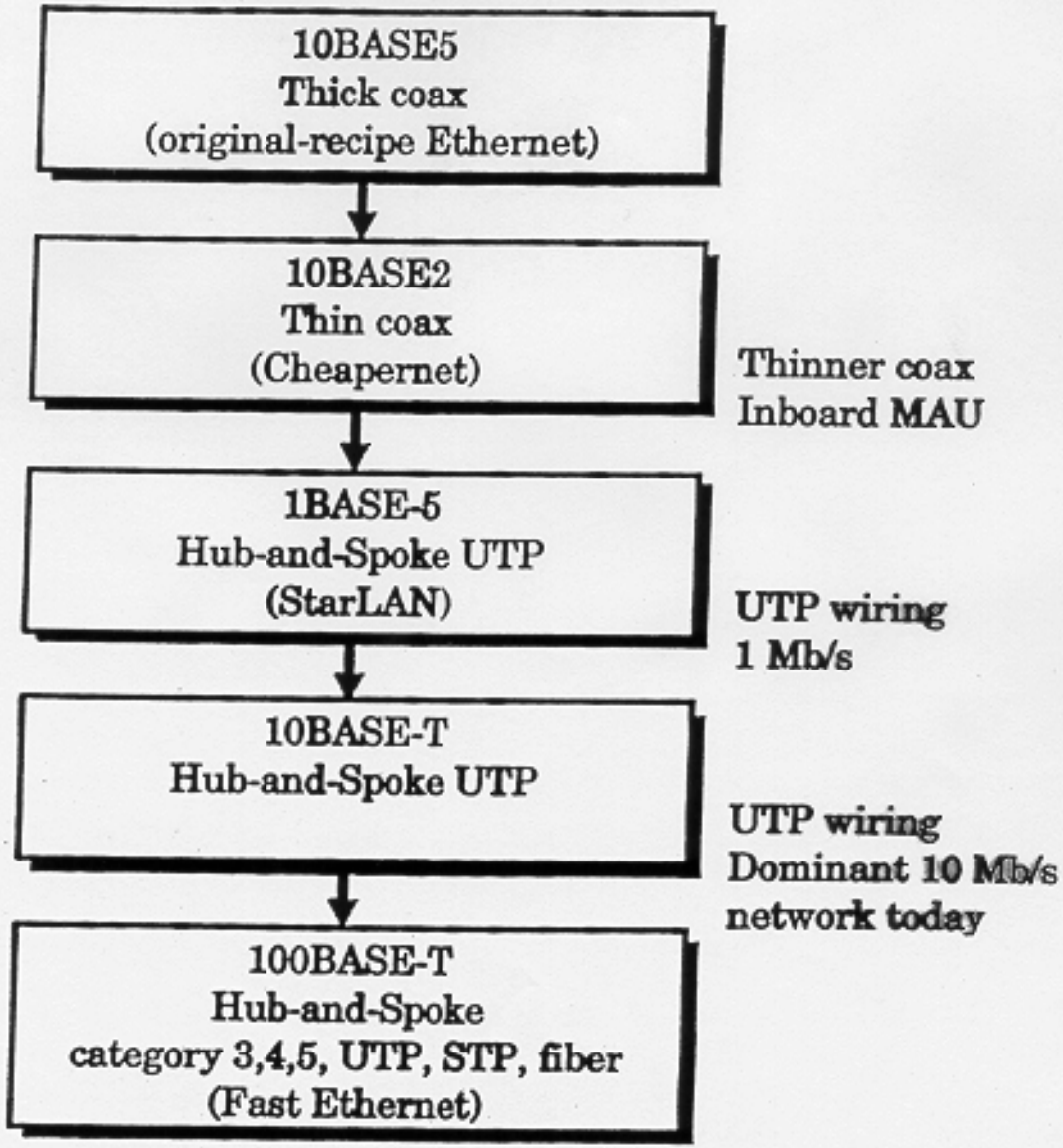


Figure 1.4 Lineage of Fast Ethernet

Ethernet Evolution

10BASE5 {1983}

- 10 Mbps
- 500 meter segment length
- Signal-regenerating repeaters
- **Thick Coax**
  - ***Advantages:*** Low attenuation, excellent noise immunity, superior mechanical strength
  - ***Disadvantages:*** Bulky, difficult to pull, transceiver boxes too expensive

