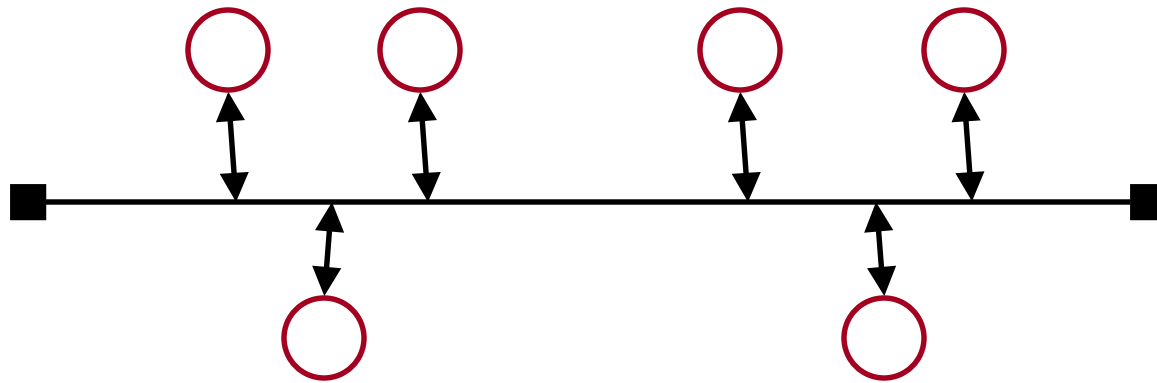# Ethernet

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.

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.
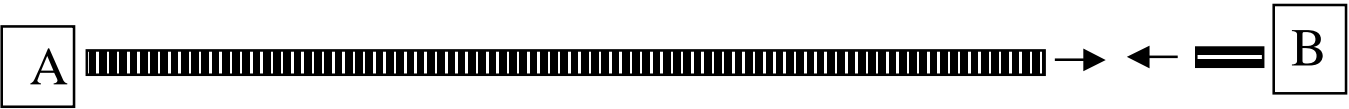
Upon collision, stations backoff using a local counter and then retransmit.

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

Networks: Ethernet
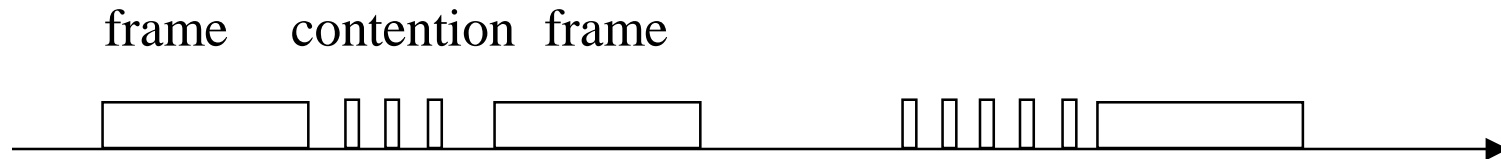
Figure 6.22

4

Ethernet

frame   contention frame

- 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***

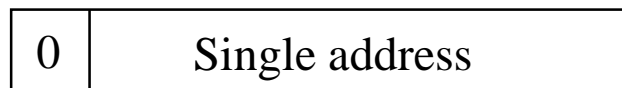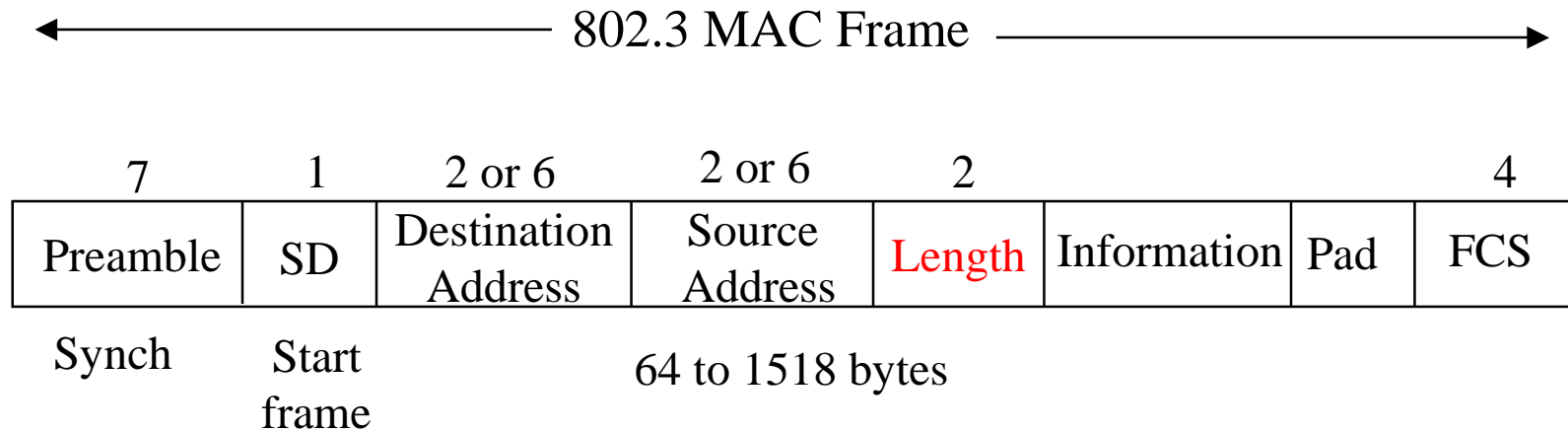- Modeled as *slotted scheme* with slot = 2 t_{prop}

