Local & Metropolitan Area Networks

CS455

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Local Area Networks

- Characteristic
  - Smaller geographical area
  - \( a < 1, \ a > 1 \) but not \( a >> 1 \)
  - Broadcasting (shared) medium
  - Medium access control is required

Difference between broadcasting and point-to-point:
Local Area Networks
Star Topology
Ring Topology
Bus Topology
Tree Topology
LAN Topologies

♣ **Topology** - Physical structure of broadcasting medium and stations

**Ring**

Repeater joins point-to-point links. Network cable passes from one DTE to another until the DTEs are interconnected in the form of a loop or ring.

Twist pair cable, Baseband coax, Optical fibre, Broadband Coax (cost of repeater is high).
LAN Topologies

♣ Topology – (continued)

**Bus/Tree**

Multipoint medium via Tap.

- Bus - Twisted pair, Baseband, Broadband coax, Optical fibre.
- Tree - Broadband coax (unidirectional nature)

**Star**

Coupler joins point-to-point from the stations.

- Passive coupler - Baseband coax, Optical fiber
- Active coupler - Twisted pair
LAN Topologies

Physical layout

Bus, Ring topology $\Rightarrow$ Star wiring

Twisted pair - cost down, maintenance, utilizing existing wire

Optical fibre, Coax - cost high, cable congestion

"a" becomes larger
LAN Topologies

Bus, Star wiring

Ring, Star wiring
## Transmission Media

<table>
<thead>
<tr>
<th>Media</th>
<th>Distance/Rate</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twisted Pair</td>
<td>100m at 1 Mbps</td>
<td>10BaseT</td>
</tr>
<tr>
<td></td>
<td>or up to 10 Mbps</td>
<td></td>
</tr>
<tr>
<td>Coaxial</td>
<td>200 or 500m at 10 Mbps</td>
<td>10Base2 thin wire</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10Base5 thick wire</td>
</tr>
<tr>
<td>Optical Fiber</td>
<td>Much higher rate</td>
<td>OC-3</td>
</tr>
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</table>
IEEE 802 Standard for LAN

- 802.2 Logical Link Control (LLC)
- 802.3 CSMA/CD
- 802.4 Token Bus
- 802.5 Token Ring
- 802.11 Wireless

- Round Robin 802.4, 802.5
- Reservation 802.6 (DQDB, MAN)
- Contention 802.3
Medium Access Control

Centralized/Distributed control
Static/Dynamic allocation

- Round robin: each station in turn is given the opportunity to transmit. During that opportunity, the station may decline to transmit or may transmit subject to a specified upper bound, usually expressed as a maximum amount of data transmitted or time for this opportunity. In any case, the station, when finished, relinquishes its turn, and the right to transmit passes to the next station in logical sequence.

  - Efficient for heavy loaded network.
Medium Access Control

- Reservation: For stream traffic.
- Contention: For bursty traffic. No control to determine whose turn it is. Simple to implement. Good for lighter or moderate loaded network.
Pure ALOHA

- **Aloha protocol (pure Aloha)**
  Invented by N. Abramson at the University of Hawaii
  Packet radio environment - shared medium

**Sender**
- Transmits a frame whenever data is presented and waits for acknowledgment:
  - roundtrip + fixed amount of time
- Retransmits a frame when a predetermined time expires:
  - randomize retransmission time
Pure ALOHA

Receiver

- Accept a frame and send ACK to sender if FCS is correct and destination address matches
- Discard a frame, otherwise
Pure ALOHA

Fixed size frame maximizes performance of ALOHA system

Overlapping of two frames in time results collision of frames

Maximum utilization of ALOHA system

infinite population model

fixed size frame

Poisson input process
Pure ALOHA

S : new frame arrivals
G : S + retransmitted frames (offered load)

at light load G \Leftrightarrow S
at heavy load G > S
assume G follows Poisson distribution
Pure ALOHA

Vulnerable period
**ALOHA**

Throughput = $G \times P$

$P$ : probability of frame doesn’t suffer a collision

$P = e^{-2G}$

Throughput = $G \times e^{-2G} \Rightarrow 1/2e$
Slotted ALOHA

Throughput = $G \times P$

$P = e^{-G}$

Throughput = $G \times e^{-G} \Rightarrow 1/e$
CSMA

CSMA series - "listen before talks"

Sender channel idle - transmits a frame
channel busy - waits until end of frame
transmission time and transmits
(1-Persistent CSMA)
When collision, it waits random
amount of time and starts again.

The larger the propagation delay the worse the performance
CSMA

Non-Persistent CSMA
  channel idle - transmits a frame
  channel busy - waits a random period in time (do not listen channel status continuously) and repeats algorithm

P-persistent CSMA (slotted channel)
  channel idle - transmits with a probability $P$
    defer with a probability $1-P$
  slot is busy - waits random time and restart
  channel busy - waits until next slot and repeat above
Throughput of CSMAs

G

0.01 persistent CSMA
Non-persistent CSMA
0.1 persistent CSMA
0.5 persistent CSMA
1 persistent CSMA
CSMA/CD

CSMA/CD - "listen while talks"

channel idle - transmits
channel busy - waits until end of frame transmission and transmits
collision - immediately stop to transmits the damaged frame and transmit a jamming signal, and waits random amount of time to start procedure again

Binary exponential backoff algorithm

0 <= r < 2^n  n: number of collision
give up transmission after 16 attempts
Ethernet

- Uses CSMA/CD (IEEE 802.3) for MAC (multiple access control).
- MAC is a sublayer of data link layer for LAN.
- Is originated from ALOHA (slotted ALOHA).
- Uses one common channel.
- Collision Detection (listening channel: ether comes to name).
- When frames are collided, it uses binary backoff algorithm to avoid another collision.
- A frame size is restricted by the network size.
- Every Ethernet device has its own world unique address to avoid if any of a network has the same address and it is assigned by manufacturer.
Token Bus (logical ring)

Functions
- Token handling: passing/receiving, priority
- Ring maintenance: addition/detection
- Fault detection and recovery: multiple/lost tokens, token pass failure duplicate address, inoperative receiver
- Sending and receiving data

Token Bus:
- Complexity
- Overhead at light load
- Priority
- Deterministic delay
Token Bus (logical ring)

A  B  D  C

Logical Ring
Token Ring

Ring topology:

Token frame: busy/free

station with data to send
- waits for a free token
- change from free to busy (circulated)
- transmits
- insert a new free token
Token Ring

fault management
active token monitor (designated station)
no token
time out: complete traversal of the longest frame
insert a free token
circulating busy token
sets a monitor bit to 1 on any passing busy token
change busy token to free

token maintenance
traffic regulation
priority
DQDB (MAN)

* Distributed Queue Dual Bus
44.736 Mbps, 155.52 Mbps
  dual bus
  reservation (immediate access when no outstanding request)
  53 bytes slotted channel
  connection oriented via virtual channel server (20 bits VCI)
DQDB (MAN)

Busy bit: 1 - slot is carrying a data
    0 - slot is not carrying a data

Request bit: 1 - request from the station at downstream
    0 - no request from the downstream

RQ: request counter
CD: count down counter