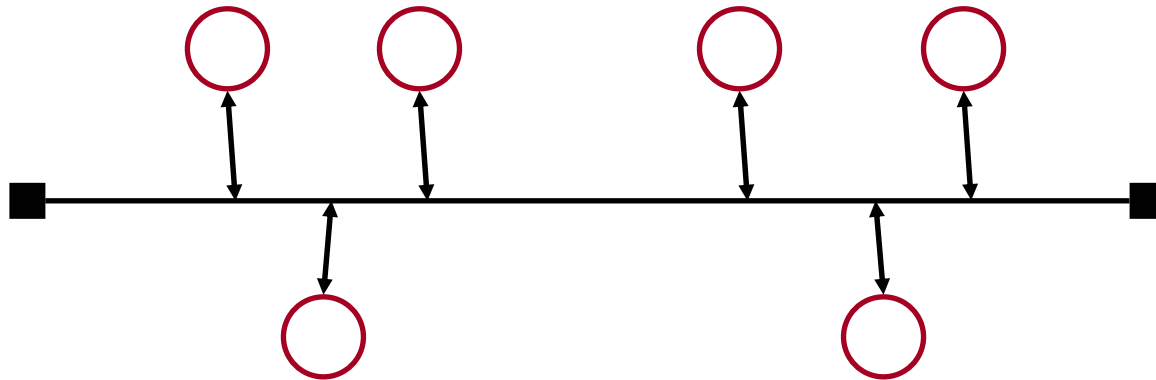# Ethernet

Ethernet [DEC, Intel, Xerox]

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

- Manchester encoding.
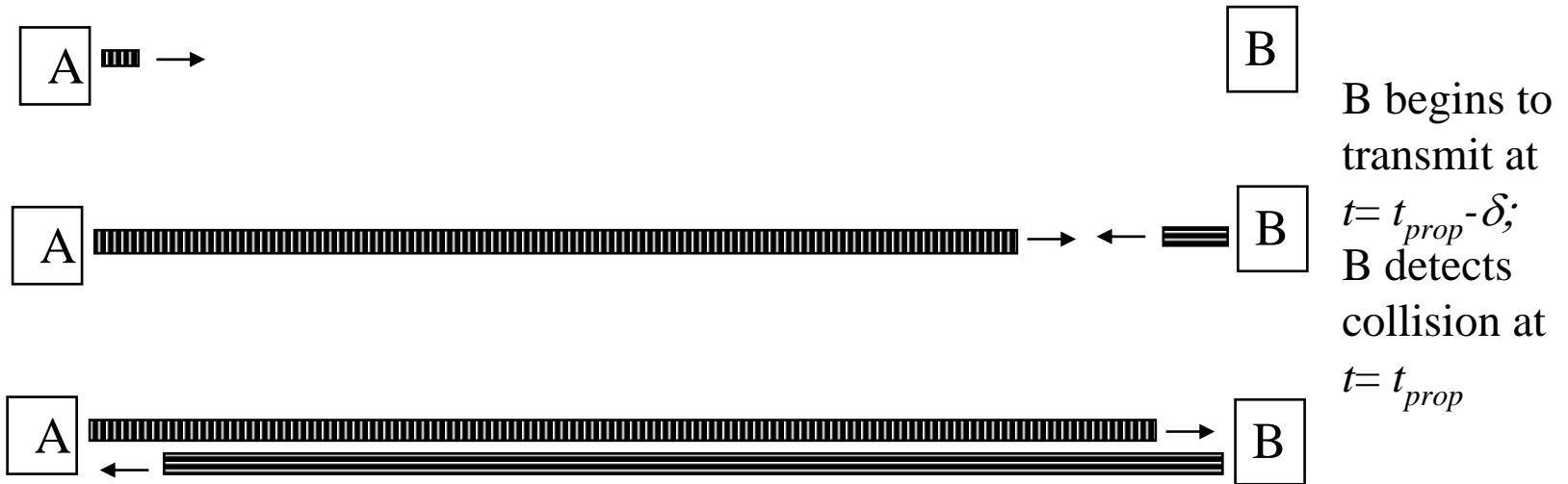
Ethernet [operational in 1974]

Initially 3 Mbps <u>baseband</u> 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
$t=0$

A ▮▯▯▯ →

B

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

A ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ → ← ▬▬ B

A ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ → B
← ▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬

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

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

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Figure 6.22

Networks: Ethernet

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Ethernet
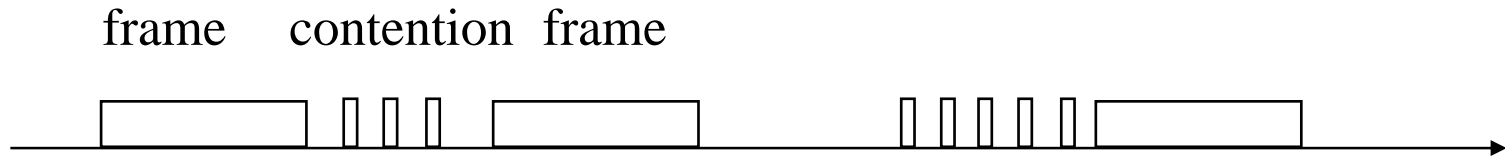
frame   contention frame

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*.
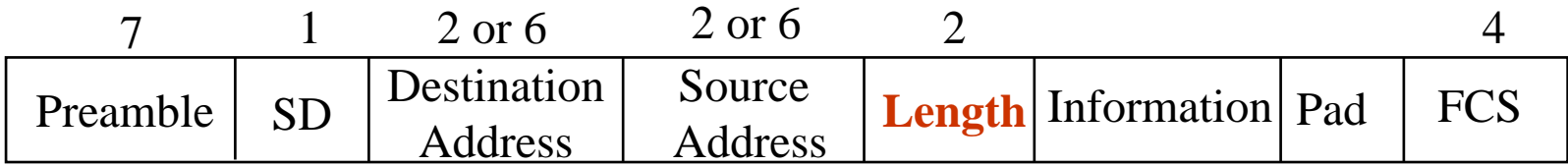
Binary Exponential Backoff (BEB)