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*.
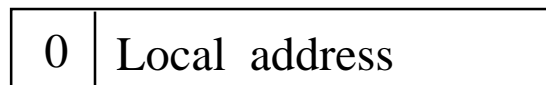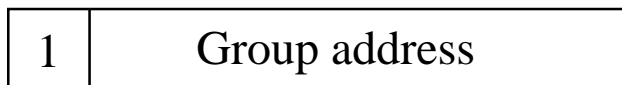
Binary Exponential Backoff (BEB)

Slotted ALOHA 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 set for 16 retries. After 16 retries, MAC gives up trying to send frame.

802.3 MAC Frame

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

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
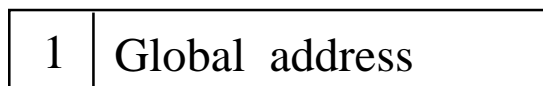
Leon-Garcia & Widjaja: *Communication Networks*

Figure 6.52

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				

Leon-Garcia & Widjaja: *Communication Networks*

Figure 6.53

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 6.54

```
┌─────────────────────────────┐
│          10BASE5            │
│         Thick coax          │
│ (original-recipe Ethernet)  │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│          10BASE2            │              Thinner coax
│         Thin coax           │              Inboard MAU
│        (Cheapernet)         │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│          1BASE-5            │
│     Hub-and-Spoke UTP       │              UTP wiring
│        (StarLAN)            │              1 Mb/s
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│          10BASE-T           │
│     Hub-and-Spoke UTP       │              UTP wiring
│                             │              Dominant 10 Mb/s
└─────────────────────────────┘              network today
               │
               ▼
┌─────────────────────────────┐
│          100BASE-T          │
│        Hub-and-Spoke        │
│ category 3,4,5, UTP, STP, fiber │
│       (Fast Ethernet)       │
└─────────────────────────────┘
```
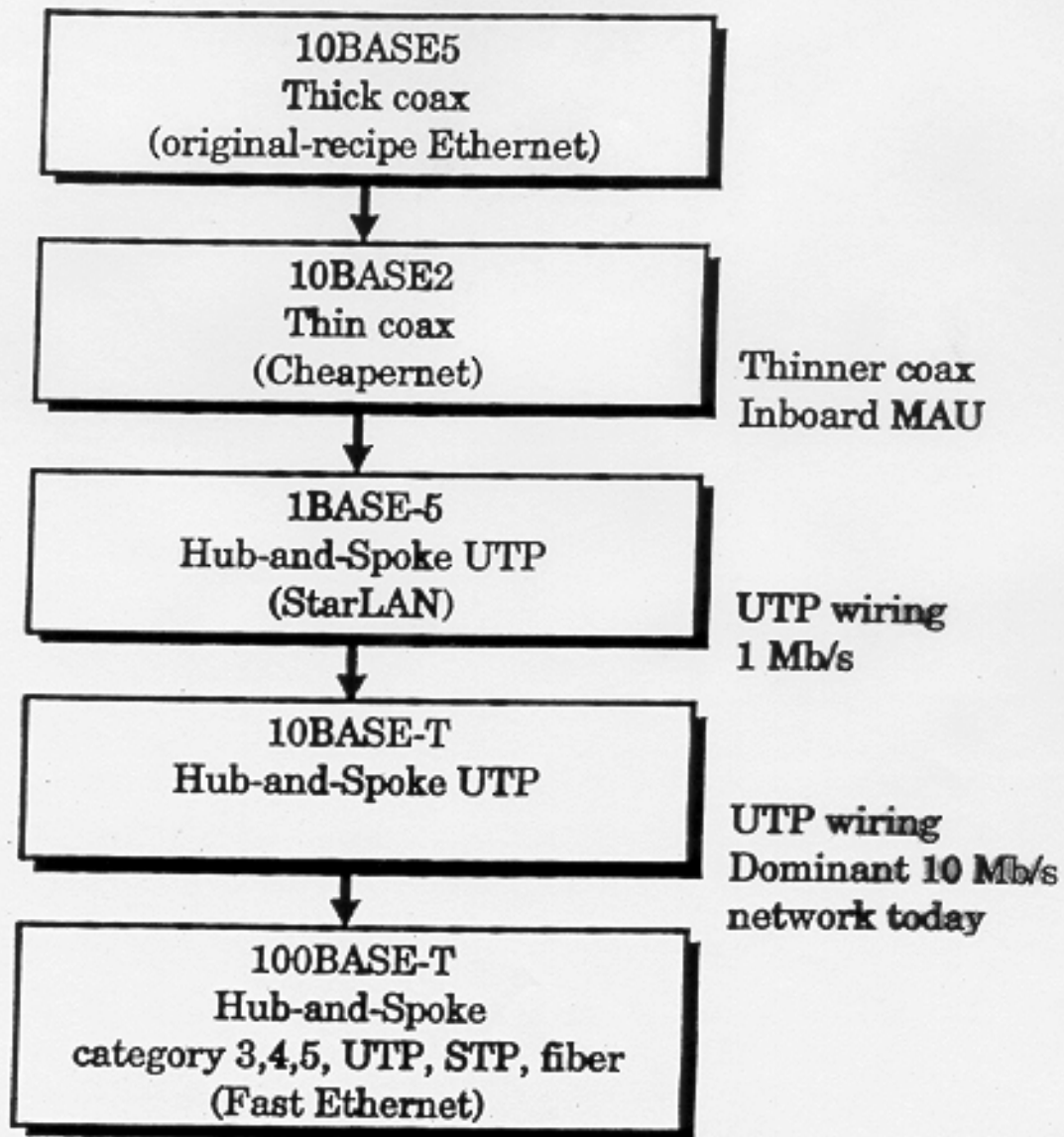
Figure 1.4 Lineage of Fast Ethernet

