Lecture 5 : Multiple Access Protocols

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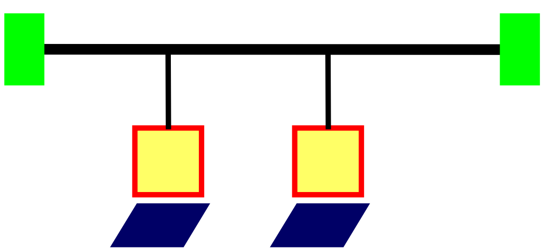
5.1 Medium Access Sublayer

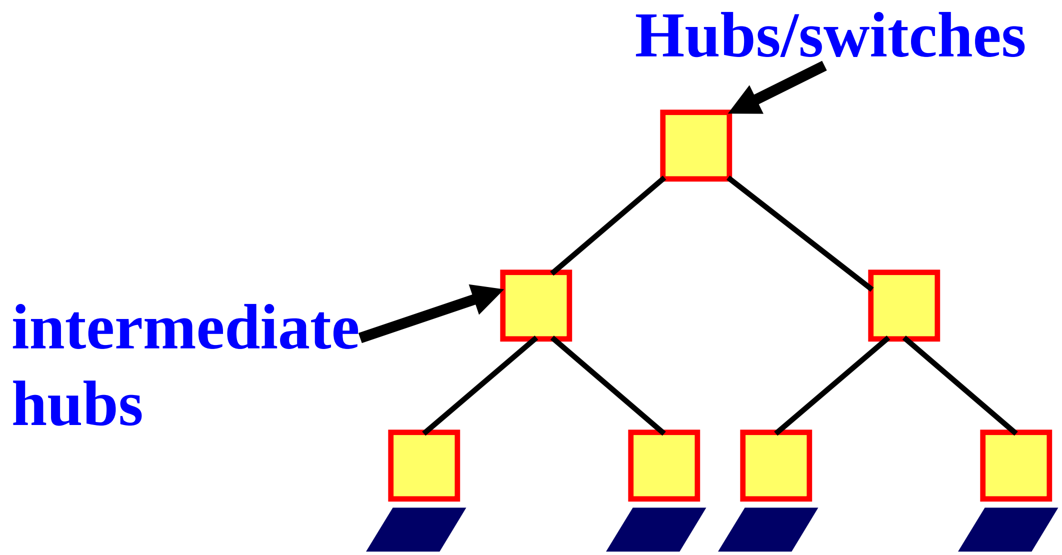
- Topology of the Network
  - Bus, Ring, Tree
- Protocols
  - IEEE 802.3 for bus topology
  - IEEE 802.4 for token bus
  - IEEE 802.5 for token ring
  - FDDI – for fibre ring
  - IEEE 802.11 for wireless networks

Network Topology

Bus topology

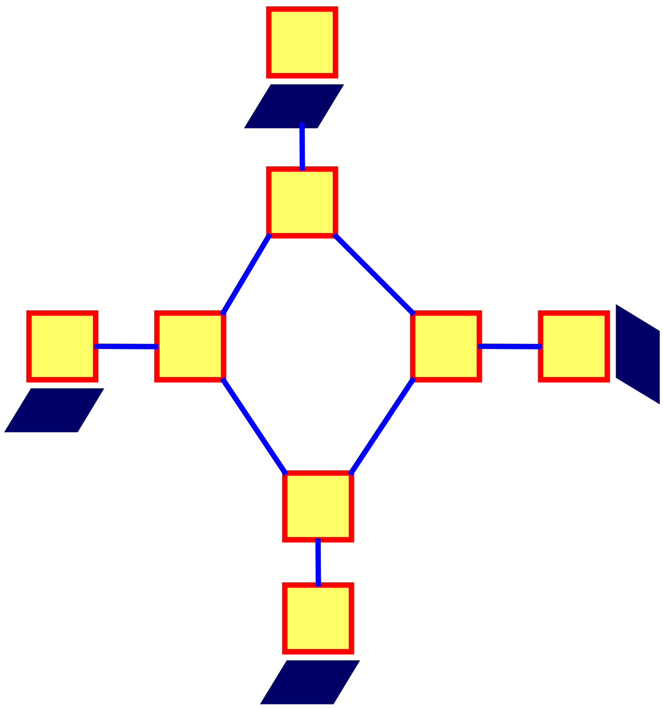


Tree topology:

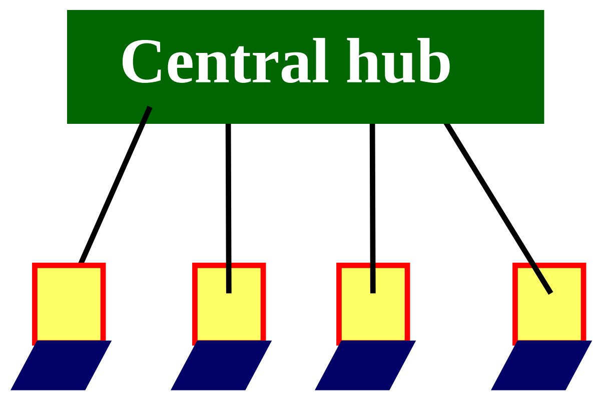


Network Topology

Ring topology

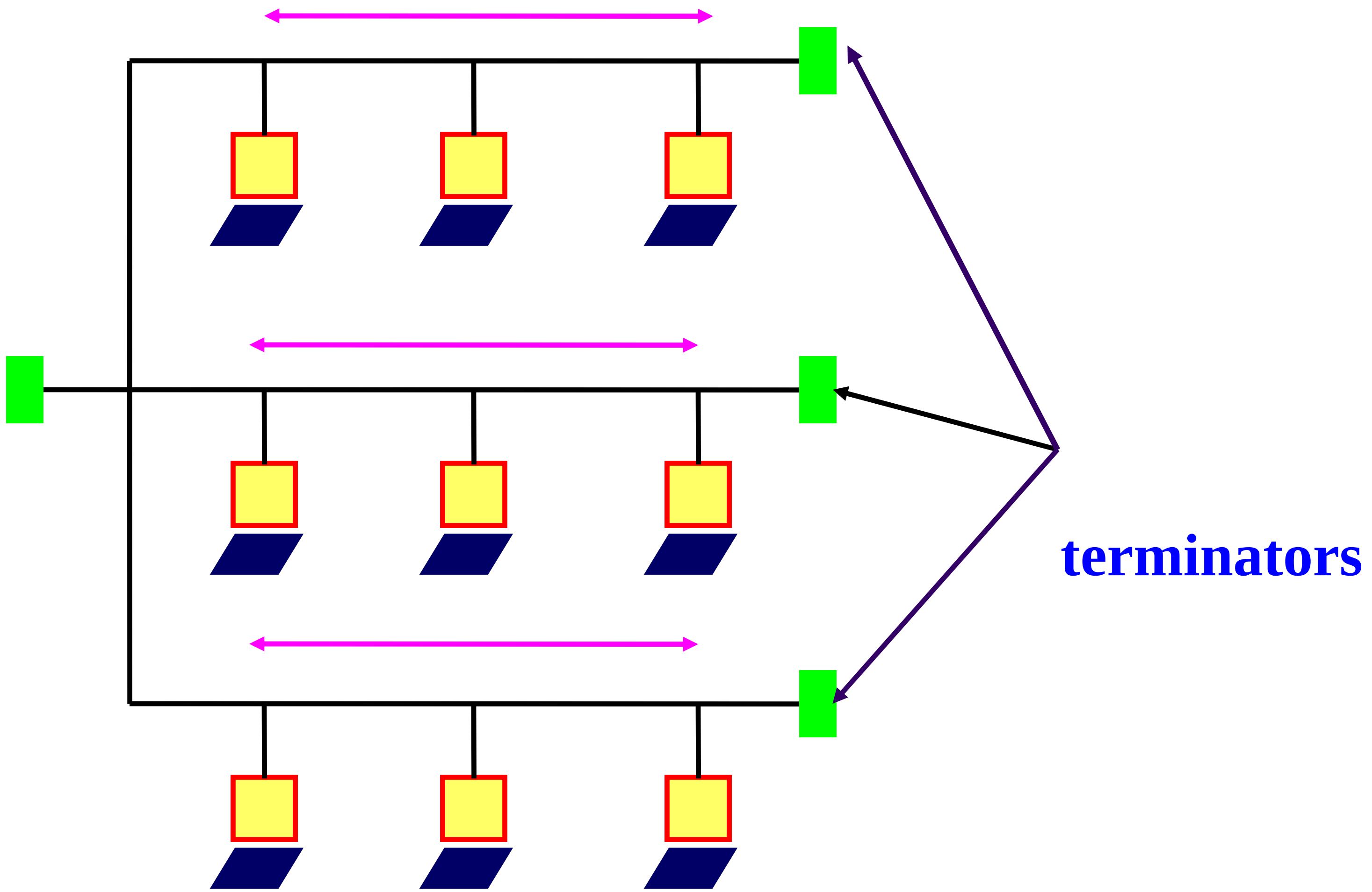


Star topology



Network Topology

Multipoint media



Tree and Bus Topologies

- multipoint medium
  - all stations attach through appropriate hardware interface called tap directly to the medium
  - full duplex operations on the bus
  - data propagates the length of medium in both directions
  - at each end bus terminated
    - absorbs any signal ➔ removes it from the bus
  - tree has a head end
  - since data propagated to all stations – addressing required!