Slotted ALOHA has been shown to be <u>unstable</u> 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.
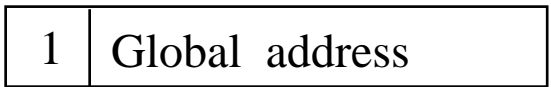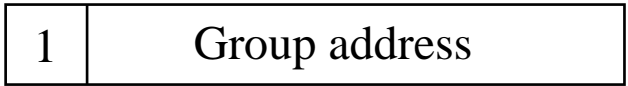
802.3 MAC Frame

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

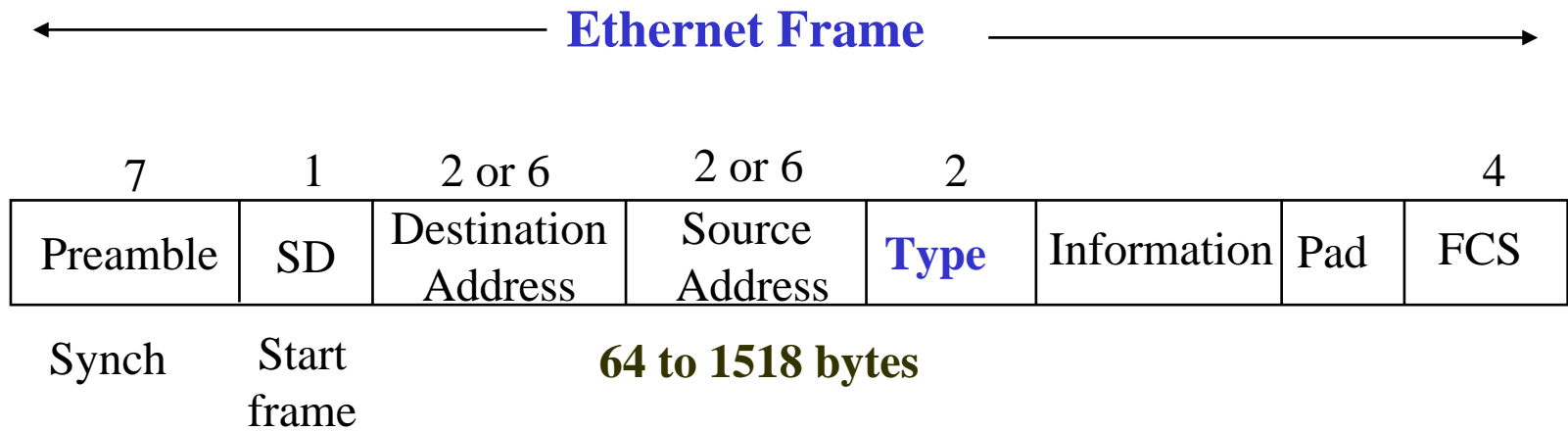| 1	Group address

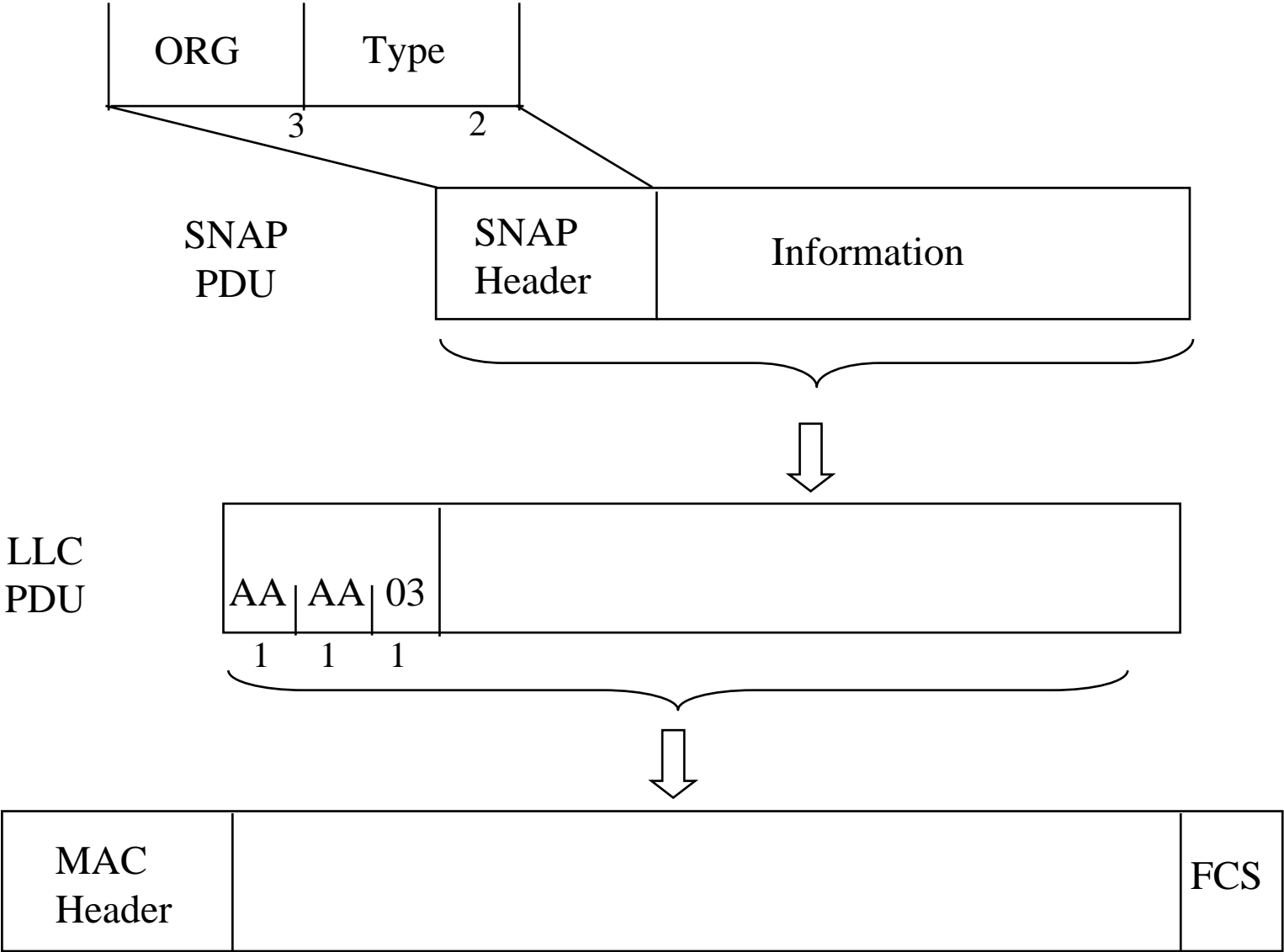| 0	Local address

1	Global address