11

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

Networks: Ethernet   13
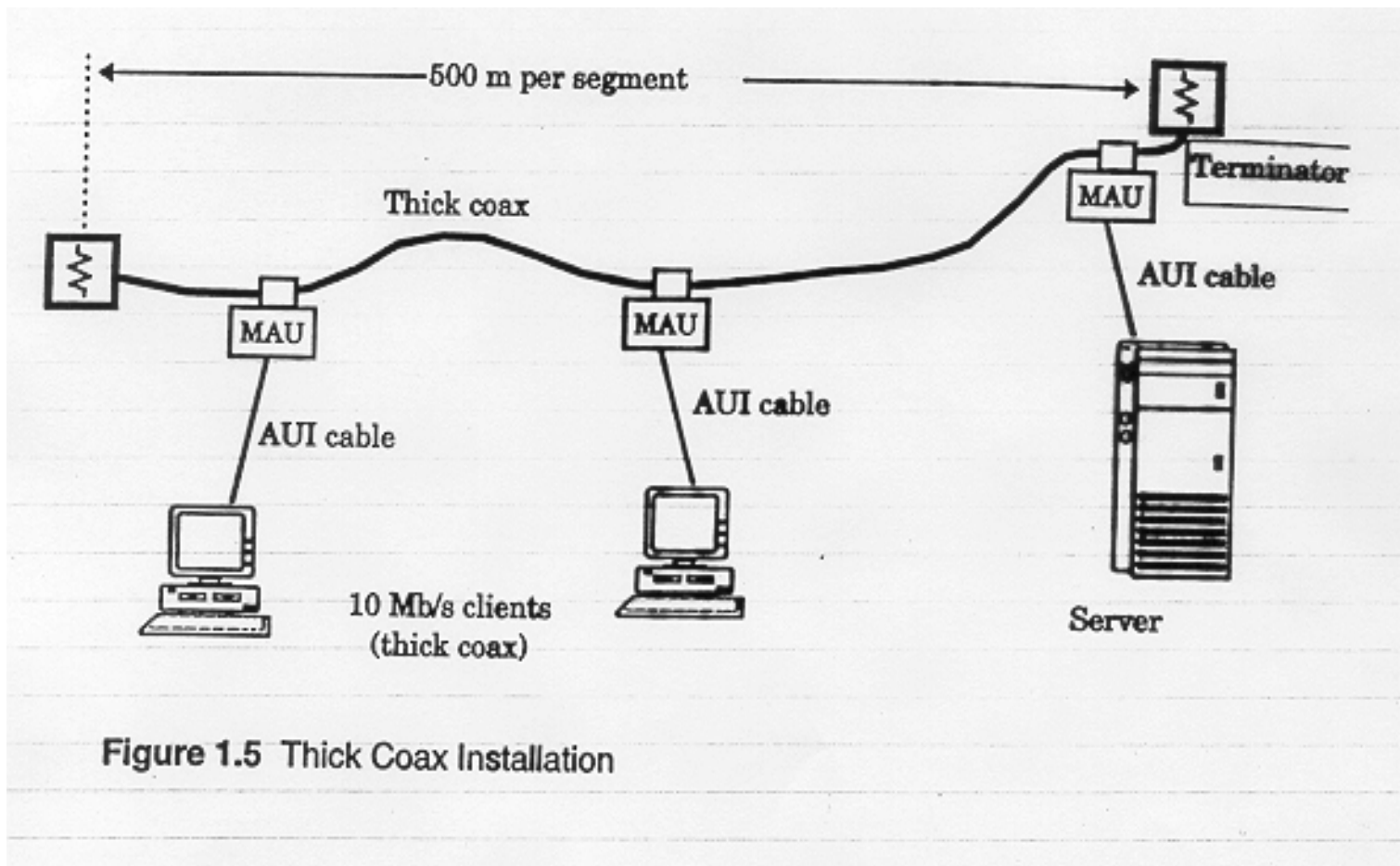
Ethernet Evolution

