University of Massachusetts Amherst

ECE697AA – Lecture 5

Link Layer: Ethernet

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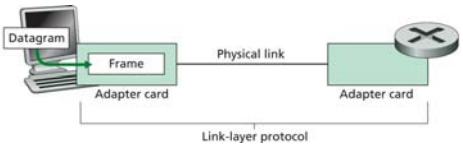
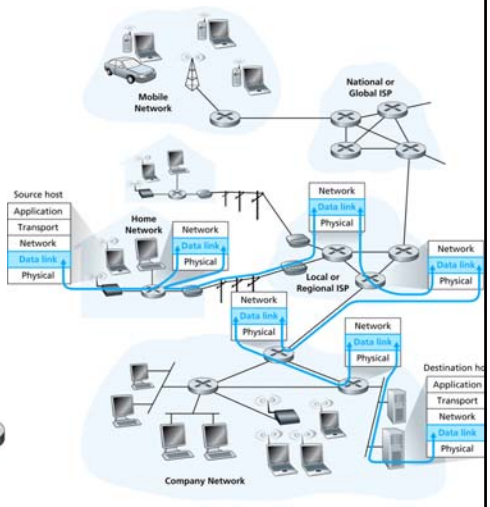
Data link layer

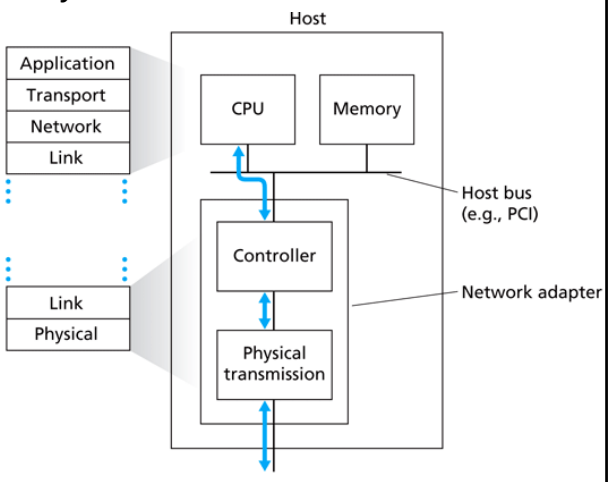
- Data links connect one device to another
  - Single hop connection
- Services
  - Framing
  - Link access
  - Flow control
  - Error detection / correction
  - Half-duplex / full-duplex





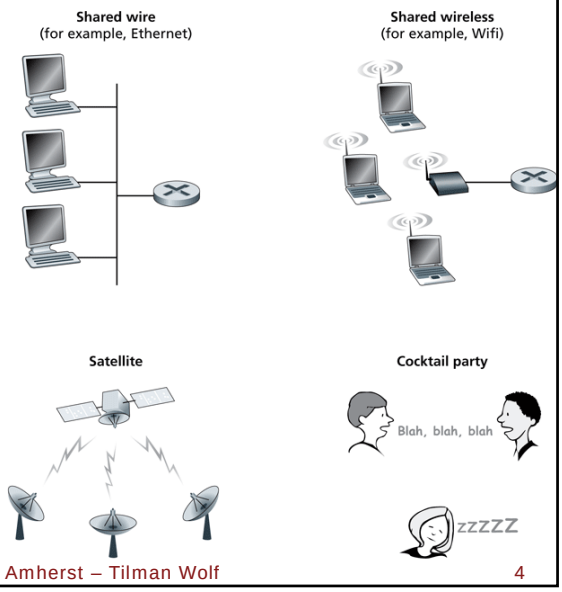
Network interface cards

- Implementation of NIC
  - Adapter connected to processor via bus
- NIC implements many functions in hardware
  - Error detection
  - Retransmission
  - Direct Memory Access (DMA)



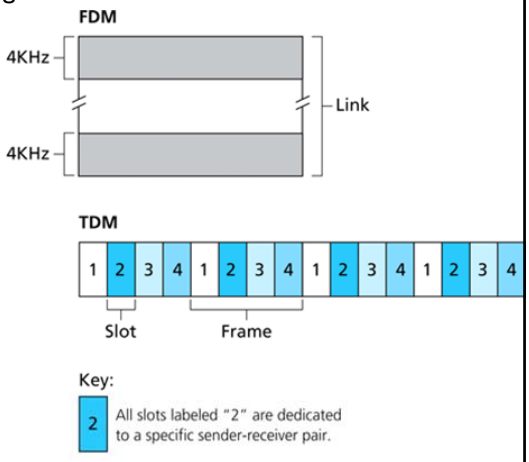
Multiple access

- Many data link layers use “shared medium”
  - Shared wire
  - Shared spectrum
- Medium Access Control (MAC) important
  - How can we coordinate sharing?