* ***Wiring represented a significant part of total installed cost.***

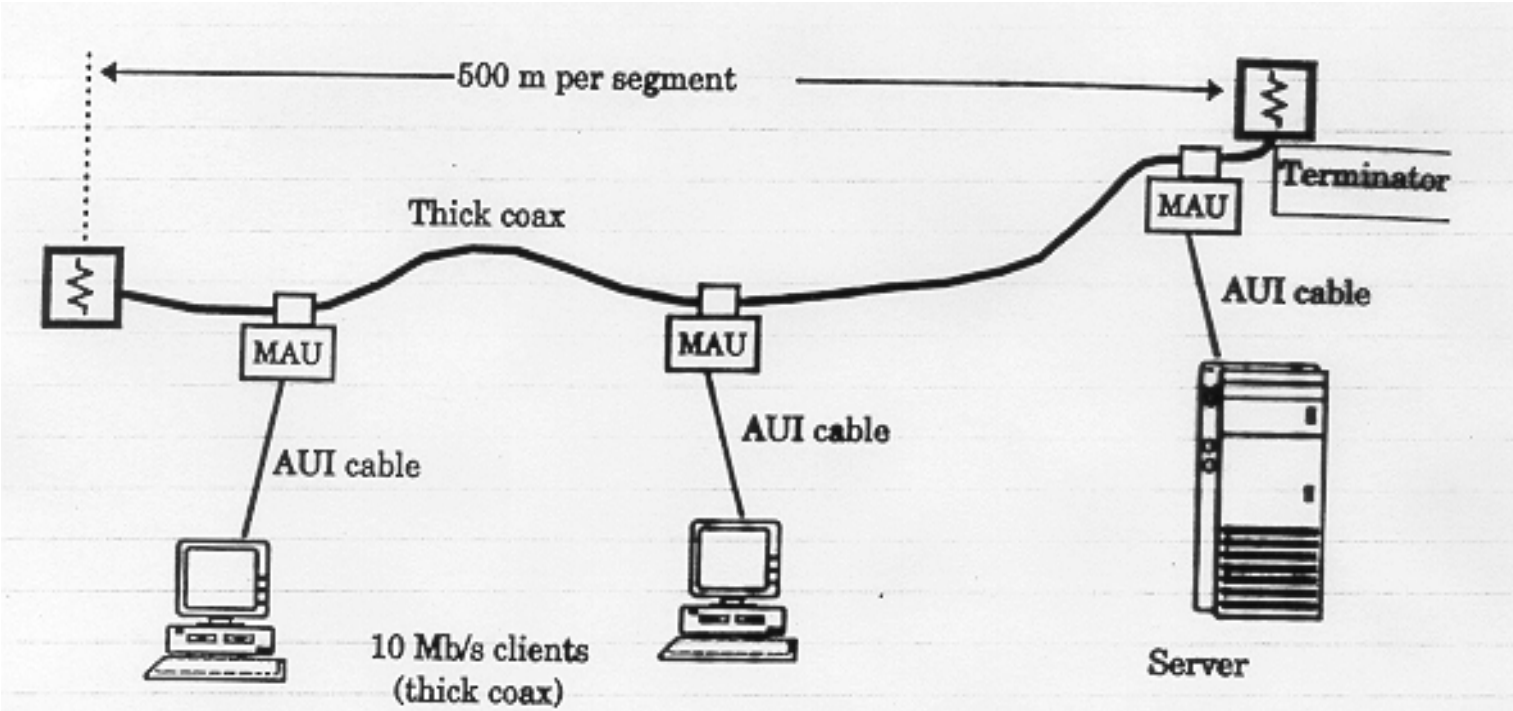


Figure 1.5 Thick Coax Installation

MAU device is physically hooked on main cable.