• 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

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Figure 6.52

Networks: Ethernet

Ethernet Frame

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

Synch   Start frame

64 to 1518 bytes

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Figure 6.53

Networks: Ethernet

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Figure 6.54

ORG	Type
3	2

SNAP PDU | SNAP Header | Information |

LLC PDU | AA | AA | 03 | |

| 1 | 1 | 1 |

802.3 Frame | MAC Header | | FCS |
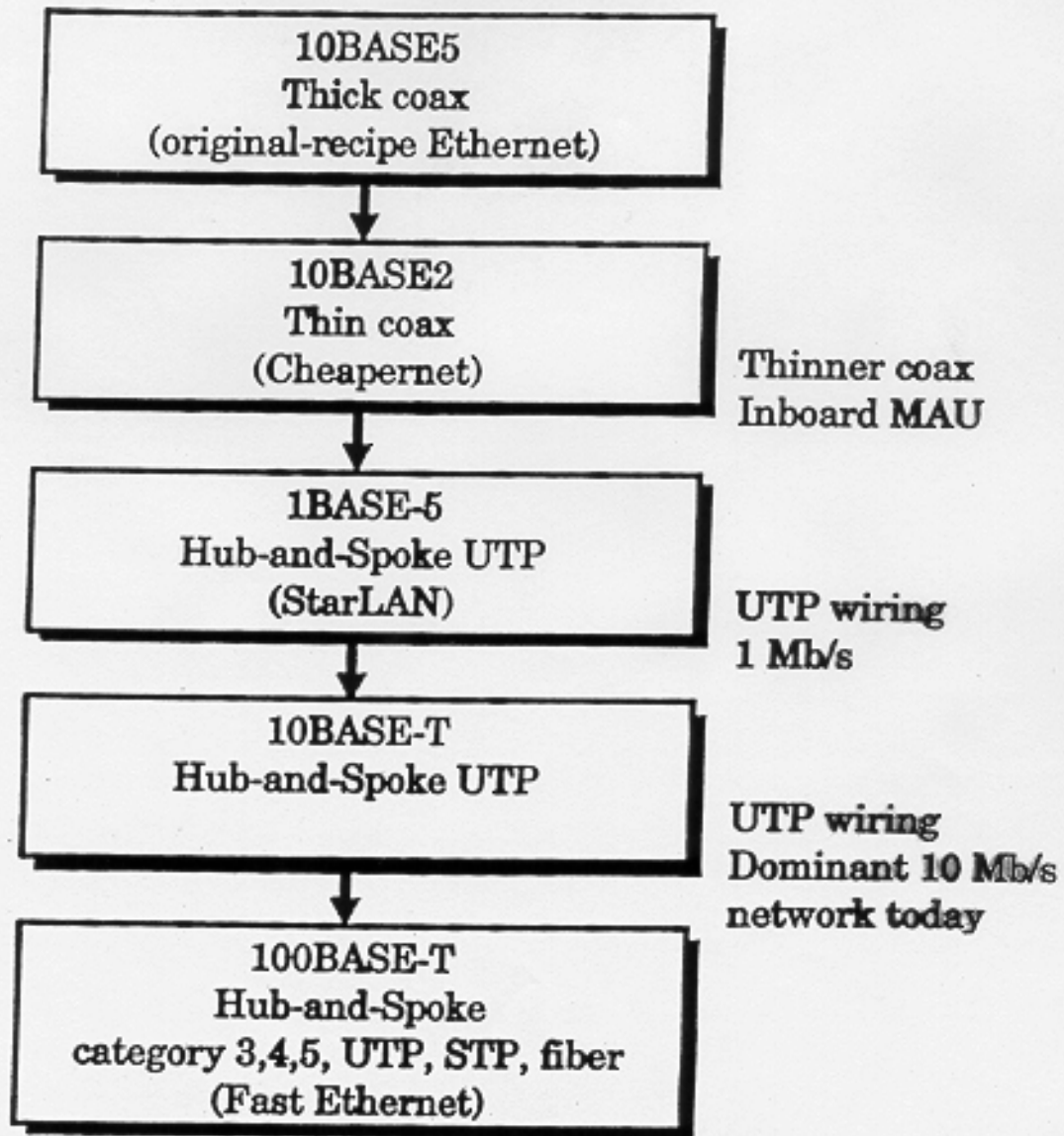
Networks: Ethernet 10

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

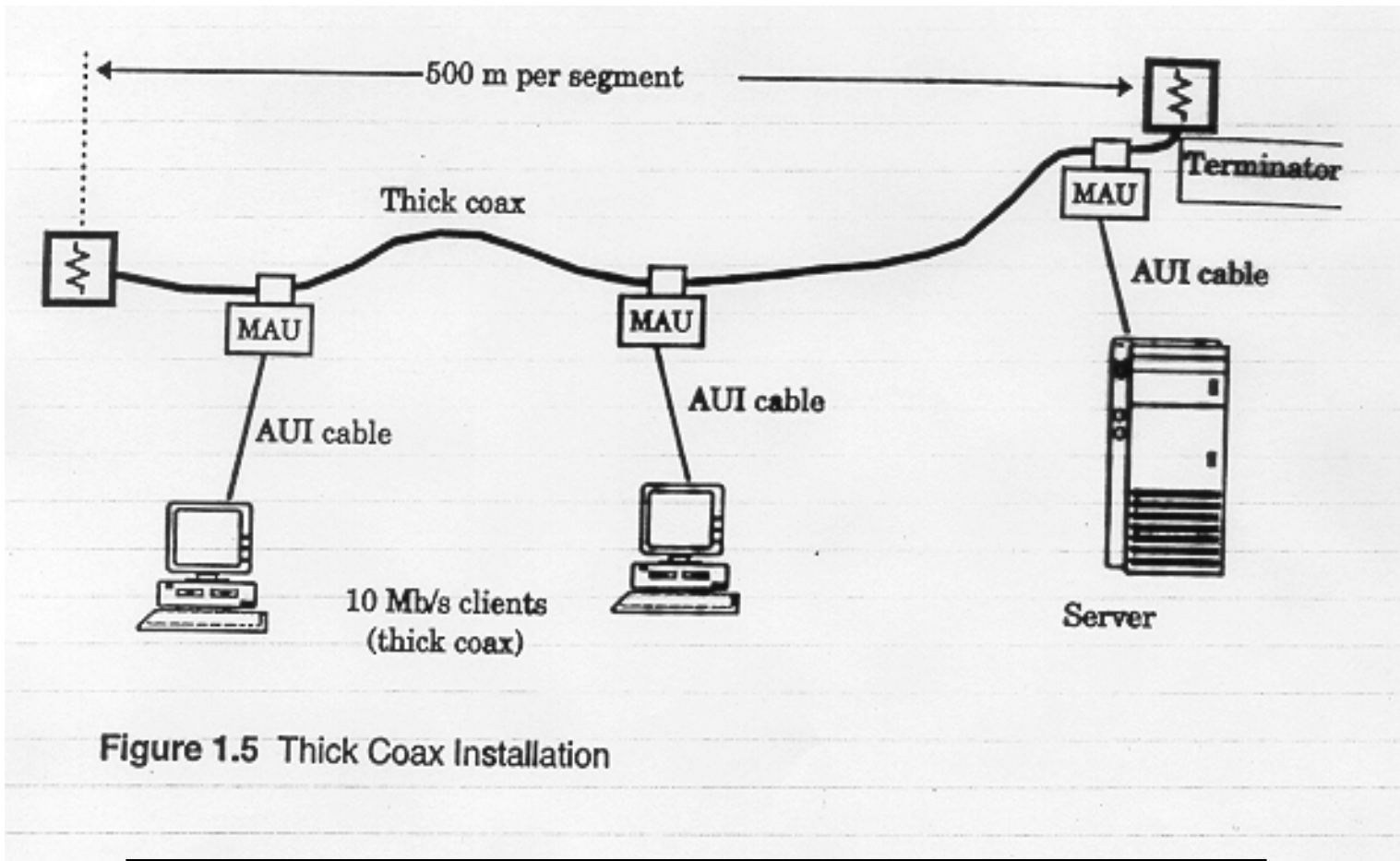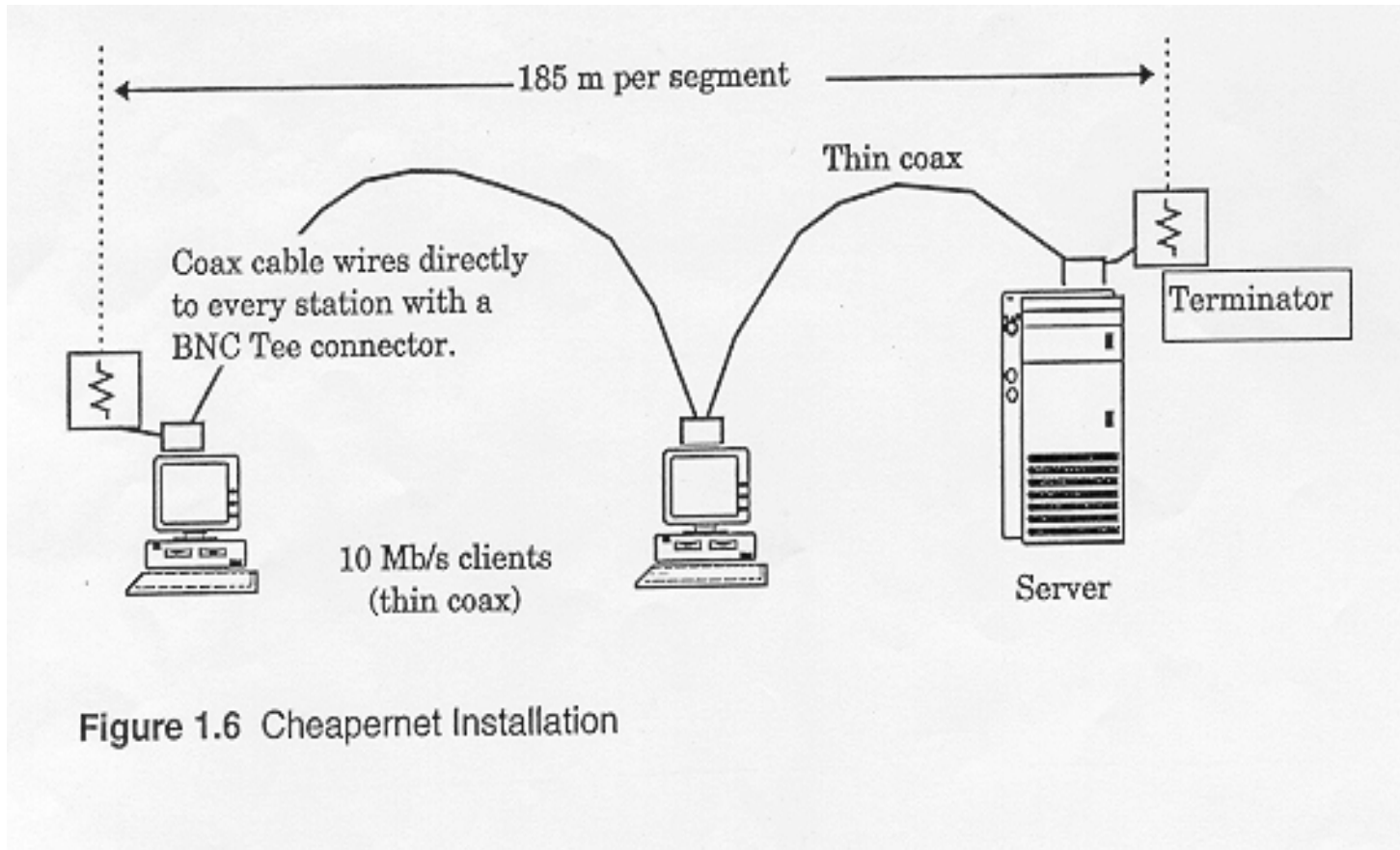* *Wiring represented a significant part of total installed cost.*

