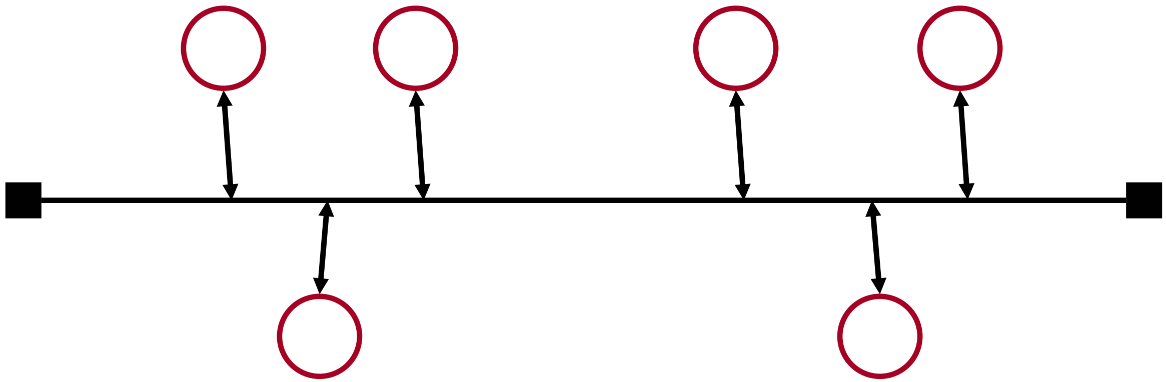
Ethernet

Ethernet [DEC, Intel, Xerox]



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

Ethernet [operational in 1974]

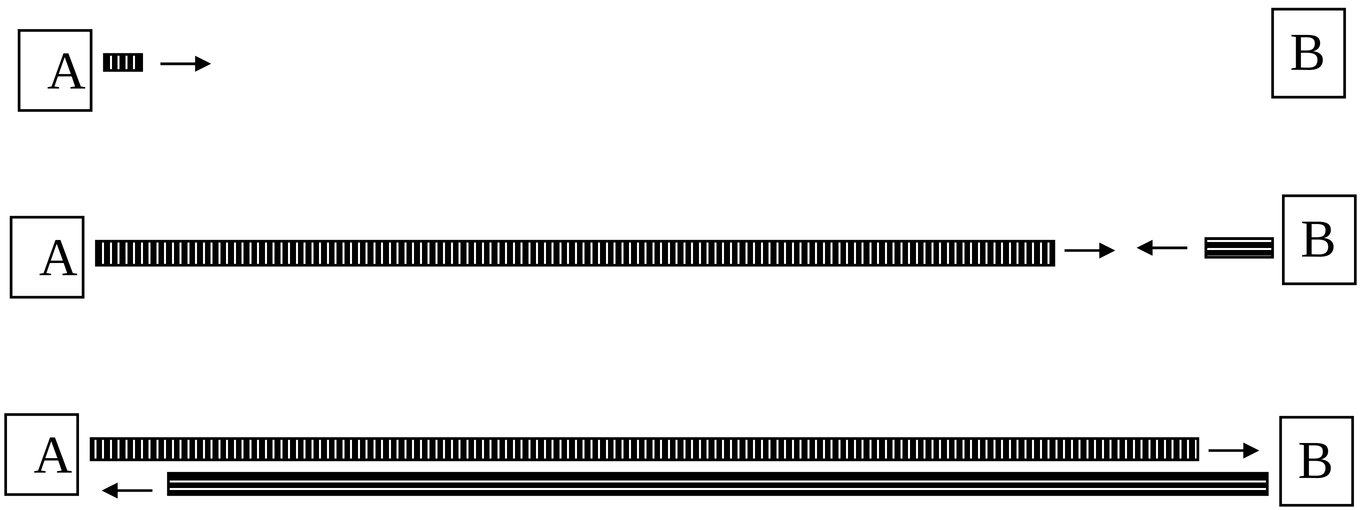
Initially 3 Mbps baseband coaxial cable (thick Ethernet).

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

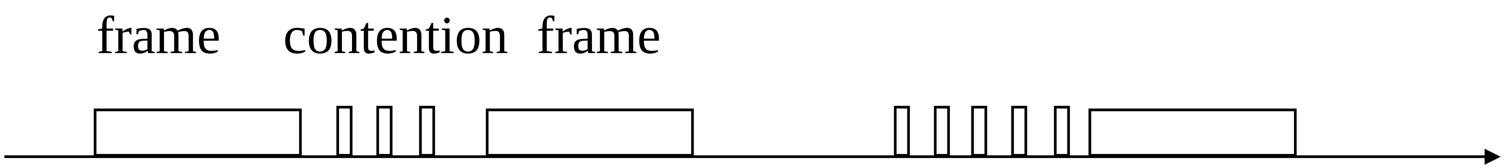


Figure 6.23

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

802.3 MAC Frame

7	1	2 or 6	2 or 6	2			4
Preamble	SD	Destination Address	Source Address	**Length**	Information	Pad	FCS
Synch	Start frame						