50 meter AUI cable from MAU to station.

Ethernet Evolution

10BASE2 *Cheapernet* {1985}

- 10 Mbps
- 185 meter segment length
- Signal-regenerating repeaters
- Transceiver was integrated onto the adapter
- **Thin Coax** (coax thinner and lighter)
  - ***Advantages:*** Easier to install, reduced hardware cost, BNC connectors widely deployed ➔ lower installation costs.
  - ***Disadvantages:*** Attenuation not as good, could not support as many stations due to signal reflection caused by BNC Tee Connector.

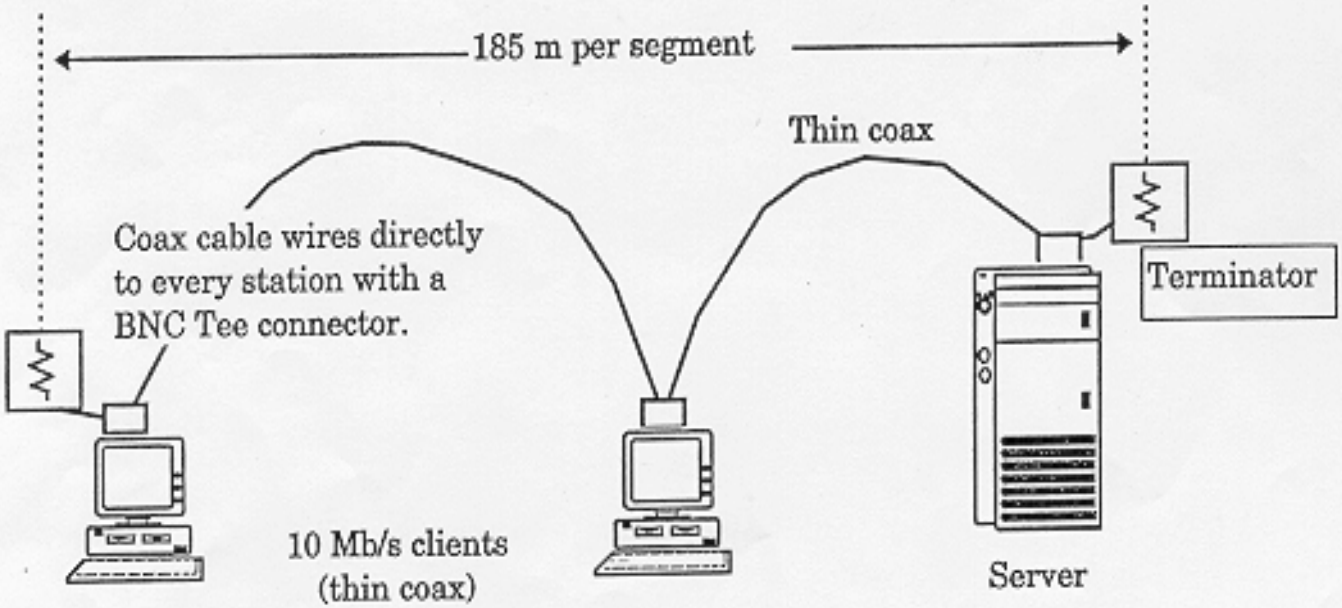


Figure 1.6 Cheapernet Installation

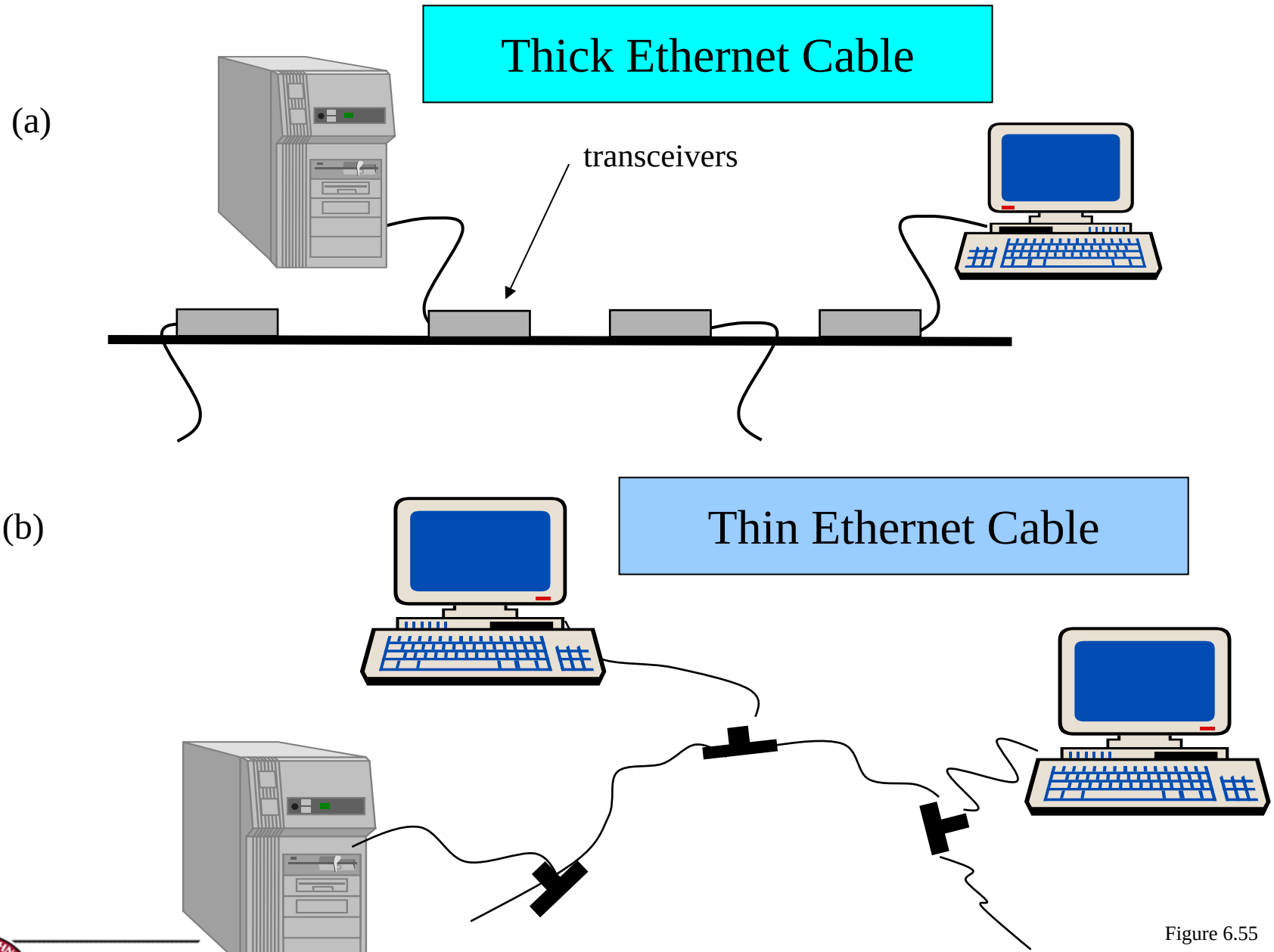


Figure 6.55

Ethernet Evolution

1BASE5 *StarLAN* {1987}

- 1 Mbps
- 250 meter segment length
- Signal-regenerating repeaters
- Transceiver integrated onto the adapter
- Hub-and-Spoke topology (star topology)
- **Two pairs of unshielded twisted pair**
  - ***Advantages:*** *Since four or more UTP are ubiquitous in buildings, it is easier to use installed wiring in the walls. Telephone wiring is hierarchical ➔ can use wiring closets.*

Ethernet Evolution

10BASET {1990} **Most popular

- 10 Mbps
- 100 meter segment length
- Signal-regenerating repeaters
- Transceiver integrated onto adapter
- Two pairs of UTP
- **Hub-and-spoke topology** {Hub in the closet}
  - ***Advantages:*** could be done without pulling new wires. Each hub amplifies and restores incoming signal.