Star Topology

- central node acts as a broadcast
- although physically a star – logically a bus
  - alternatively central node acts as a switch. frame switching – copy frame – send out on destination link
- problem – central point failure

Ring Topology

- Repeaters joined by point to point links in a closed loop.
  - no buffering
- unidirectional links
- destination recognises its frames & copies it
- frame removed by source
- in all topologies ONLY one station transmits at a time

Transmission in Networks

- Networks
  - Point-to-Point
  - Broadcast Networks
- Broadcast networks
  - Only one station transmits at a time →competition
    - who gets access to the channel
  - conference calls:
    - between six people – only one channel –
      - Who gets access?
  - multiaccess or random access channels

Broadcast Network-Solutions

- static allocation
  - wasteful of Bandwidth
    - more senders than channels
- Solution: Dynamic allocation of channels!

Key Assumption in Broadcast Networks

- Station model
  - N independent stations
  - Each user generates a frame for transmission
  - Pr[frame generated in time Δt] = $\lambda \Delta t$
    - arrival rate for new frame λ
  - Once frame generated – station blocks
    - does nothing until frame transmitted.

Key Assumption in Broadcast Networks

- Single channel assumptions:
  - Single channel for all communication
  - All stations can transmit and receive on it
  - All stations get a fair share of the channel

Key Assumption in Broadcast Networks

- Collision assumption:
  - Two frames transmitted at the same time
    - signal garbled
  - All stations can detect collisions
  - A collided frame is retransmitted
  - Errors only due to collision

Key Assumption in Broadcast Networks

- Continuous time:
  - Frames can begin at any instant of time
  - No master clock dividing time into discrete intervals.
- Slotted time:
  - time divided into slots
  - frames start at the beginning of a slot
  - multiple frame / slot

Key Assumption in Broadcast Networks

- Carrier Sense:
  - Station can tell whether channel is in use
  - If carrier sensed – do not transmit
    - What is carrier sense – an electrical signal
- No carrier sense:
  - Station cannot detect carrier
  - go ahead and transmit
  - Later worry about success or failure