64 to 1518 bytes

0	Single address
1	Group address

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

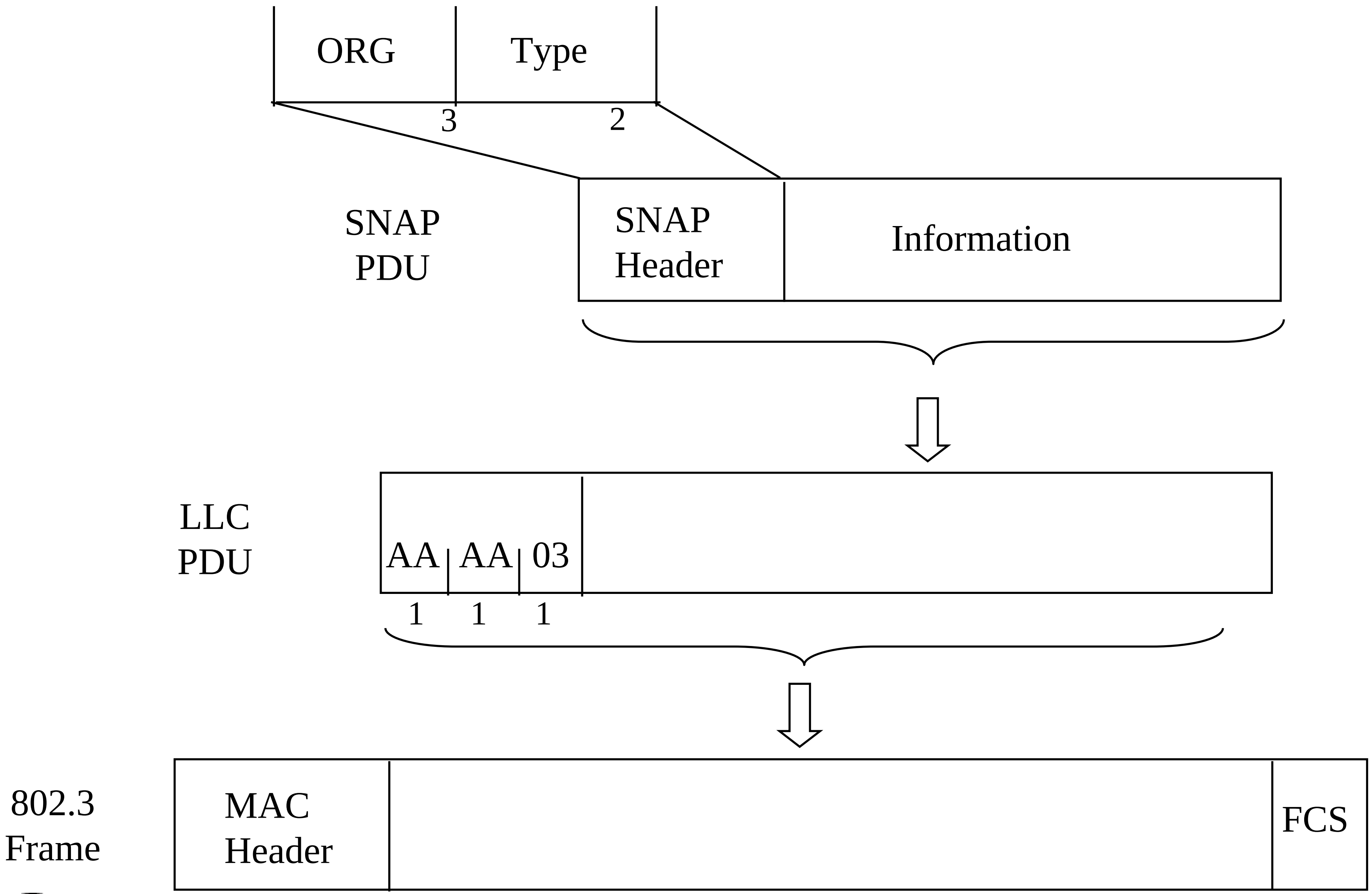
0	Local address
1	Global address

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

Ethernet Frame

7	1	2 or 6	2 or 6	2			4
Preamble	SD	Destination Address	Source Address	**Type**	Information	Pad	FCS
Synch	Start frame						

64 to 1518 bytes


ORG
Type
3
2
SNAP
PDU
SNAP
Header
Information
LLC
PDU
AA
AA
03
1
1
1
802.3
Frame
MAC
Header
FCS