The Hub Concept

- Separate transmit and receive pair of wires.
- The **repeater** in the hub retransmits the signal received from **any** input pair onto **ALL** output pairs.
- *Essentially the **hub** emulates a **broadcast channel** with collisions detected by receiving nodes.*

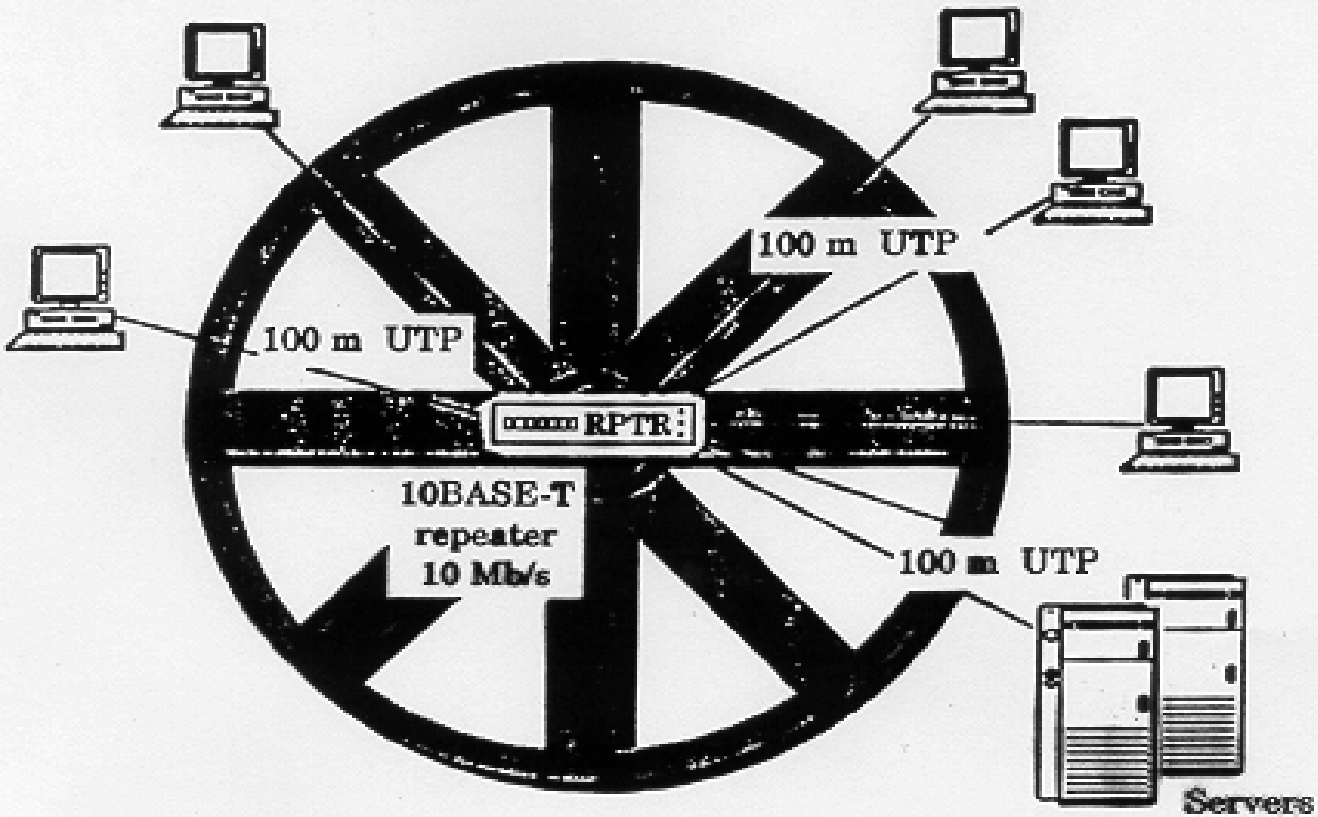
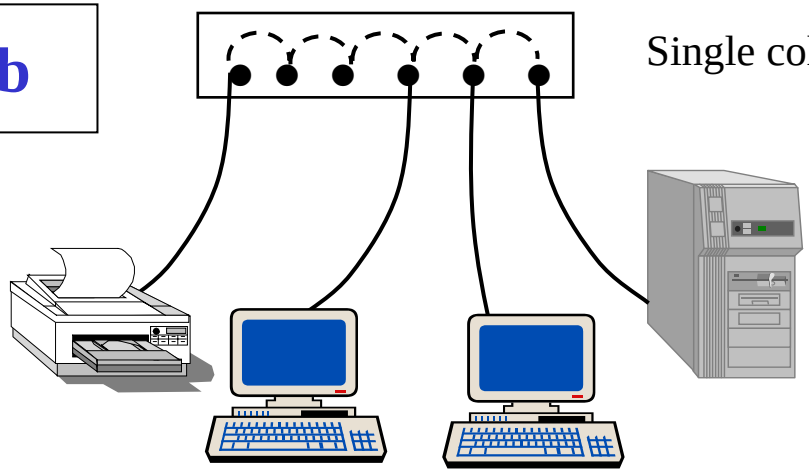


