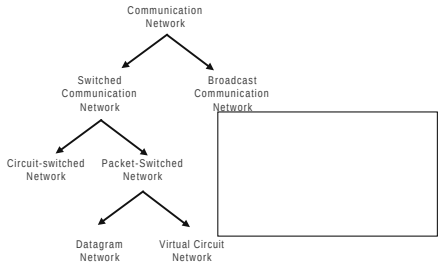
Local Area Networks (LANs)

Ethernet (IEEE 802.3)

Introduction

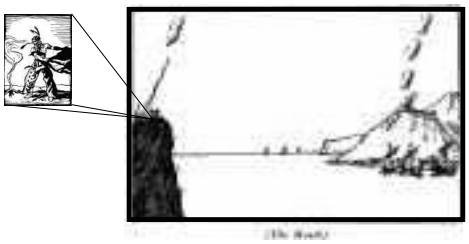


Broadcast Networks

- Recall that in broadcast networks:
  - Each station is attached to a transmitter/receiver which communicates over a medium shared by other stations
  - Transmission from any station is received by all other stations
  - There are no intermediate switching nodes

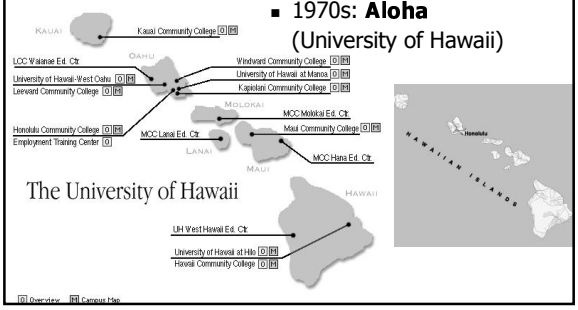
Early Broadcast Networks

- 1500 AD: Smoke signals

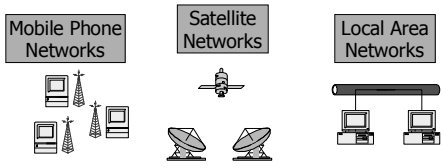


More Recently

- 1970s: **Aloha** (University of Hawaii)



Today's Broadcast Networks



The Multi-Access Problem

- If more than one source transmits at a time on the broadcast channel, a collision occurs
- The multi-access problem: How to determine which station can transmit?

Multi-access Protocols

- Protocols that resolve the multi-access problem dynamically are called **(Multi-access)** Protocols
- Different types of multi-access protocols
  - Contention protocols resolve a collision after it occurs. These protocols execute a collision resolution protocol after each collision
  - Collision-free protocols ensure that a collision can never occur

Evolution of Contention Protocols

Aloha — Developed in the 1970s for a packet radio network

Slotted Aloha — Improvement: Start transmission only at fixed times (slots)

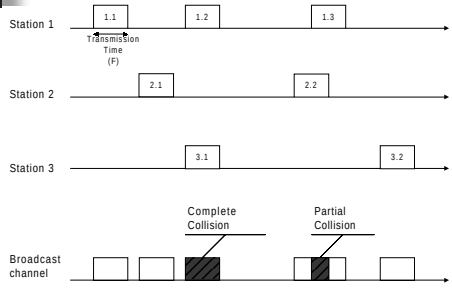
CSMA — CSMA = Carrier Sense Multiple Access
Improvement: Start transmission only if no transmission is ongoing

CSMA/CD — CD = Collision Detection
Improvement: Stop ongoing transmission if a collision is detected

Aloha

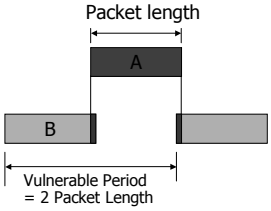
- All stations send frames to a central node, which broadcasts them
- Whenever a station has data, it transmits
- Sender listens to broadcast and checks for collisions
- Sender retransmits after some random time if there is a collision

Collisions in (Pure) ALOHA



The Vulnerable Period in Aloha

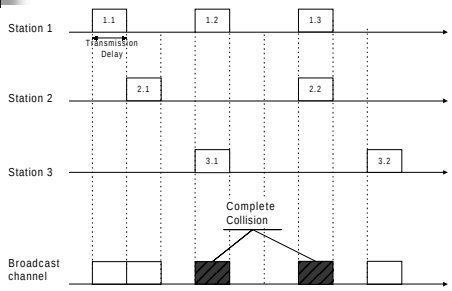
Vulnerable Period:
What is the time interval during which arrival of packet B implies a collision with packet A?