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.
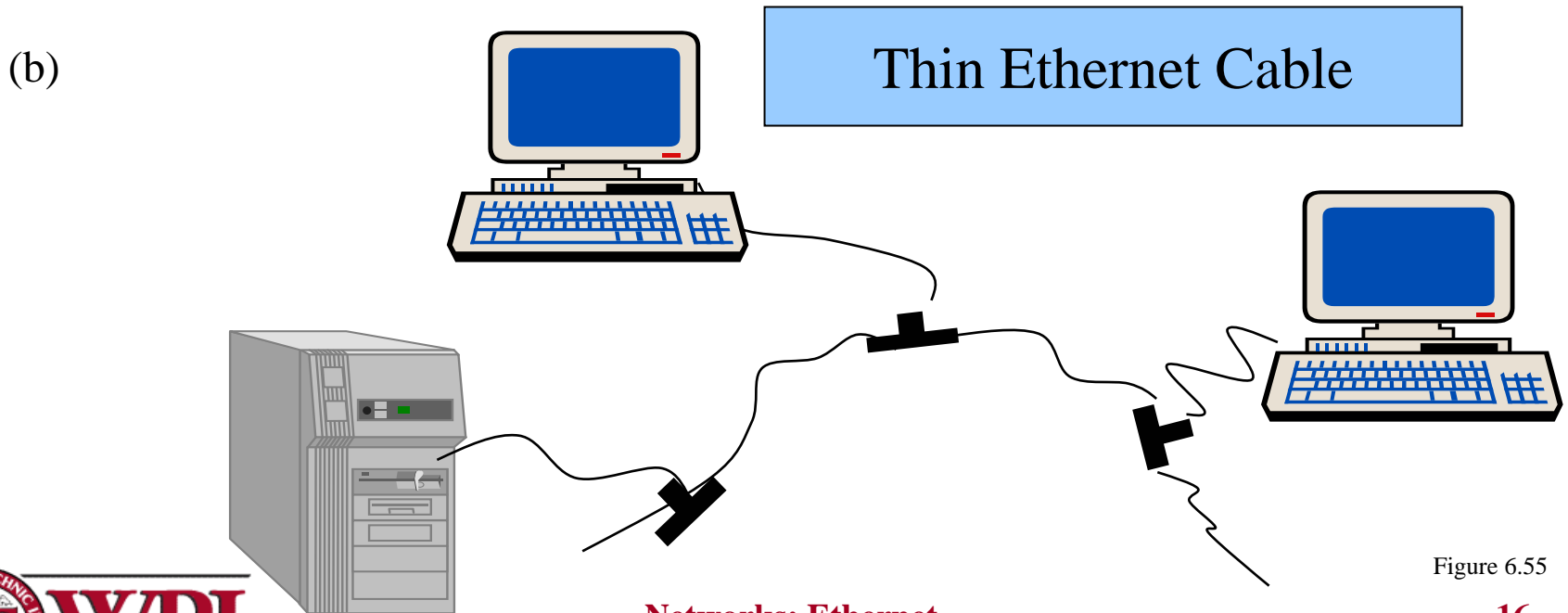
Figure 1.6 Cheapernet Installation

- 185 m per segment
- Thin coax
- Coax cable wires directly to every station with a BNC Tee connector.
- Terminator
- 10 Mb/s clients (thin coax)
- Server