Figure 1.7 10BASE-T Hub-and-Spoke Architecture

Twisted Pair Ethernet

(a) **hub**



Single collision domain

(b) **switch**

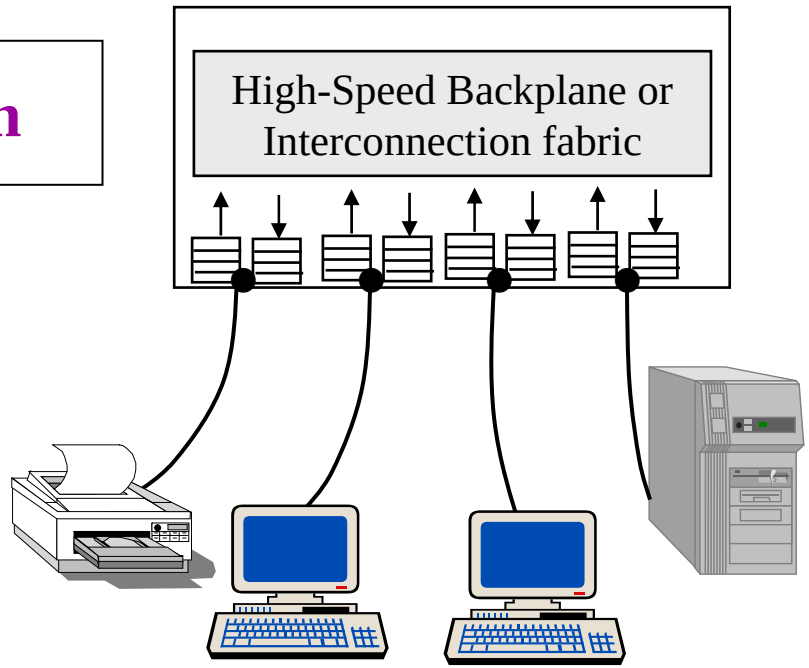


Figure 6.56

Switched Ethernet

* Basic idea: improve on the **Hub** concept
- The switch *learns destination locations* by remembering the ports of the associated source address in a table.
- The switch may not have to broadcast to all output ports. It may be able to send the frame **only** to the destination port.
- ➔ **a big performance advantage over a hub**, if more than one frame transfer can go through the switch concurrently.