Slotted ALOHA (S-ALOHA)

- **The Slotted Aloha Protocol**
  - Slotted Aloha - Aloha with an additional constraint
  - Time is divided into discrete time intervals (**=slot)**
  - A station can transmit only at the beginning of a frame
- As a consequence:
  - Frames either collide completely or do not collide at all

Collisions in S-ALOHA



The Vulnerable Period in Slotted Aloha

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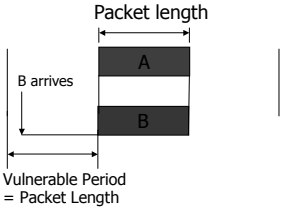
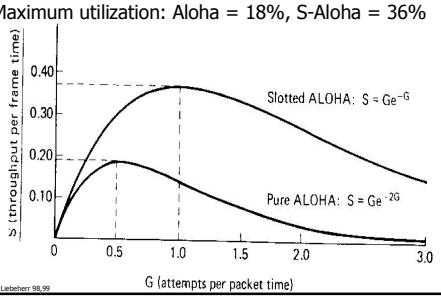
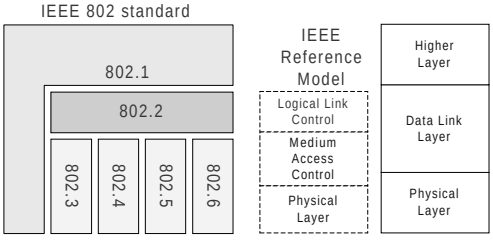


Comparison of ALOHA and S-ALOHA

Maximum utilization: Aloha = 18%, S-Aloha = 36%



IEEE 802 LAN Standard



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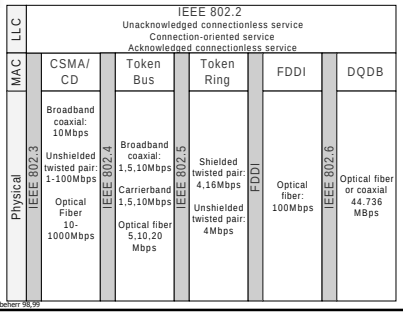
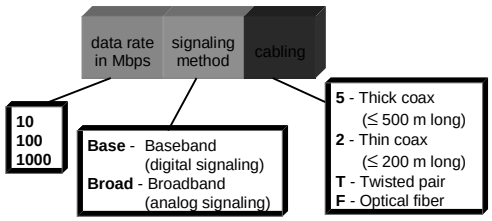


IEEE 802.3 Standard The Ethernet

- Ethernet is the most successful LAN technology today
- Developed originally at the Xerox Palo Alto Research Center (Xerox PARC)
- Standardized by DEC, Intel, and Xerox in 1978
- Forms basis of the IEEE 802.3 standard
- Standard includes
  - Hardware specification (Physical Layer)
  - Protocol specification (Link/MAC Layer)

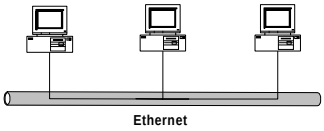
Ethernet Hardware Specifications

- Physical layer configurations for 802.3 LANs



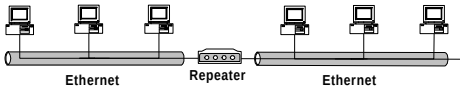
Bus Topology

- 10Base5 and 10Base2 Ethernets have a bus topology



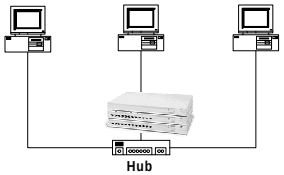
Repeaters

- Maximum length of a segment is 500m (10Base5) and 200m (10Base2)
- Span can be extended by connecting segments via repeaters (4 maximum)
- Repeaters do not isolate collisions