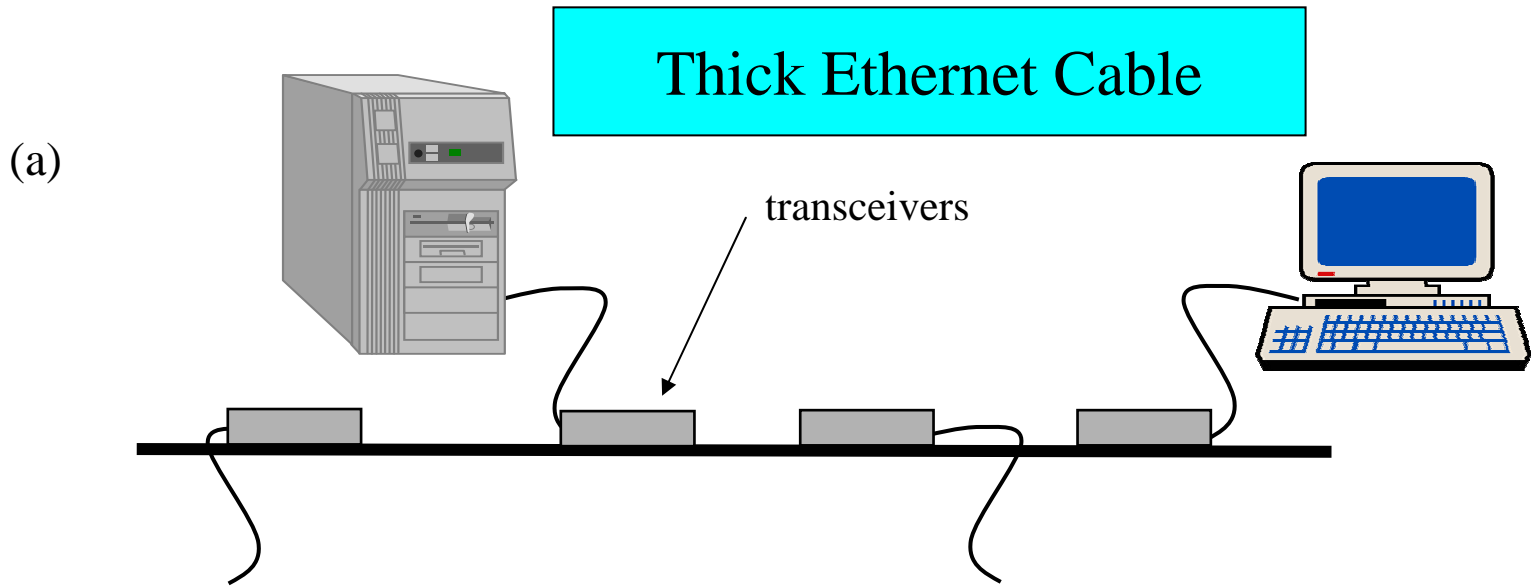(a) Thick Ethernet Cable — transceivers

(b) Thin Ethernet Cable

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 <u>ubiquitous</u> 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.*
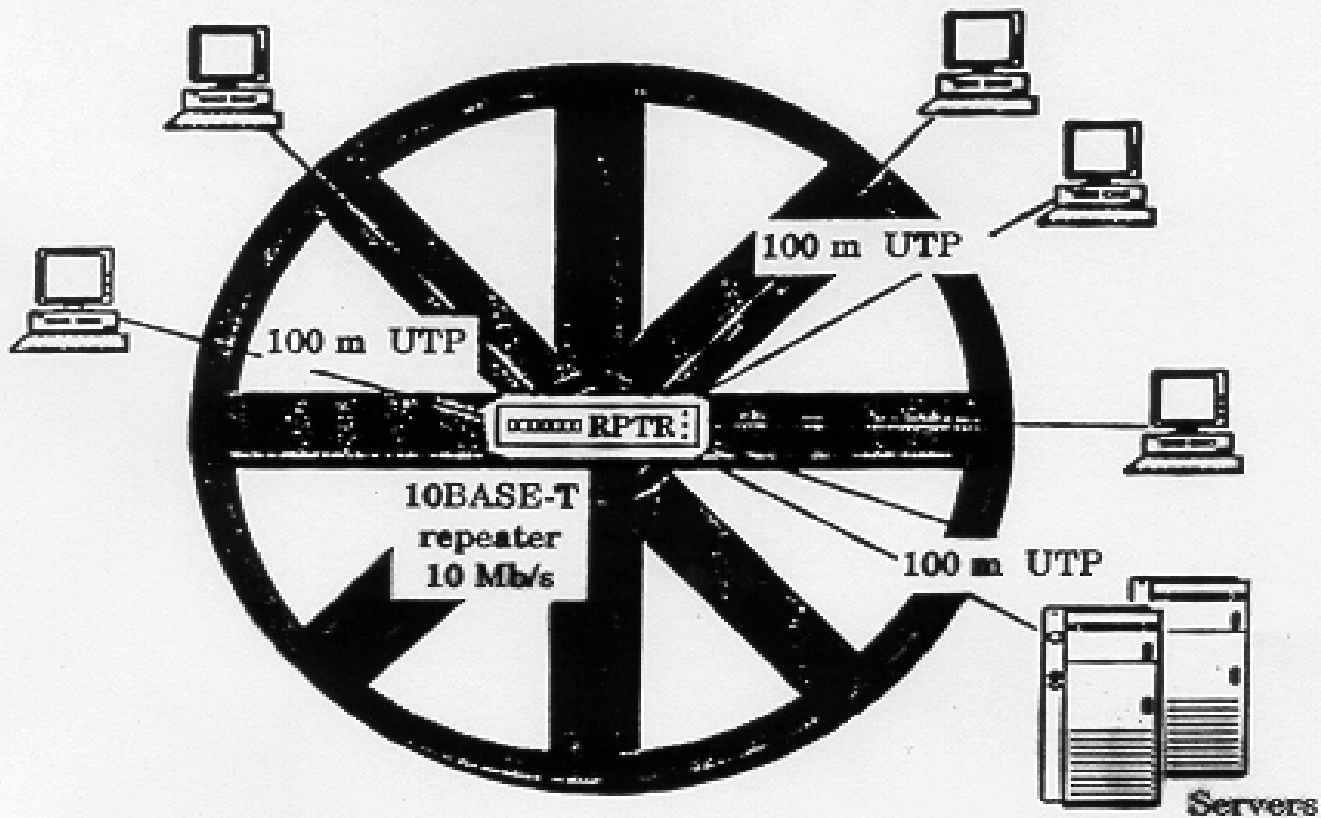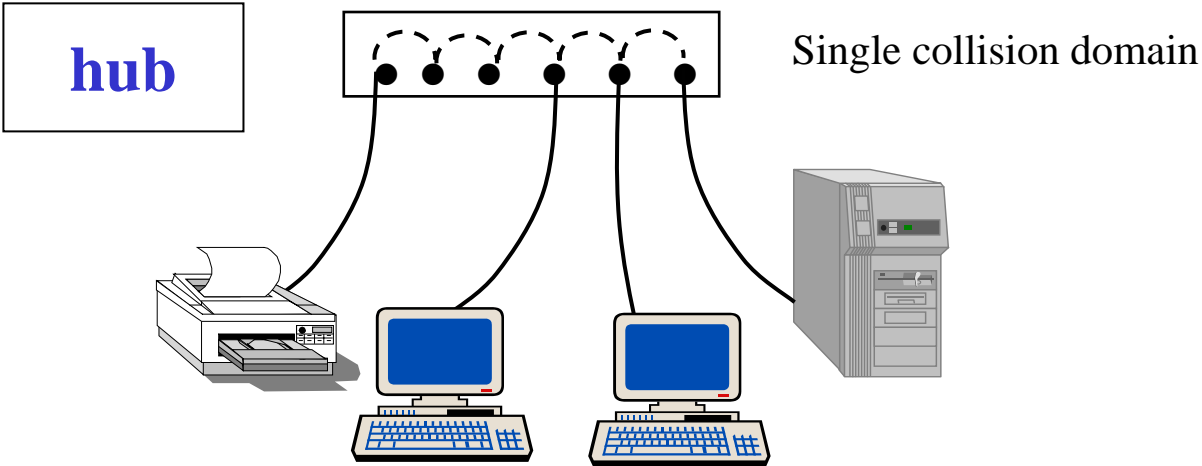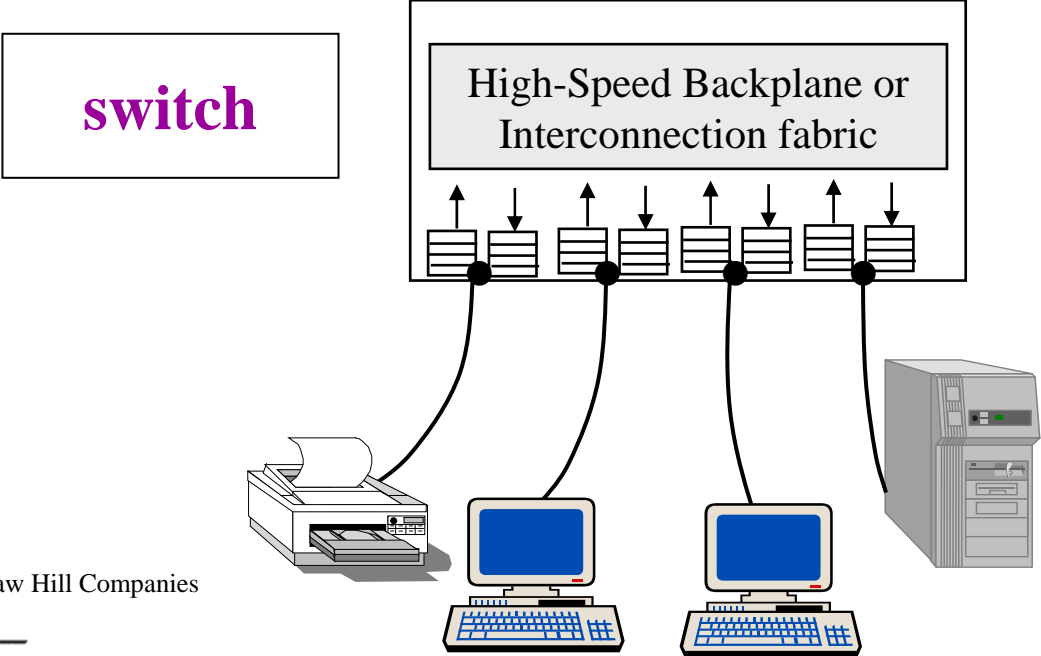
Figure 1.7 10BASE-T Hub-and-Spoke Architecture