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
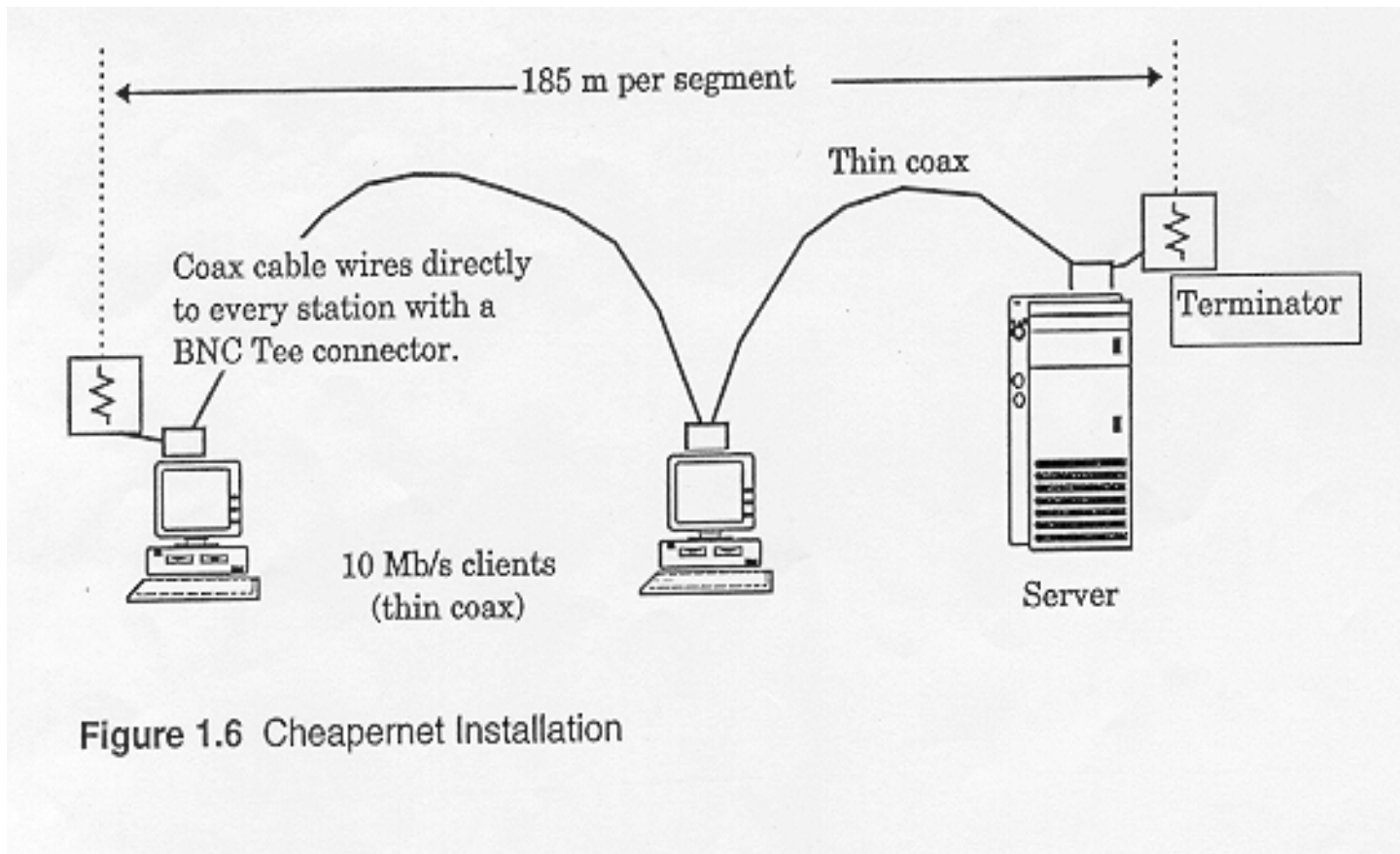