Star Topology

- With 10Base-T, stations are connected to a hub in a star configuration



- The distance of a node to the hub must be ≤ 100 m

Fast Ethernet

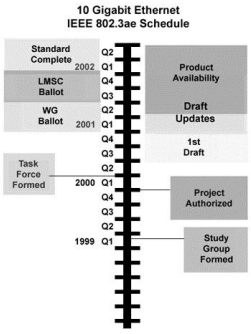
- Fast Ethernet is synonymous with Ethernet at 100 Mbps rates
- Standard: IEEE 802.3u
  - 100BASE-T4 (100 Mbps over telephone-grade twisted pair)
  - 100Base-TX (100 Mbps over Category 5 twisted pair)
  - 100Base-FX (100 Mbps over Fiber Optics)

Gigabit Ethernet

- Data rate is 1 Gbps = 1000 Mbps
- Standard: IEEE 802.3z
- Physical Layers:
  - 1000Base-SX short-wave laser over multimode fiber
  - 1000Base-LX long-wave laser over single mode fiber and multimode fiber
  - Twisted pair version
- Used for backbone of a campus area network

10 Gigabit Ethernet

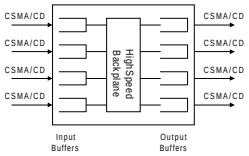
- A new Ethernet standard thought to possibly replace backbone link technology in the near future. Good bye SONET, ATM, etc.
- Find more on: www.10gea.org



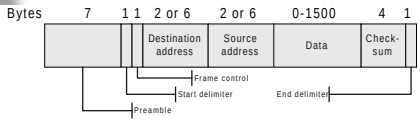
Timeline

Ethernet Switches

- Ethernet switches allow to completely avoid collisions
- Each port is isolated and builds its own collision domain



Ethernet Protocol Specifications: Frame Format



- Preamble is a sequence of 7 bytes, set to "10101010" for each byte. Preamble helps receiver to synchronize with bit pattern before actual frame is received
- At 10 Mbps, a frame must be at least 46 bytes long. Otherwise, a station may not detect a collision of its own transmission
- Maximum frame size is set to 1500 bytes of data, minimum frame size is set to 512 bits.

Ethernet Addresses

- Each Ethernet card comes with a hardwired 6-byte address (the physical address)
- Example representation:
  - 8:0:2b:e4:b1:2
- Each address is globally unique
- Prefix determines manufacturer
  - Advanced Micro Devices has 8:0:20 prefix

Broadcast/Multicast

- The broadcast address: Broadcast is indicated by setting the packet's address field to FF:FF:FF:FF:FF:FF
- Multicast addresses: Any address that starts with a 1 is considered a multicast address

Ethernet Adaptor: Receiver Side

- Receiver:
  - Receives packets addressed to the card's physical address
  - Receives packets addressed to the broadcast address
  - Receives packets addressed to any multicast address the card is listening to
  - Receives all packets when operating in promiscuous mode

Ethernet Adaptor: Transmitter Side

- Transmitter:
  - Waits for line to become idle
  - Transmits data and listens for collisions
  - If collision is detected sends a jam signal
  - Waits for a number of slots then retransmits
- Transmission issues:
  - When to retransmit?
    - The exponential backoff algorithm
  - What is the slot size?

Exponential Backoff Algorithm

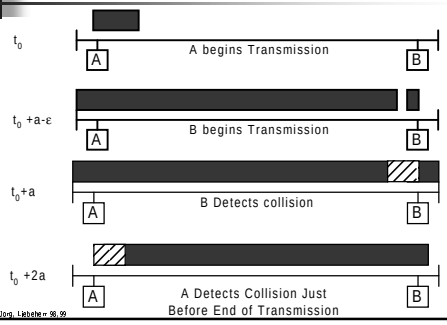
- Ethernet uses the exponential backoff algorithms to determine when a station can retransmit after a collision

Algorithm:
- Set "slot time" equal to T
- After first collision wait 0 or 1 slot times
- After i-th collision, wait a random number between 0 and $2^i - 1$ time slots
- Do not increase random number range, if i=16
- Give up after 16 collisions

Slot Size

- Slots must be large enough for collisions to be detected
- **Question:** How long does it take to detect a collision?
- **Answer:** In the worst case, twice the maximum propagation delay of the medium
- **`Slot size = 2 propagation delay`**

Explanation: Collision Detection



Ethernet Minimum Packet Length Constraint

- Packets should be long enough for collisions to be detected
- Minimum packet size requirement in Ethernet is 64 bytes (14 byte header + 46 bytes of data + 4 byte CRC)
- Padding is used if data size is less than 46 bytes