Twisted Pair Ethernet

(a) **hub**

Single collision domain

(b) **switch**

High-Speed Backplane or
Interconnection fabric

Figure 6.56

Networks: Ethernet

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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.
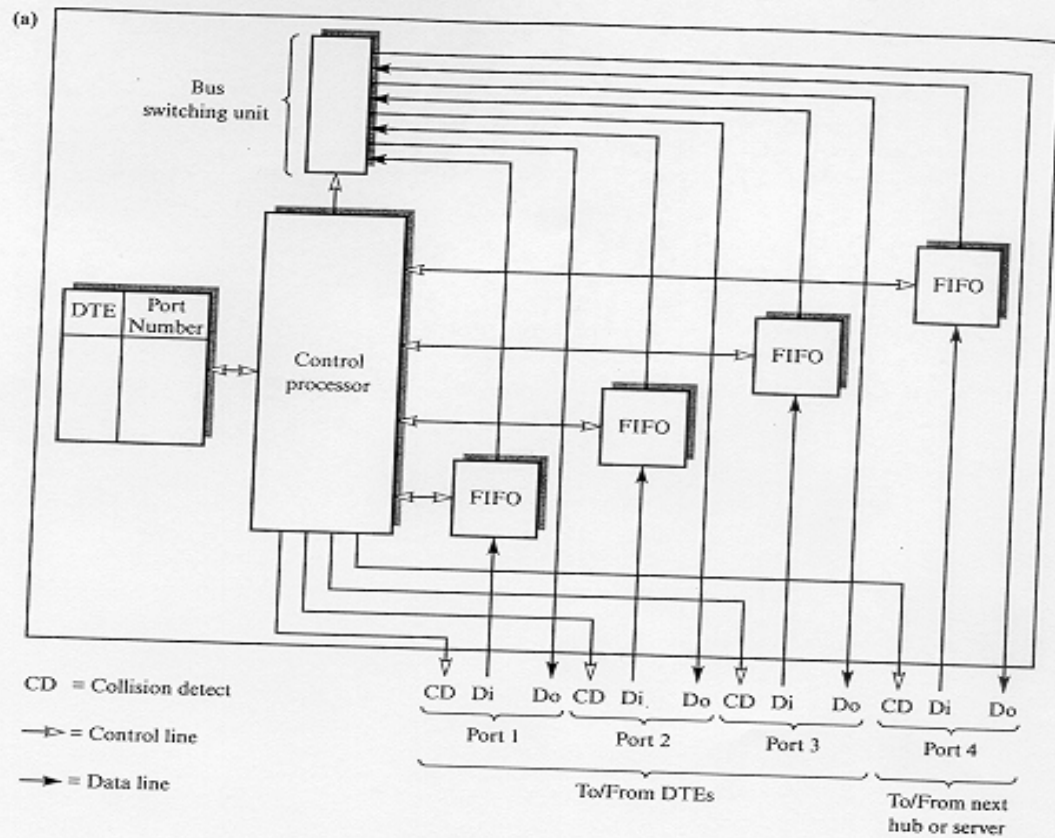
(a)