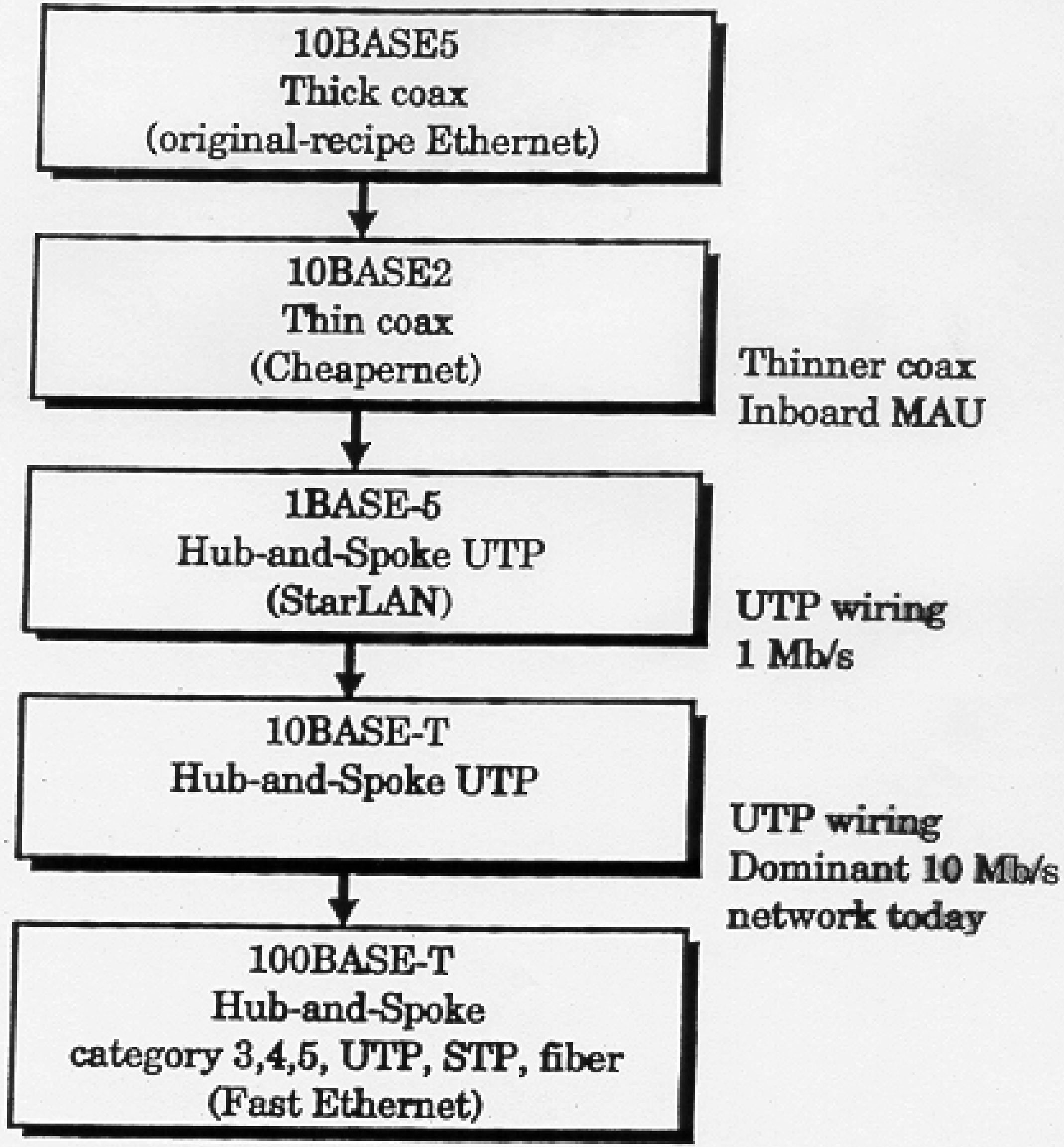


Figure 1.4 Lineage of Fast Ethernet

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.*

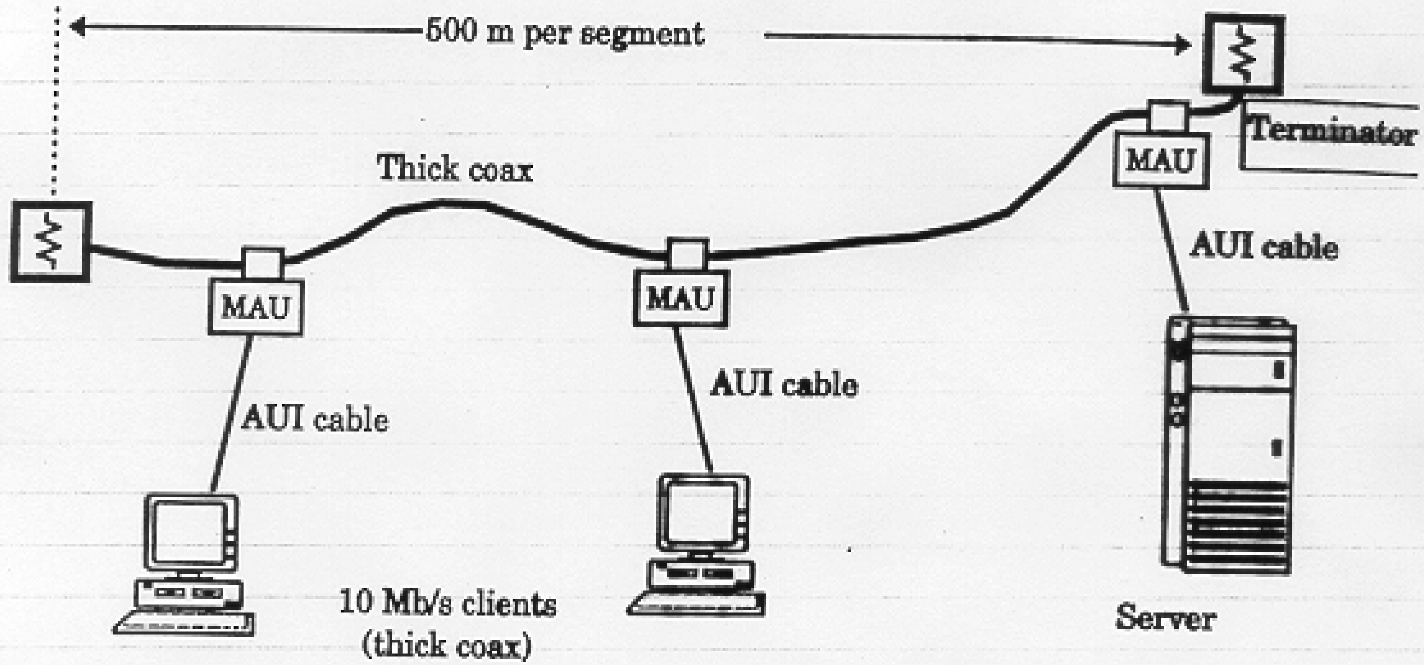


Figure 1.5 Thick Coax Installation

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.