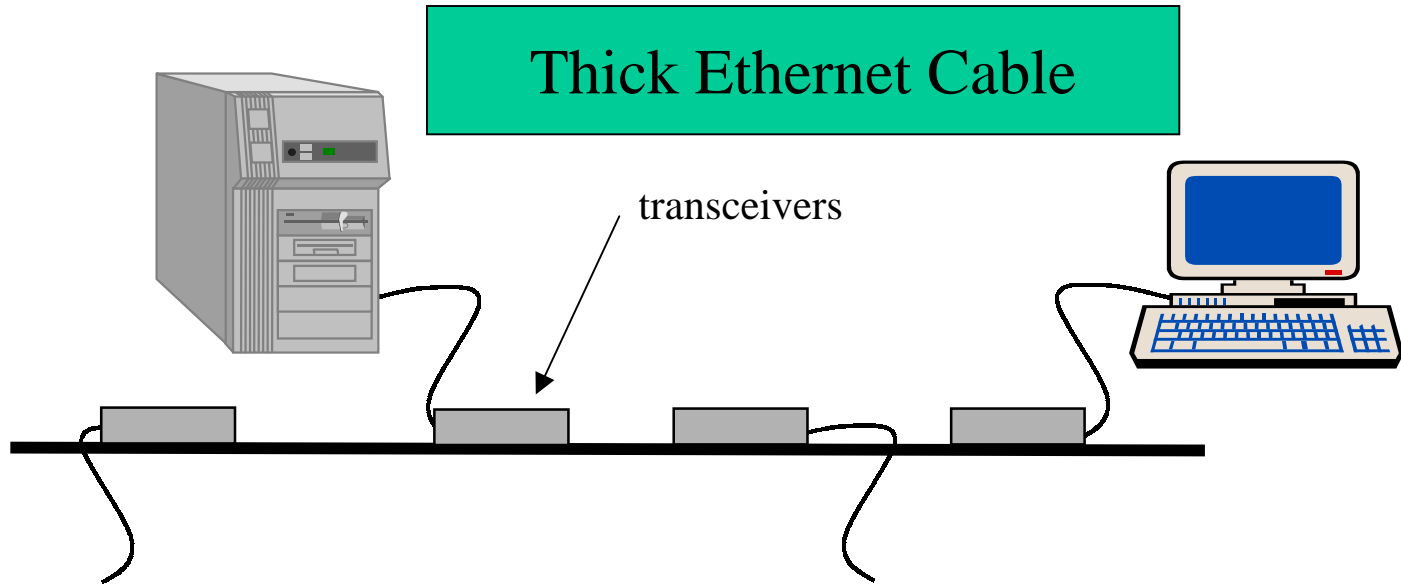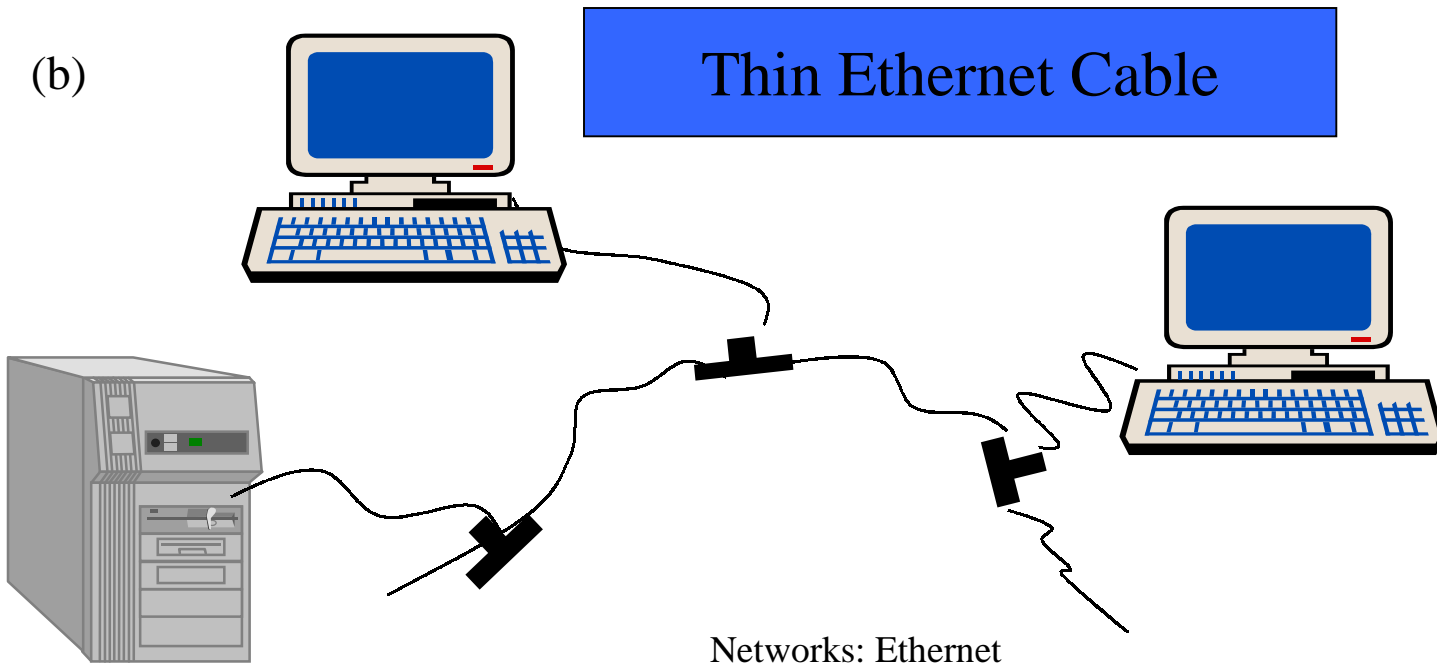
185 m per segment