Bus switching unit

DTE | Port Number

Control processor

FIFO

FIFO

FIFO

FIFO

CD = Collision detect

—▷ = Control line

—▶ = Data line

CD   Di   Do   CD   Di   Do   CD   Di   Do   CD   Di   Do
Port 1   Port 2   Port 3   Port 4

To/From DTEs   To/From next hub or server

(b)

$n \times 10$ Mbps

Switching hub

Server DTE

10 Mbps

Client DTE

Client DTE

Client DTE

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

Networks: Ethernet

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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: *Tanenbaum's discussion considers a more powerful switch that reduces collisions even further!!*
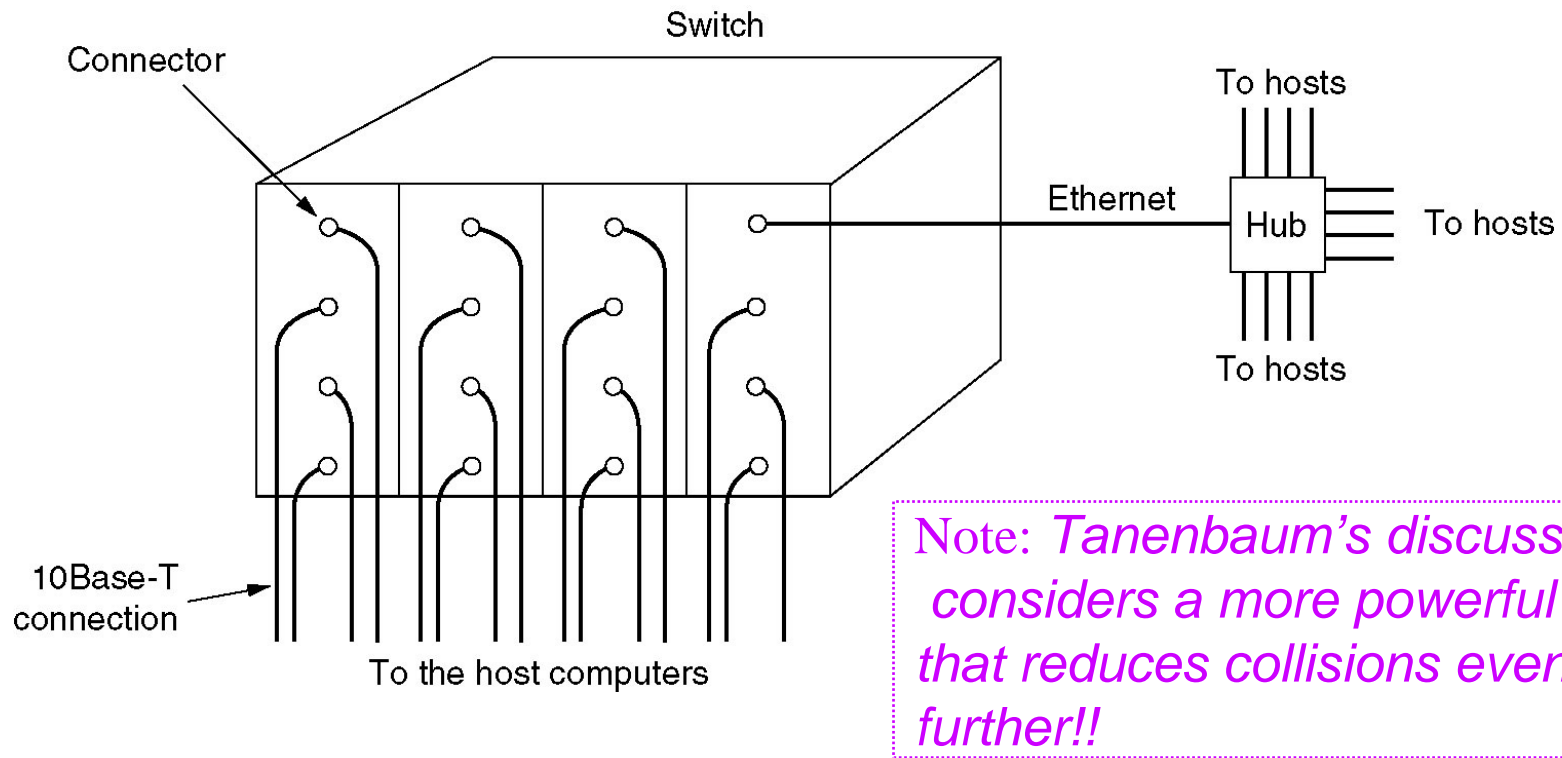
Figure 4-20. A simple example of switched Ethernet.

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.**

Fast Ethernet
Switch

Server

Ethernet
Switch

100 Mbps links

Ethernet
Switch

10 Mbps links

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Figure 6.57

Networks: Ethernet