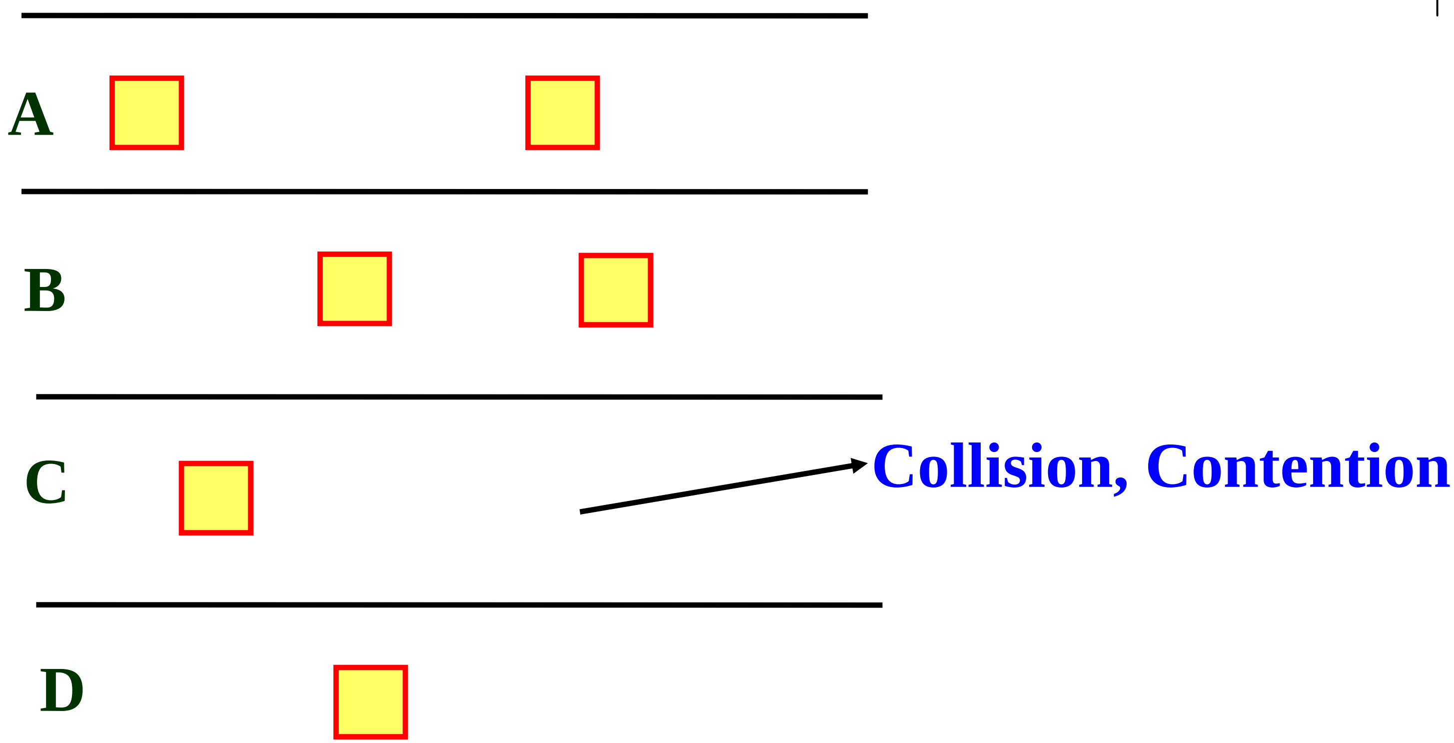
5.2 Multiple Access Protocols: ALOHA

- ALOHA
  - pure
  - slotted
- Basic idea: User transmit whenever they have data to send
- Collision detection:
  - use feed back property to determine collisions
- Originated as part of packet switched radio networks

ALOHA

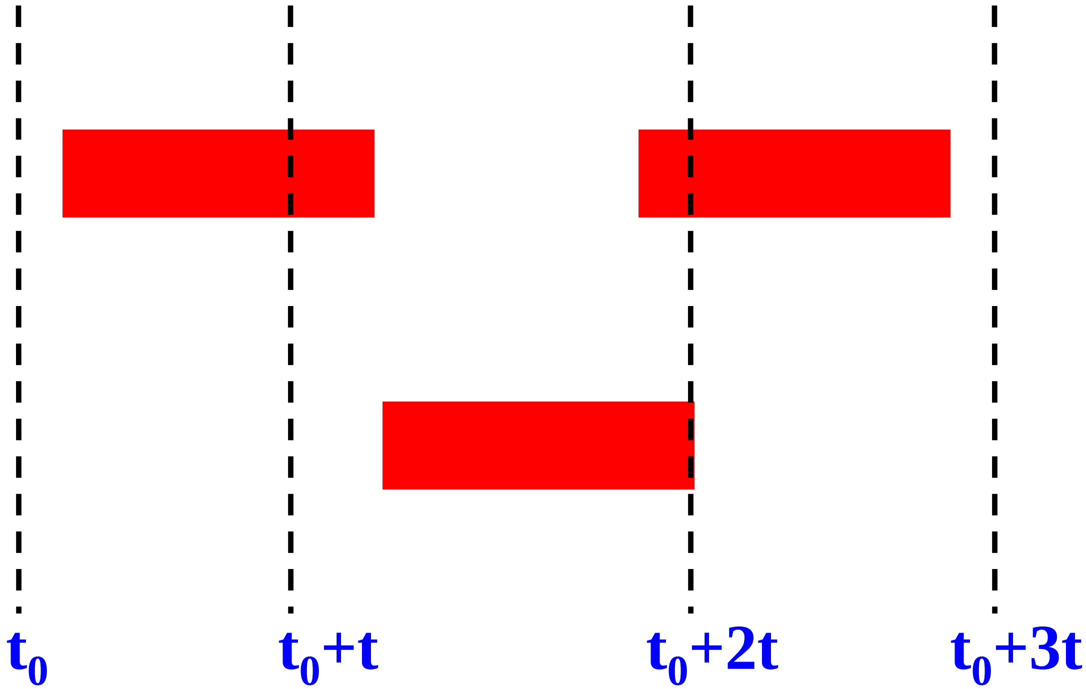
- Very inefficient: 18%
  - Solution: Slotted ALOHA
- Slotted ALOHA
  - Time divided into Slots
    - Transmission only in slots
    - Efficiency : 36%

ALOHA



Collision Resolution: **Wait random amount of time before retransmitting**

ALOHA: Throughput



t – time required to send a frame

Throughput: maximised when frames across stations of same size

ALOHA: Efficiency

- population: infinite number of users generate frame (in a frame time)
  - S frames/frametime
  - Assume Poisson Distributed
  - S < 1 – only then possible to successfully transmit.
  - S > 1 – almost all frames suffer collision
  - G – number of attempts/frame

ALOHA: Efficiency

- Throughput: $S = GP_0$
  - P_0 – Probability that a frame does not suffer collision
    - Low Load:

$$S \approx 0$$

$$G \approx S$$

Low Collisions, few transmissions

- High Load:

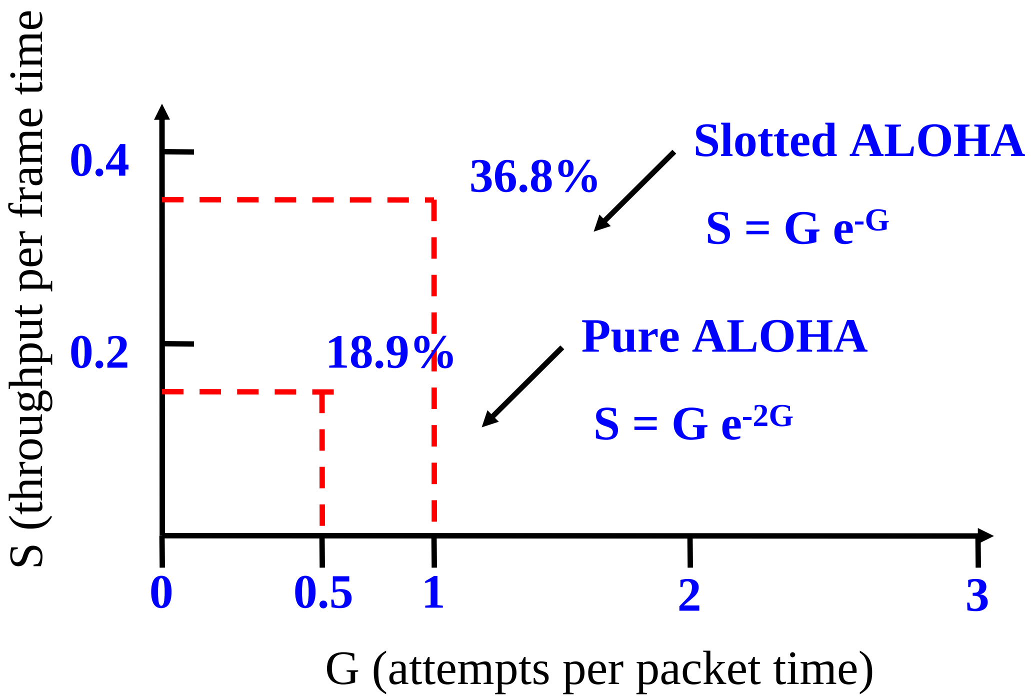
$$G > S$$

High Collisions, almost every frame collides

ALOHA-Analysis

- Probability of zero frames: e^{-G}
- In an interval two frames long –
  - number of frames generated is 2G
- Probability that no other traffic – during vulnerable period
  - $P_0 = e^{-2G}$
  - $S = G\ e^{-2G}$
- Max Throughput: G = 0.5, S = 1/2a (a is the propagation delay

ALOHA: Throughput vs Load



Successful transmission/frame time $S = G P_0$

Carrier Sense Transmission

- ALOHA: Utilisation very poor
  - need a better solution
- CSMA – Carrier Sense Multiple Access Protocols
- CSMA / CD – Additional overhead over CSMA –
  - once collision detected stop transmitting
- Ethernet Xerox Palo Alto Research

Carrier Sense Transmission

- All stations can detect when a station is idle / busy.
- Collision detection (CD)
  - collision a host listens as it transmits
  - knows when a collision has occurred (change in signal levels on the line)

Carrier Sense Transmission

- When station has data to send :
  - Listen to the channel
    - busy – then wait
    - idle – transmit
  - If collision occurs
    - wait random amount of time and then retransmit
- p–persistent:
  - station transmits with a probability p – when idle