Thin coax

Coax cable wires directly to every station with a BNC Tee connector.

Terminator

10 Mb/s clients (thin coax)

Server

Figure 1.6 Cheapernet Installation

(a)

Thick Ethernet Cable

transceivers

(b)

Thin Ethernet Cable

Networks: Ethernet

Figure 6.5 16

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 {approved in 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.

Hub Concept

- Separate transmit and receive pair of wires
- The repeater in the hub retransmits the signal received on <u>any</u> input pair onto ALL output pairs.
- *Essentially the **hub** emulates a broadcast channel with collisions detected by receiving nodes.*
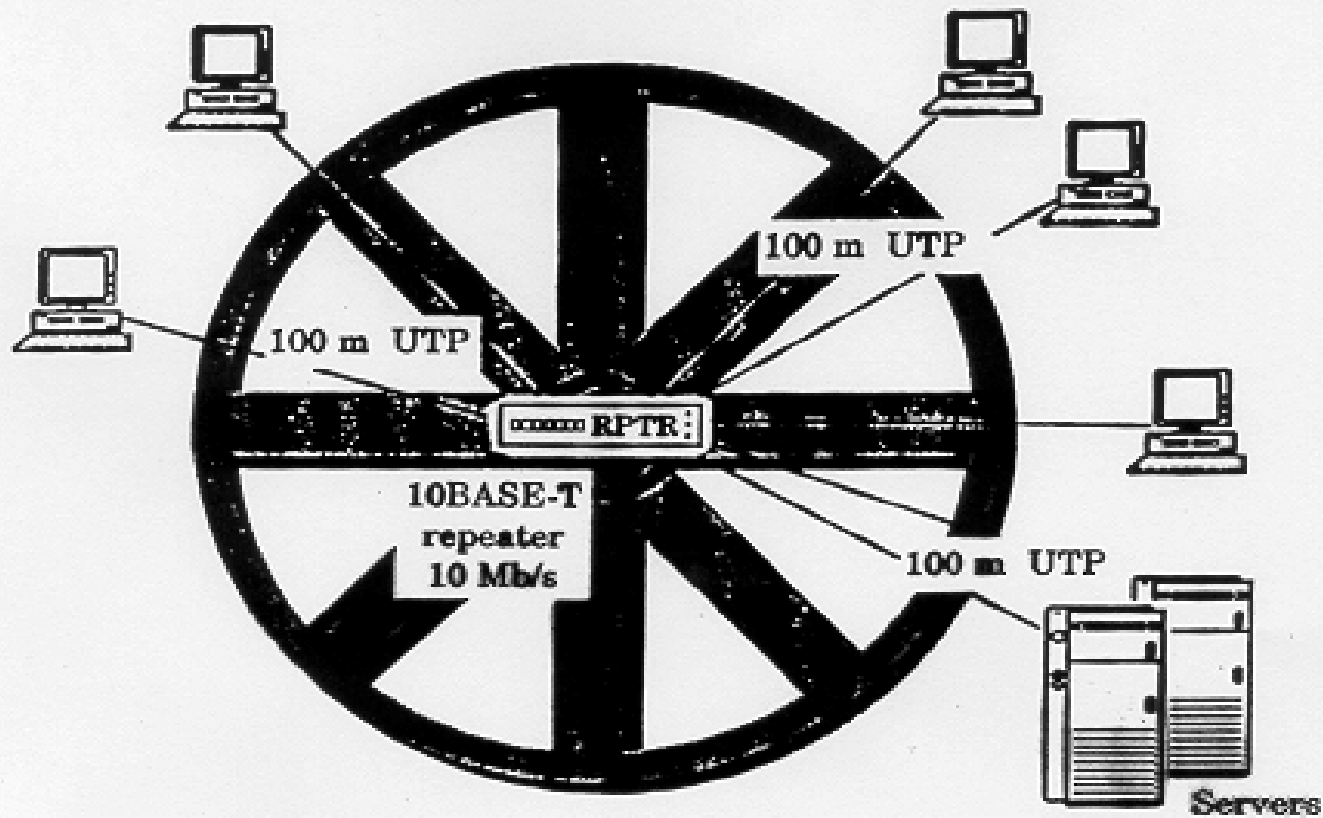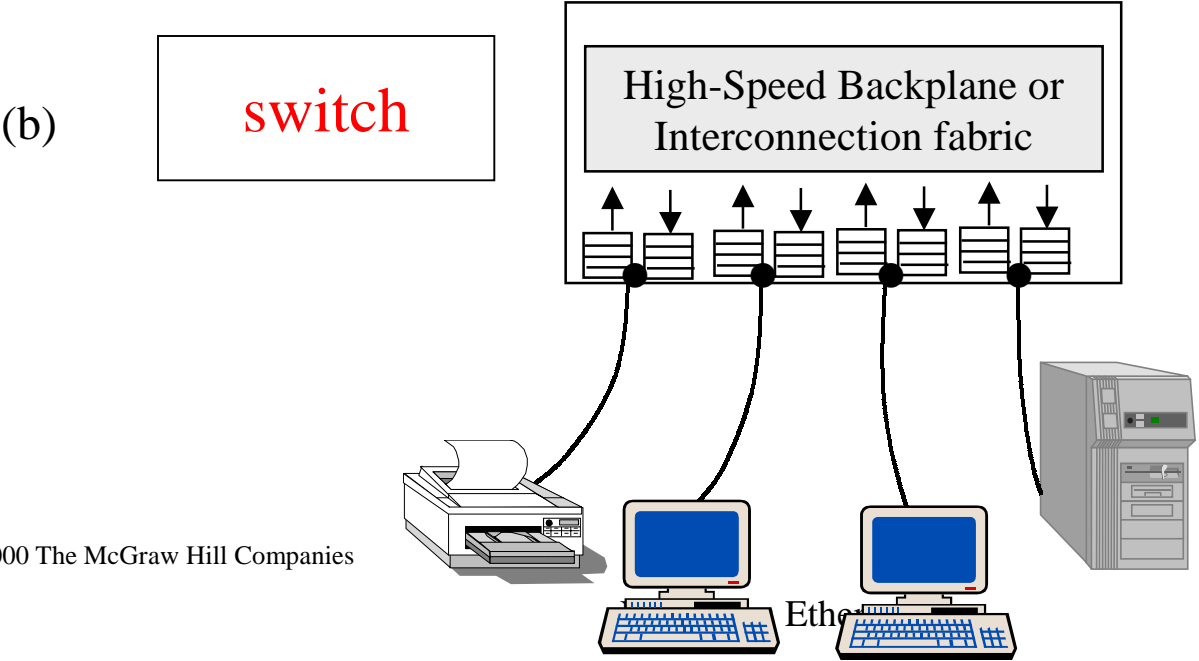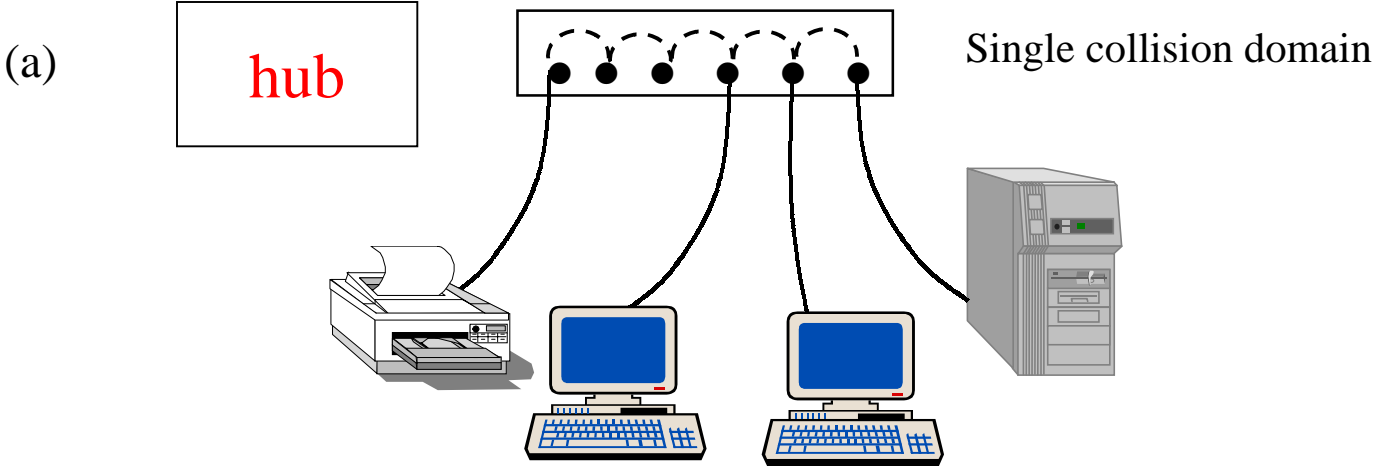
Figure 1.7 10BASE-T Hub-and-Spoke Architecture

Labels within figure:
- 100 m UTP
- 100 m UTP
- 100 m UTP
- RPTR
- 10BASE-T repeater 10 Mb/s
- Servers

Twisted Pair Ethernet

(a)

hub

Single collision domain

(b)

switch

High-Speed Backplane or Interconnection fabric

Ethernet

Figure 6.56

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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.