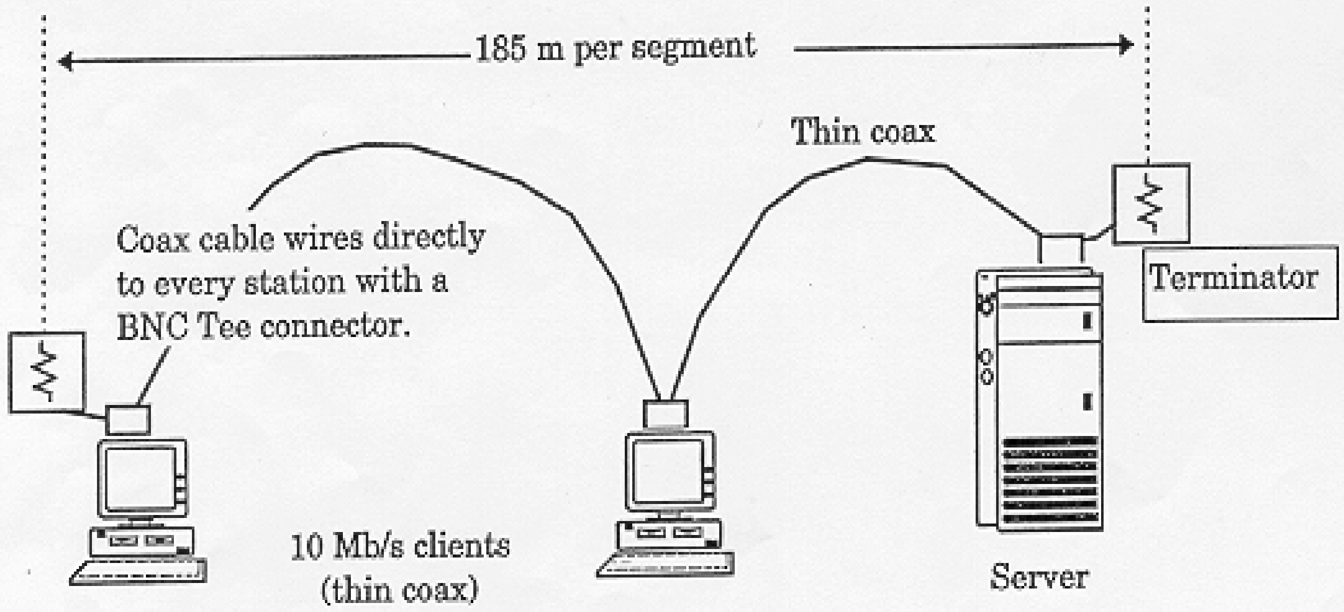
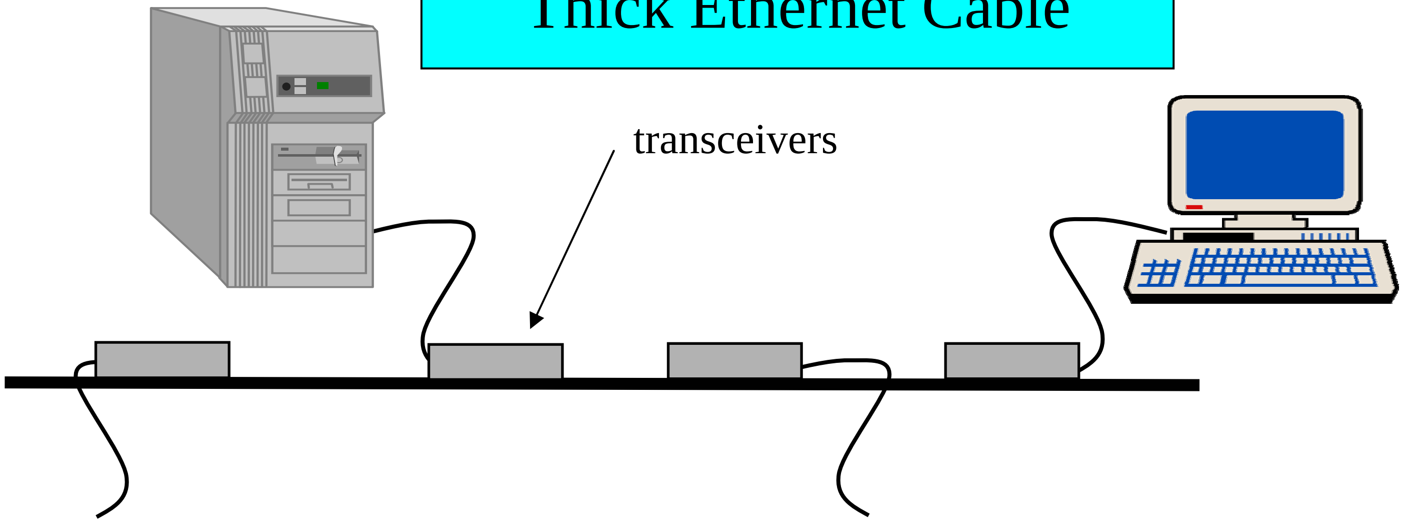


Figure 1.6 Cheapernet Installation

Thick Ethernet Cable

(a)



Thin Ethernet Cable

(b)