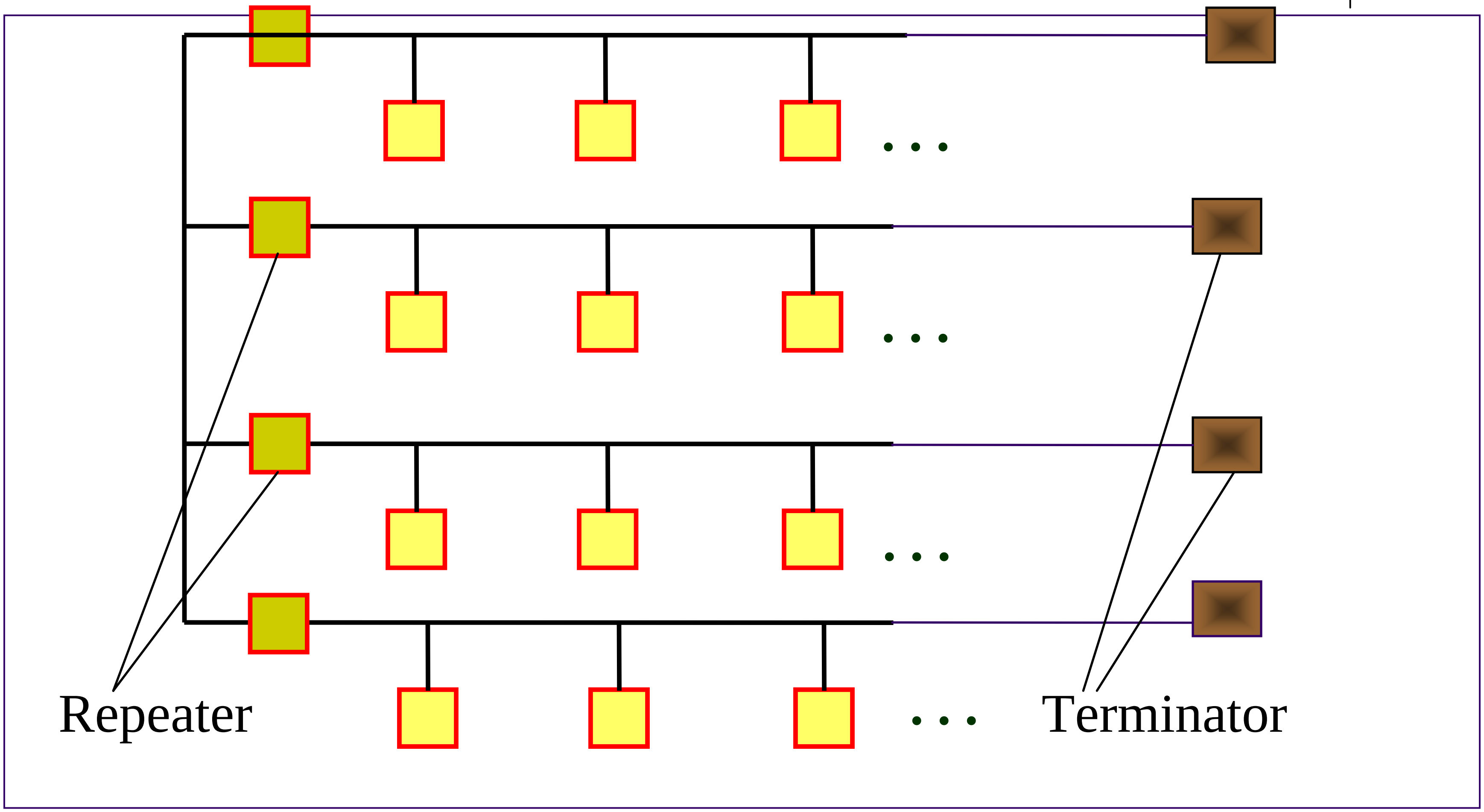
Carrier Sense Transmission

- Issues – propagation delays become worse with large a.
  - two stations back off for same time retransmit more collision

5.3 Ethernet: Miscellaneous

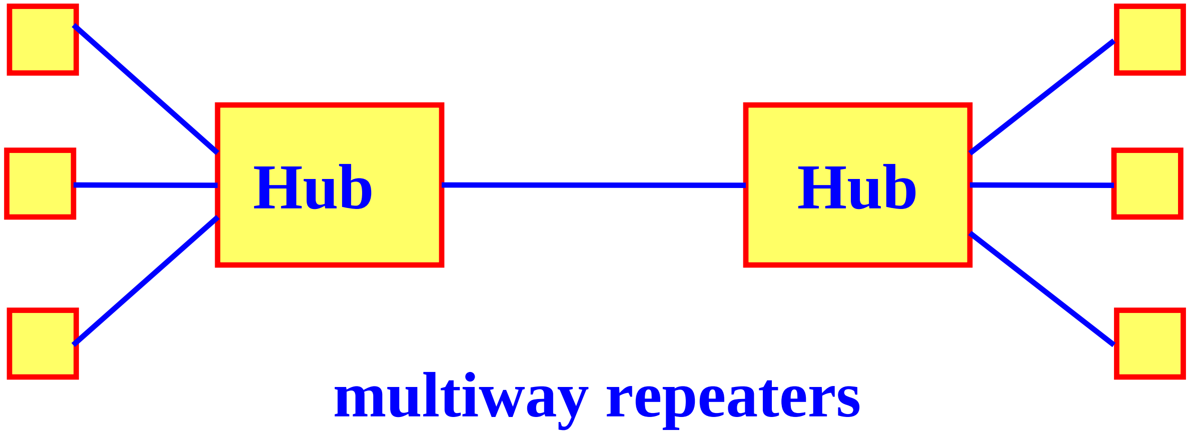
- Cable: 10/100 Base T
  - 10/100 Mbps
  - T – twisted pair
    - Splice T-joint in cable
  - Cables are connected to machines which connect to a hub
  - Maximum cable length from machine to hub
    - 100m
- Encoding: Manchester encoding