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 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.

➔ Extra buffering inside hub to handle speed mismatches.

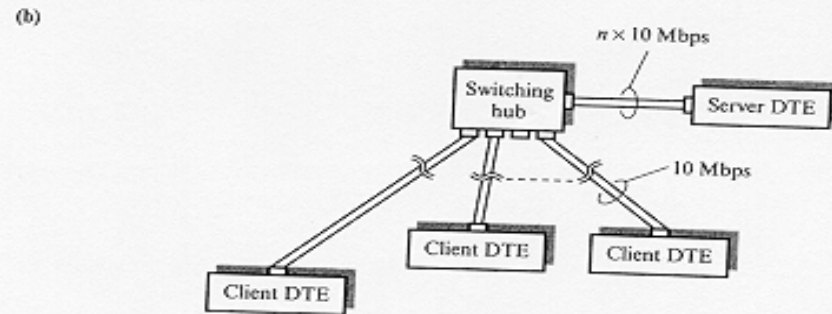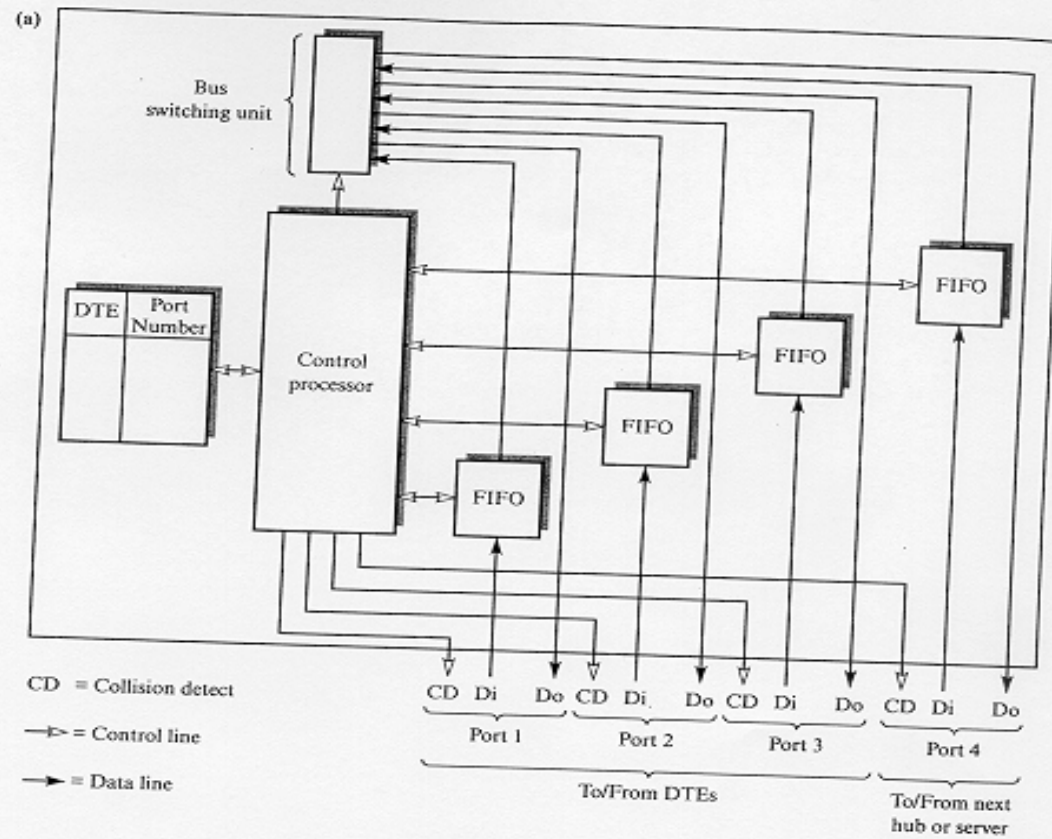- Can be further *enhanced* by higher rated port **full-duplex.**

(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 × 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 25

Fast Ethernet

Server

Ethernet Switch

100 Mbps links

Ethernet Switch

10 Mbps links

Leon-Garcia & Widjaja: *Communication Networks*

Figure 6.57

Networks: Ethernet

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