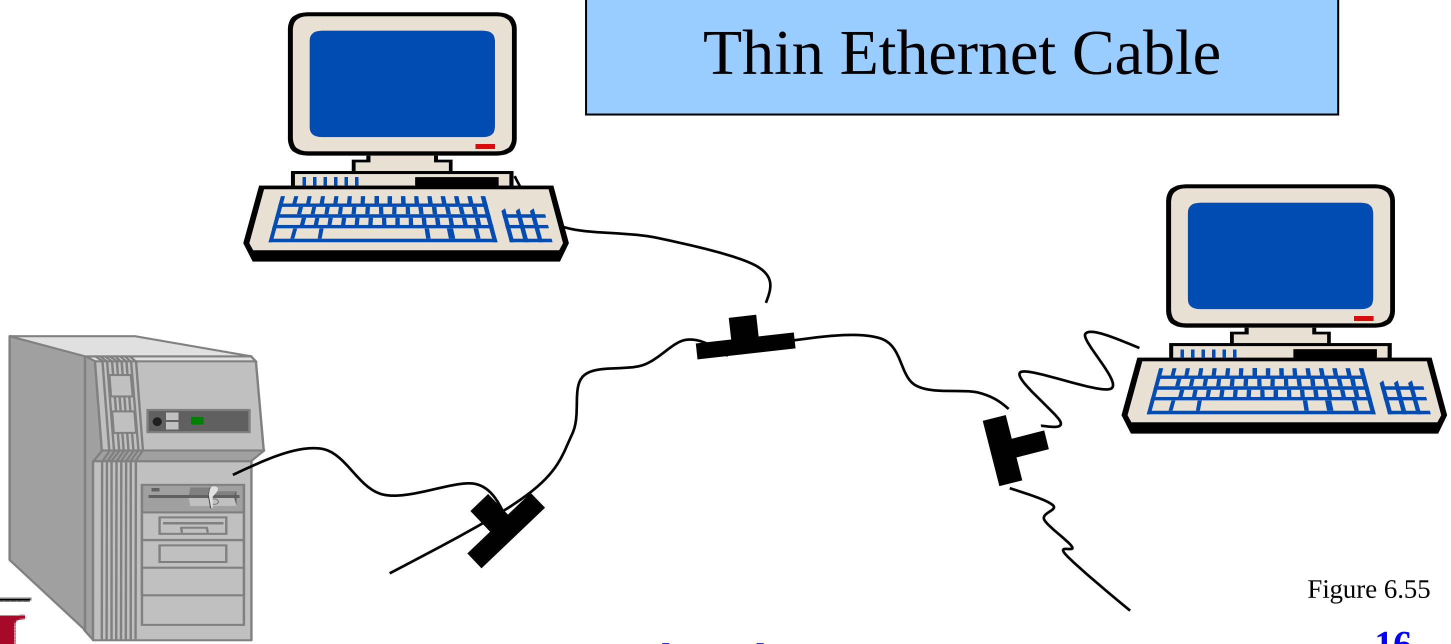


Figure 6.55

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.*

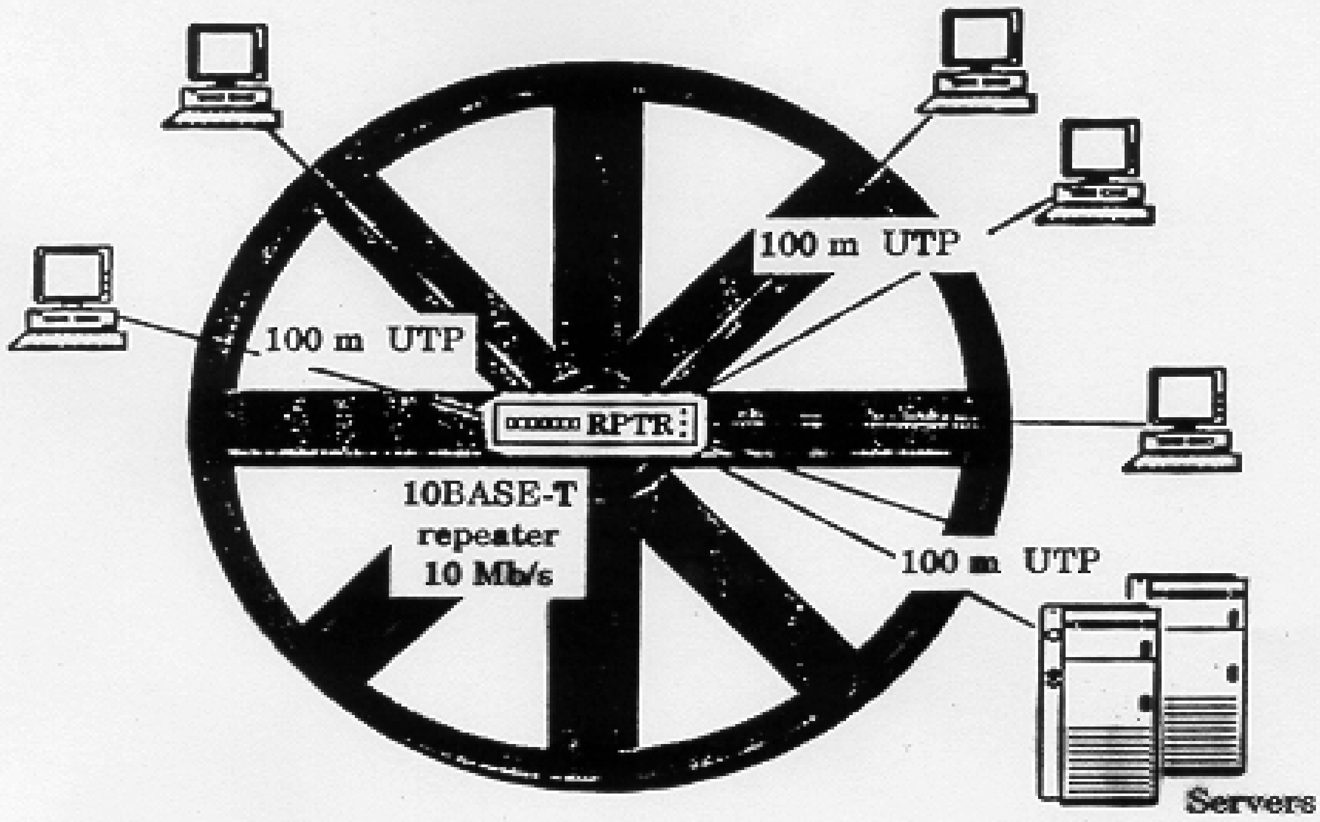
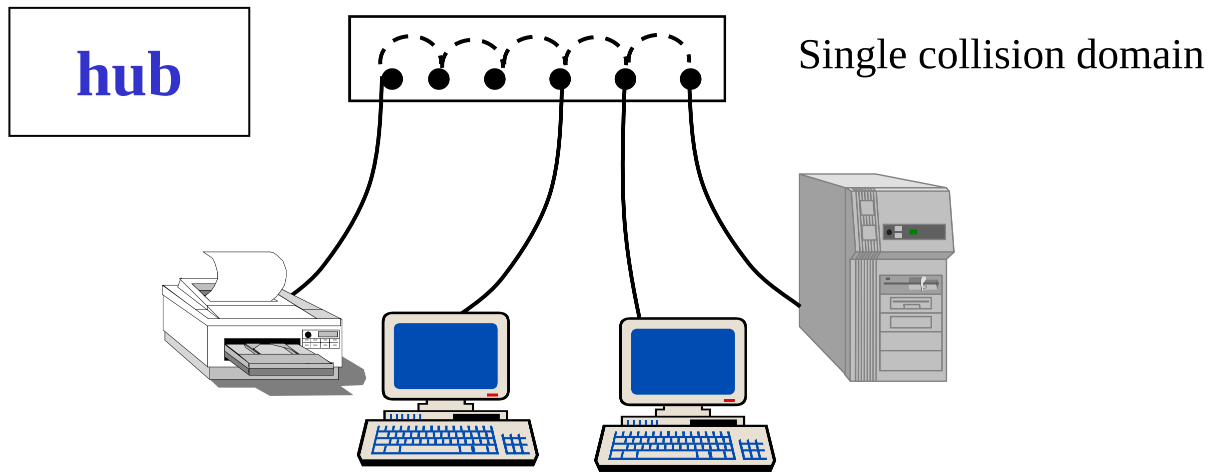