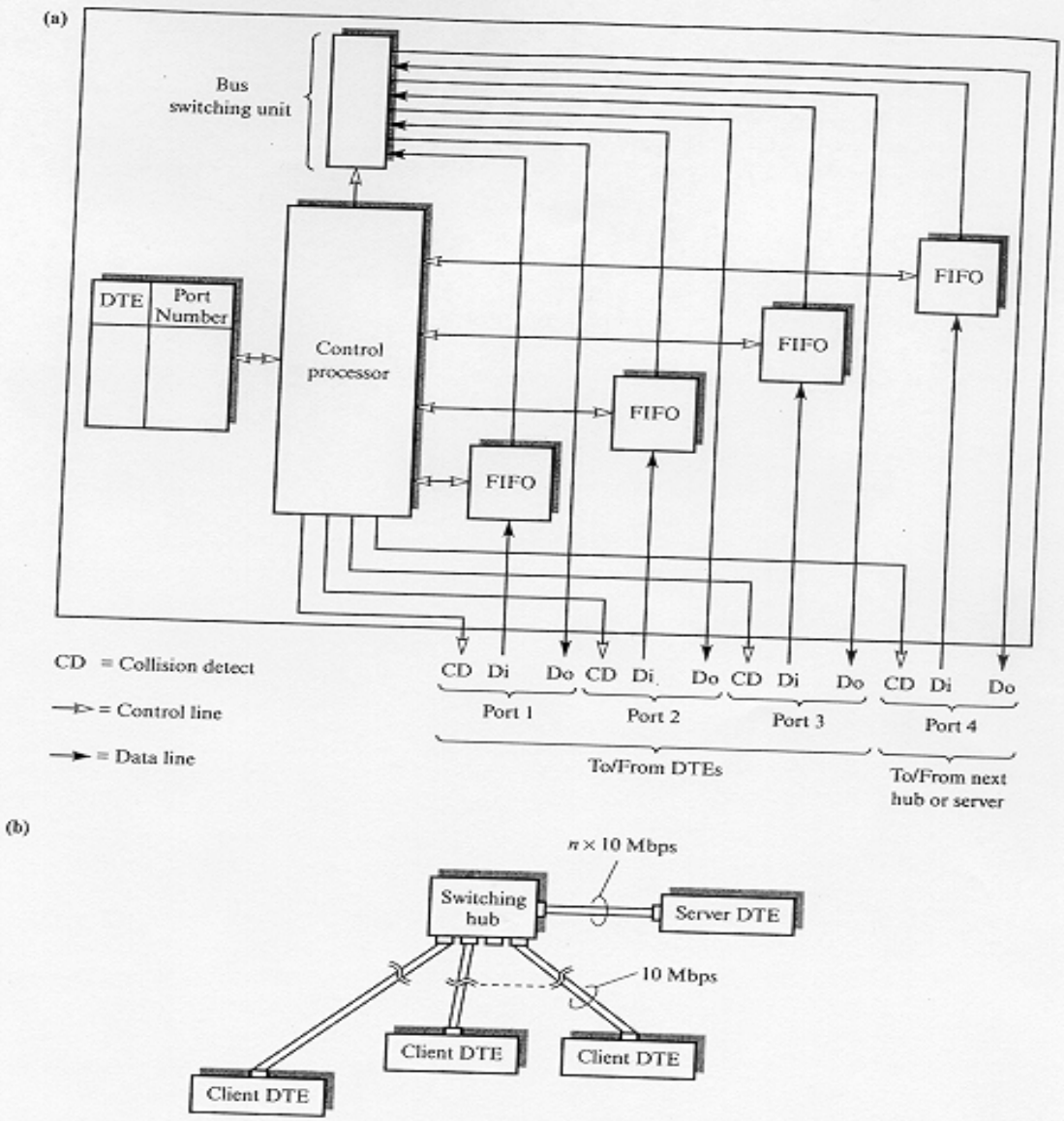
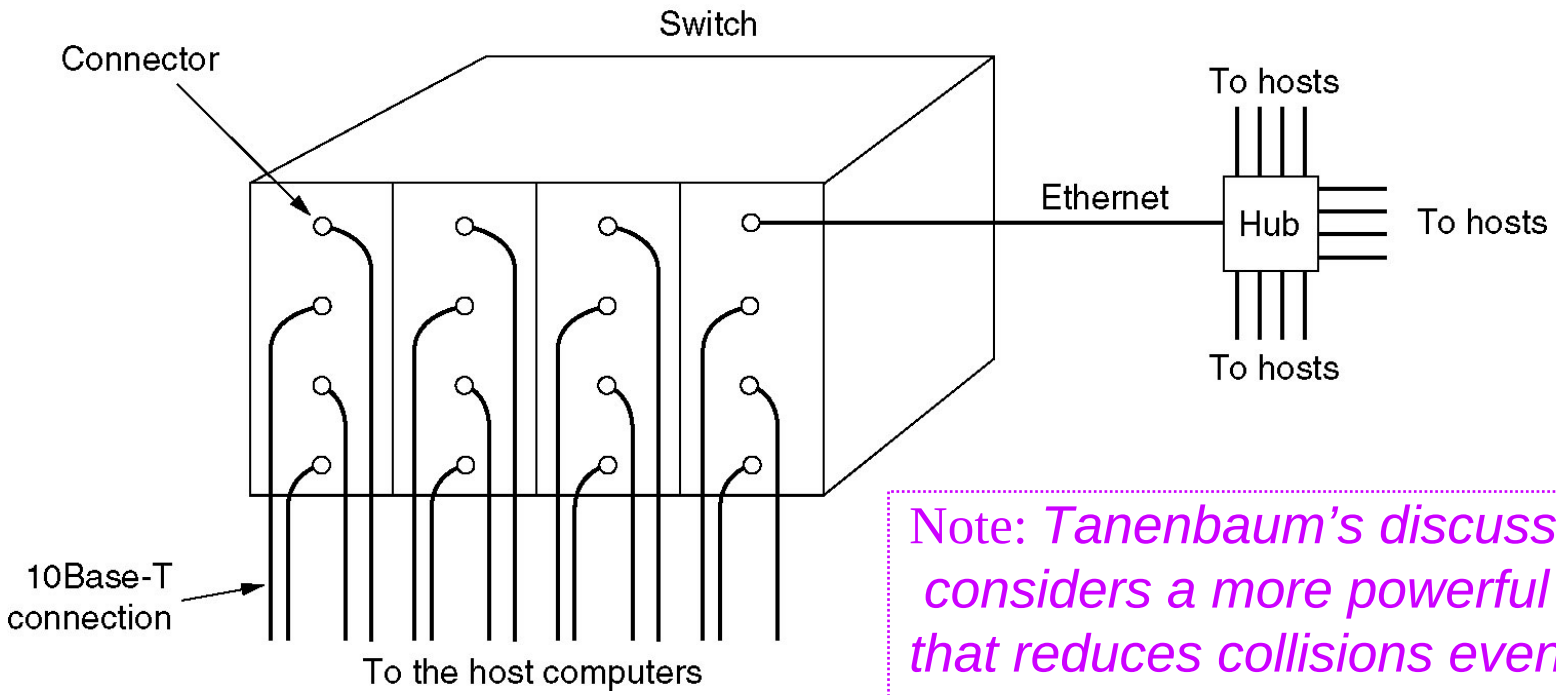


Figure 7.2
Ethernet switching:
(a) switching hub schematic;
(b) switching hub derivative.

Switched Ethernet

- The advantage comes when the **switched Ethernet** backplane is able to repeat more than one frame in parallel *(a separate backplane bus line for each node)*.
  - The frame is relayed onto the required output port via the port's own backplane bus line.
- Under this scheme *collisions are still possible* when two concurrently arriving frames are destined for the same station.
- **Note – each parallel transmission can take place at 10Mbps!!**

Switched Ethernet



Note: *Tanenbaum's discussion considers a more powerful switch that reduces collisions even further!!*

Figure 4-20.A simple example of switched Ethernet.

Switched Ethernet Hub

- Since servers are often shared by multiple nodes, one can employ a **switching hub** with a port which operates at a higher rate than the other ports.

➔**This requires extra buffering inside the hub to handle speed mismatches.**

- Can be further *enhanced* by higher rated port **full-duplex.**