A Typical Ethernet LAN



Terminators attached at the end of each segment absorb the signal

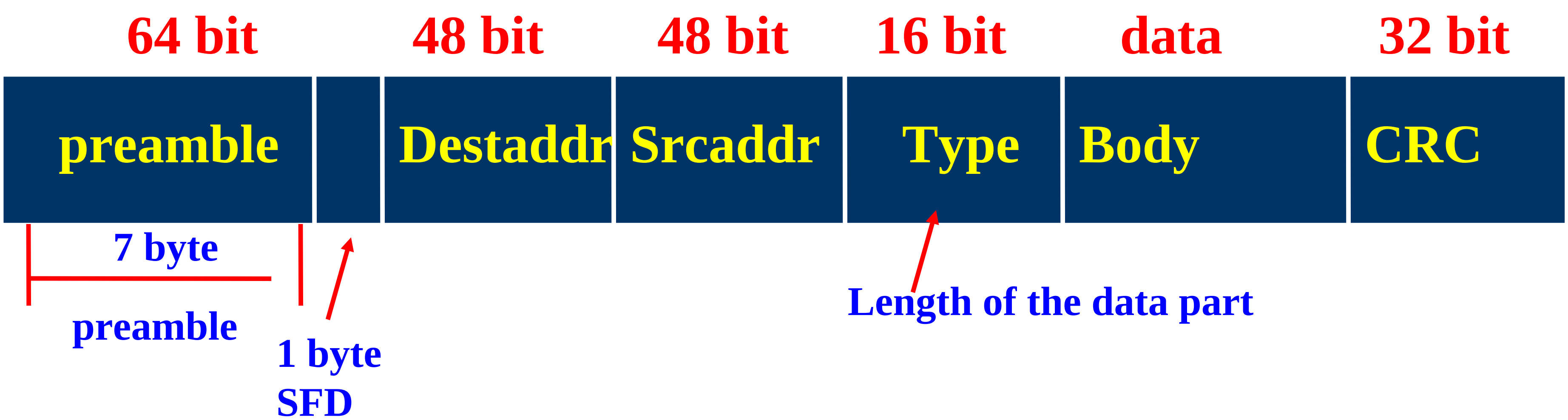
Hub based communication



daisy chain a number of hosts

- almost like a star
- data transmitter on one segment received by every body else
- single channel multi access
- same collision domain

The Ethernet Frame Format



Ethernet Frame Format

- Data in each frame – maximum 1500 bytes, minimum 46 bytes
- Bit oriented protocol
- Ethernet frame: 14 byte header (6 byte dest + 6 byte src + 2 byte type)
- Adapter – attaches preamble, CRC, postamble before transmitting and receiving adapter, removes them

Ethernet Frame Format

- Every ethernet host has a unique address
  - 48 – bit address:
  - Example: 8 : 0 : 2b : e4 : b1 : 2
  - 4 bit nibbles
  - each manufacturer of Ethernet device is allocated a fix prefix (24 bit)
  - Example: AMD: 24 bit 8 : 0 : 20
  - manufacturer ensures suffix is unique
  - frame transmitted is received by every adapter connected to Ethernet

Adapter Functions

- adapter recognises frame meant for itself passes to host (unicast address)
- adapter runs in promiscuous mode
  - listen to all frames
  - adapter must be programmed to do this
- adapter accepts frames with multicast address
  - provided adapter has been programmed to listen that address

Adapter Functions

- No centralised control
- Two station begin transmitting at the same time
- Each sender can detect collisions – receiver detects collision sends
- A 32 bit jamming sequence is sent to indicate a collision

Ethernet Conventions

- **Minimal transmission:**
- **64 bit + 32 = 96 bit**
- **Preamble + jamming sequence**
- **To ensure frame did not collide with another send**
  - **14 bytes header + 46 bytes data + 4 byte CRC = 512 bits**

Ethernet Example

- **2500 m + 4 repeaters**
- **10 Mbps – delay 51.2** μs
- **= 512 bits**
- **collision detected –**
  - **use binary exponential backoff**
- **First: 0, 51.2** μs
- **Second: 0, 51.2** μs**,102.4** μs

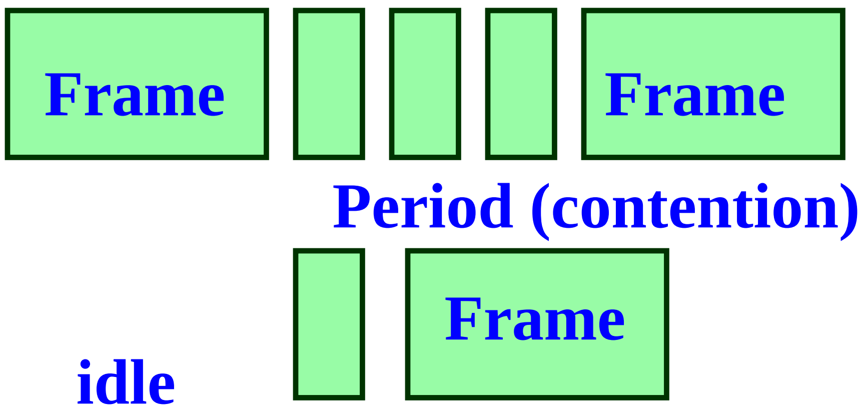
Ethernet Conventions

- **Collision again**
- wait k $\times$ 51.2 μs
- for 0, $2^3 - 1$
- randomly select k between $0 - 2^n - 1$
- n – number of collision experienced
- retry upto 16 times