Figure 1.7 10BASE-T Hub-and-Spoke Architecture

Twisted Pair Ethernet

(a)



(b)

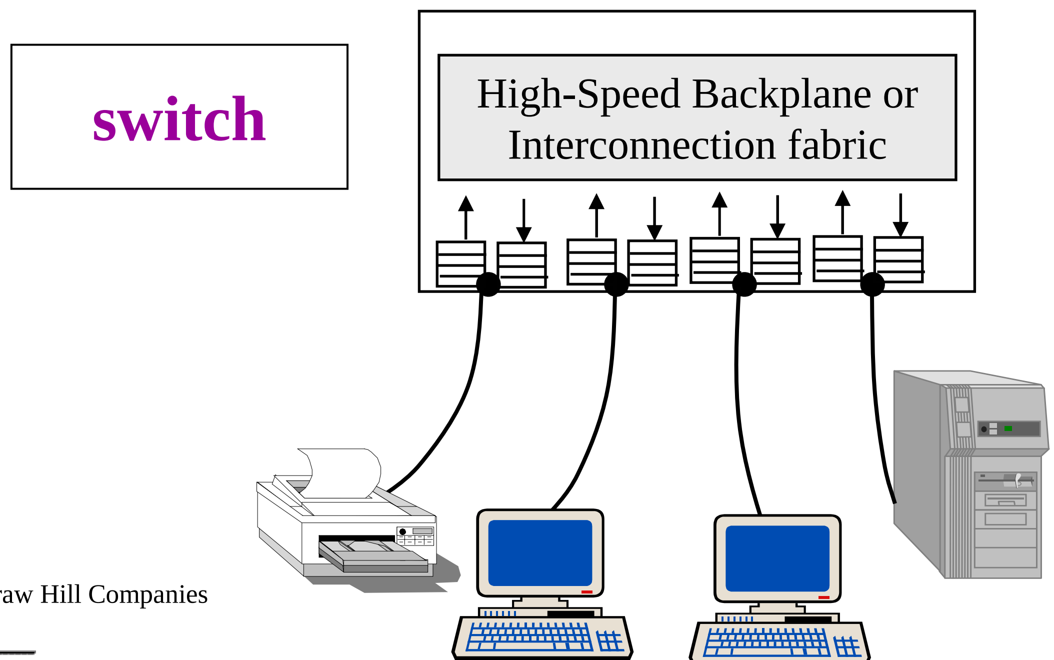


Figure 6.56

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.

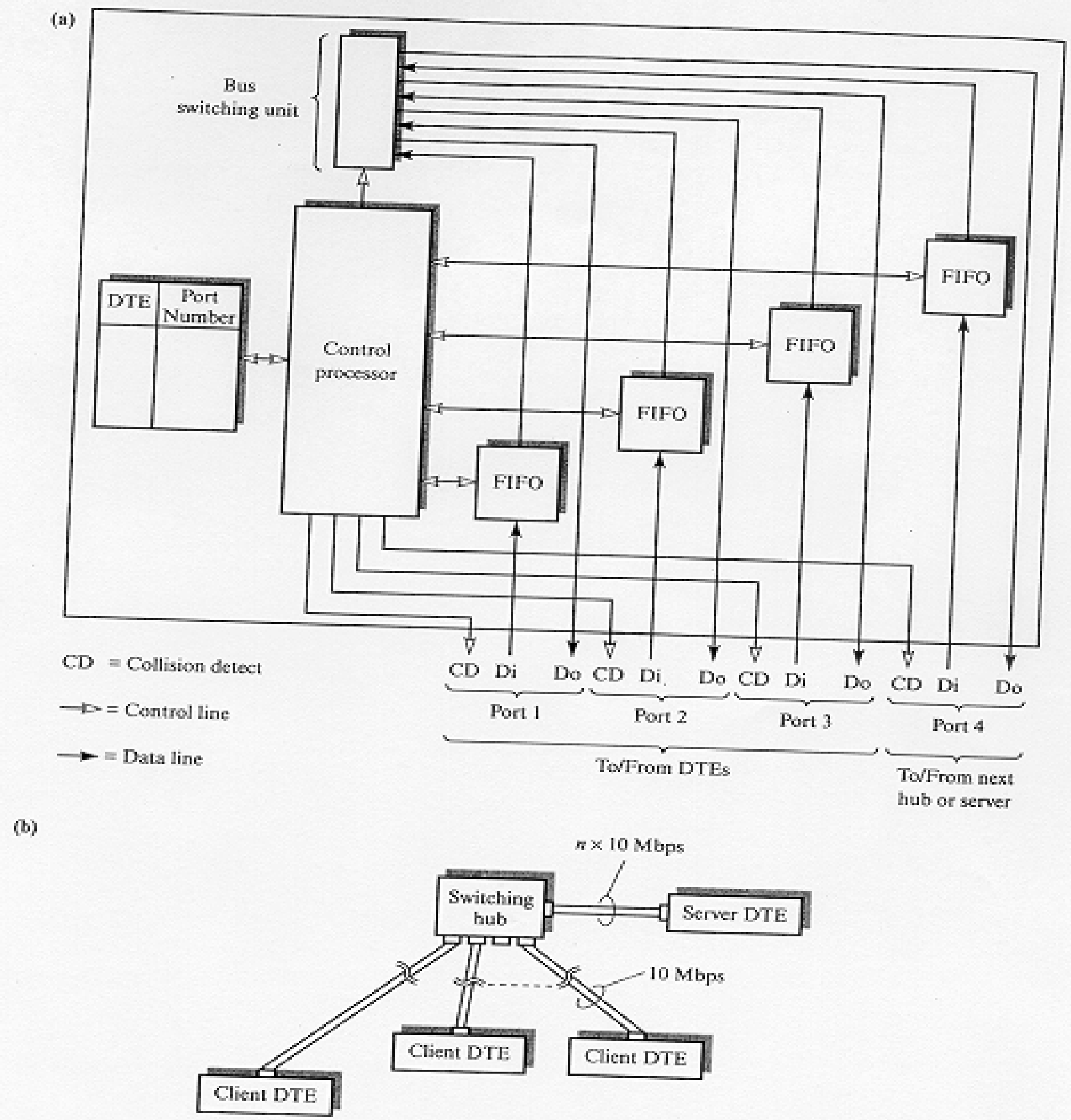
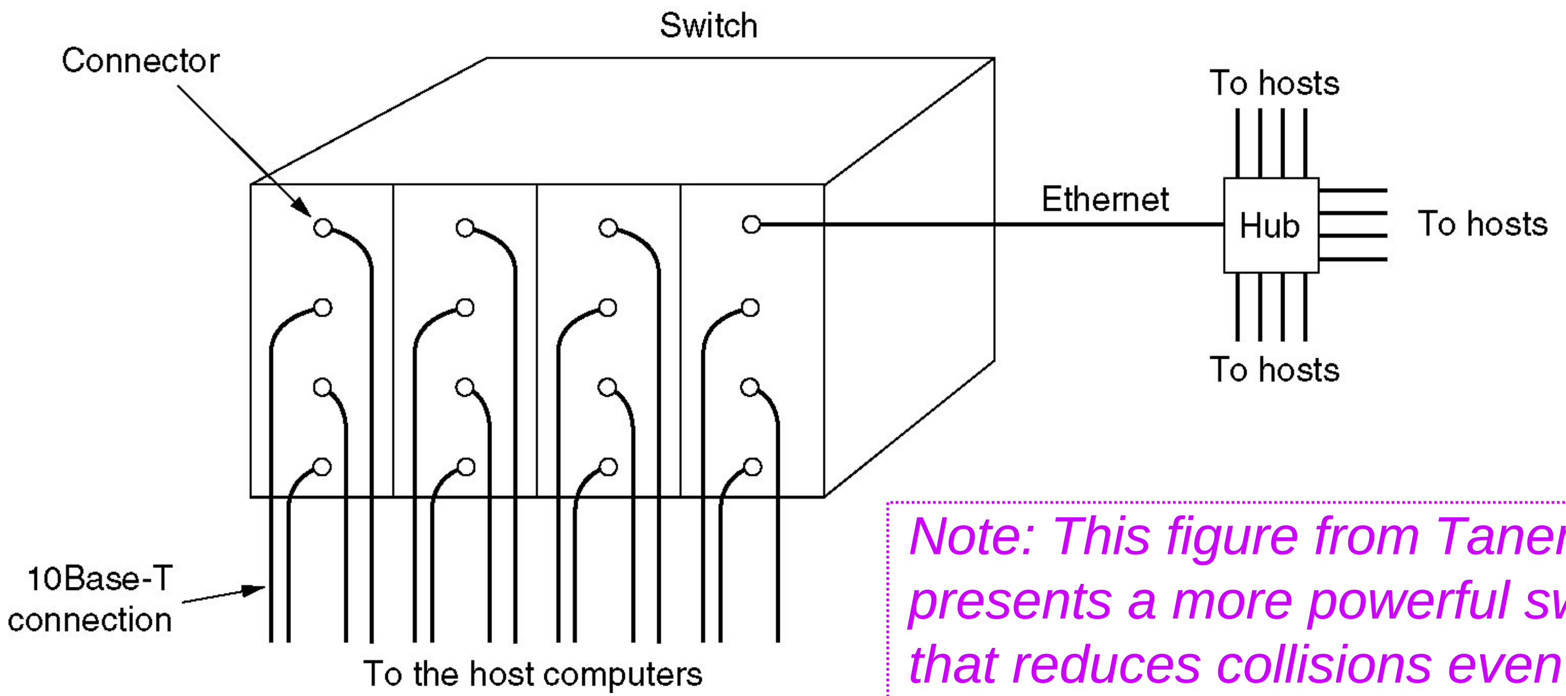