Popularity of Ethernet

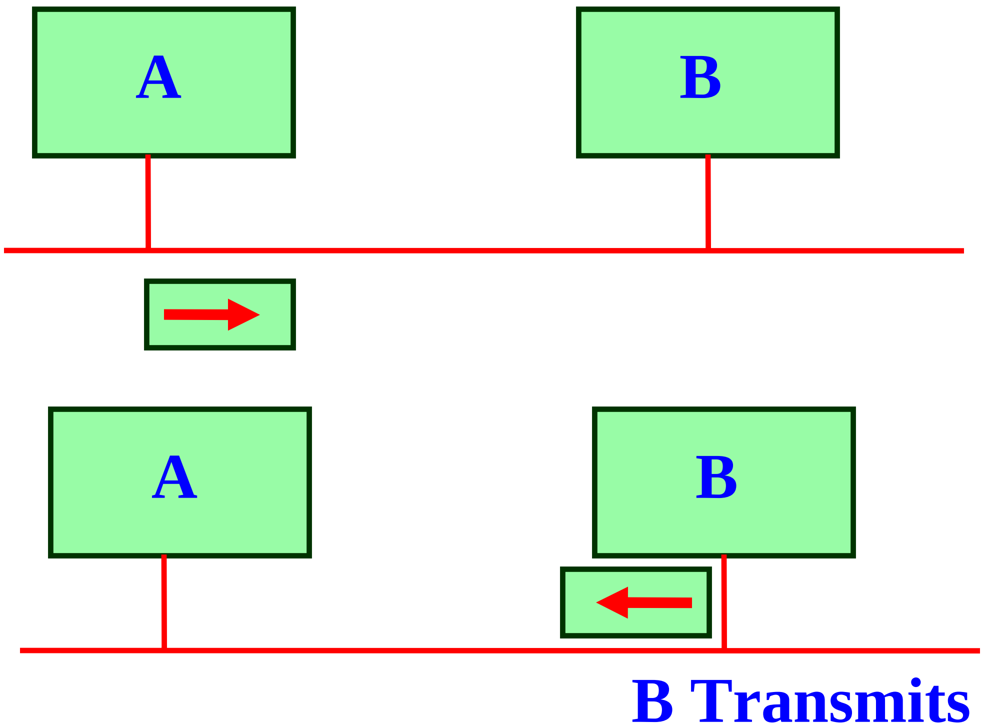
- 200 hosts / NW
- Most Ethernets shorter than 2500 m
  - delay 5 μs rather than 51.2 μs
- No routing
- No configuration
- Easy to add new hosts
- Cable cheap, adapter cheap – switch based approaches expensive

Ethernet: Overhead: Collision detection



Contention detection: Depends on propagation delay

Ethernet: Collision detection



Ethernet Analysis

- B detects collision
  - sends jammer to A
  - Jammer takes *2a* time to reach A
- frame size 1
- *2a* – end to end propagation delay
- CSMA / CD : medium organised as slots
  - length is *2a*

Ethernet Analysis

- slot time - max time from start of frame to detect collision = *2a.*
- CSMA analysis:Assumptions
  - infinite population
  - Poisson arrival
  - unslotted non persistent
  - fixed frame size

Ethernet Analysis

$$P[success] = e^{-aG}$$

$$Offered\ Load\ S\ = Ge^{-aG}$$

$$a\ is\ the\ propagation\ delay$$

$$Frame\ time\ is\ 1$$

CSMA – *p-persistent*

- Station acquires a slot
- *p-* probability of transmission during a slot
- Let *k* be the number of stations
- The probability that only one station transmits in a slot is
- A $= kp(1-p)^{k-1}$

CSMA – *p-persistent*

- Mean length of contention interval

$$E[(i\text{-}1)\ \ collision\ slots\ followed\ by\ a\ success]$$

$$= \sum_{i=1}^{\infty} iP^{i-1}(1-P)$$

$$= \sum_{i=1}^{\infty} i(1-A)^{i-1}A$$

$$= \frac{1-A}{A}\, slots$$

Efficiency

$$\textit{time in slots for transmitting data} = \frac{1}{2a}$$

$$Utilisation = \frac{\frac{1}{2a}}{\frac{1}{2a} + \frac{1-A}{A}}$$

$$k \to \infty, A \to 1/e$$

$$Utilisation = \frac{1}{1+3.44a}$$

Timing Diagram

Transmission interval 1/2a slots

Sequence of slots with no transmission or collision