Figure 7.2
Ethernet switching:
(a) switching hub schematic;
(b) switching hub derivative.

Switched Ethernet

- The advantage comes when the **switched Ethernet** backplane is able to repeat more than one frame <u>in parallel</u> *(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: This figure from Tanenbaum presents 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.**

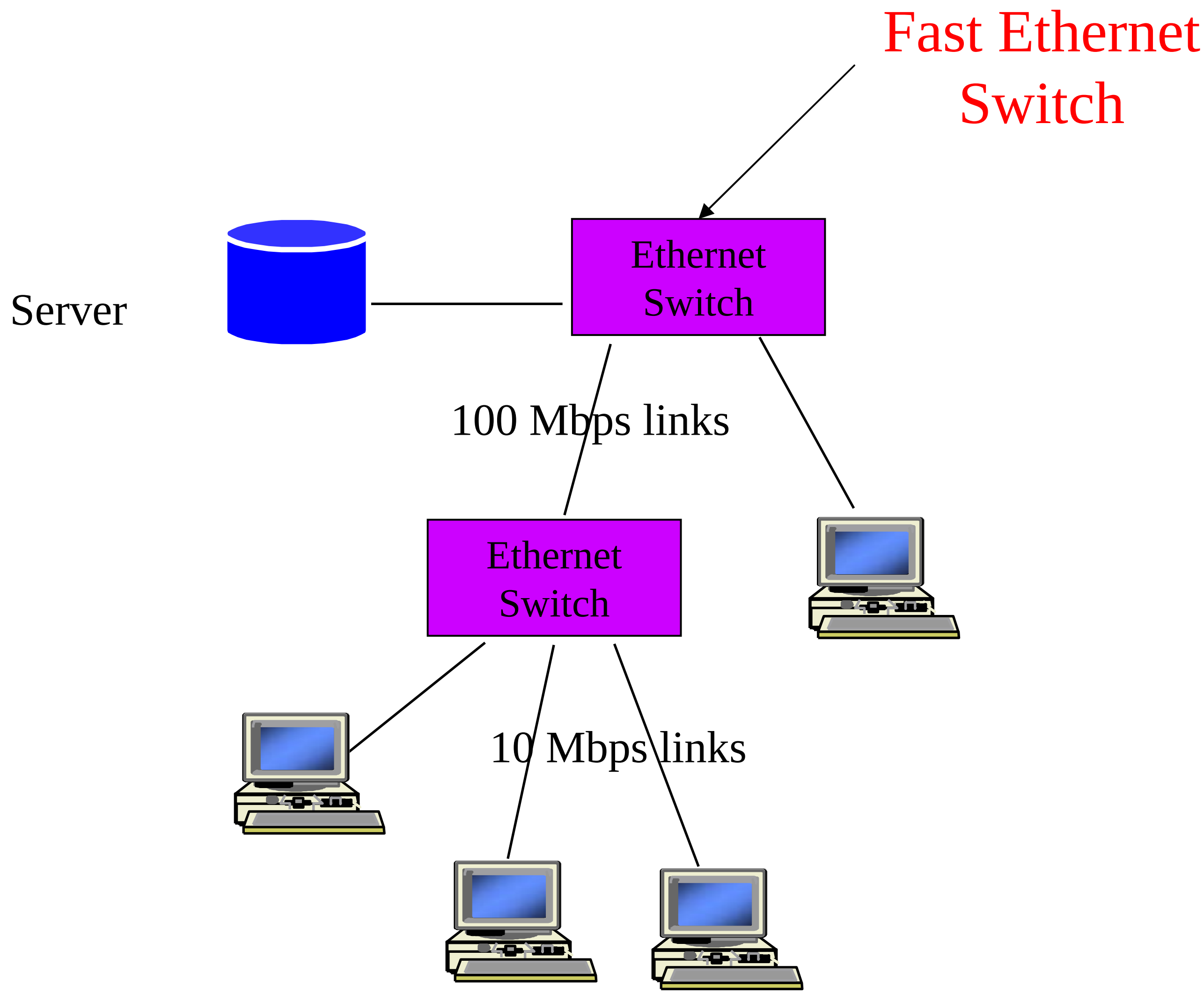

Fast Ethernet
Switch
Server
Ethernet
Switch
100 Mbps links
Ethernet
Switch
10 Mbps links

Figure 6.57