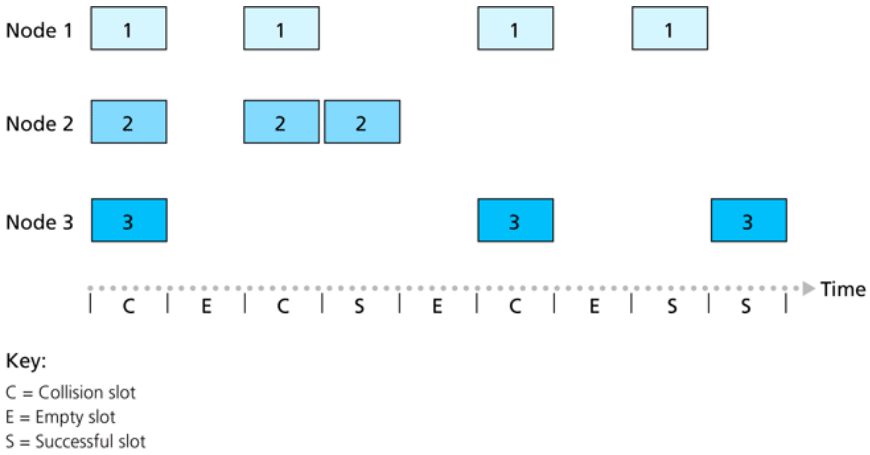
Multiple access

- Medium Access Control Approaches:
  - Channel partitioning
    - » TDM, FDM, CDMA
  - Random access protocols
    - » ALOHA, CSMA/CD
  - Taking turns protocol
    - » Polling, token-passing
- Random access used in Ethernet
  - How does it work?



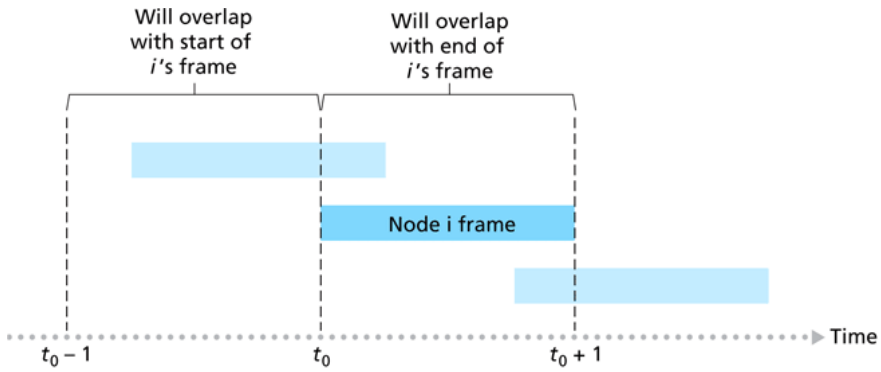
Slotted ALOHA

- Multiple stations may send at the same time?
  - What happens if collision occurs?



Pure ALOHA

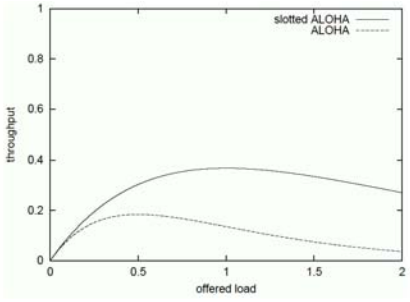
- Station can send whenever it is ready
  - Avoids synchronization challenge in Slotted ALOHA



- How does performance differ (pure vs. slotted)?

ALOHA throughput

- Slotted ALOHA analysis
  - Probability that k frames are generated during interval
    - » Poisson distribution: $Pr[k]=G^k e^{-G}/k!$
    - » G is rate of frame generation (new and retransmission)
  - Probability of successful transmission
    - » Success if no other frame generated (P_0): $S=GP_0=Ge^{-G}$
- ALOHA analysis
  - Frame overlaps two slots
  - Probability that no other frame is generated during two slots:
    - » $P_0=e^{-2G}$
    - » Success $S=GP_0=Ge^{-2G}$
- Max throughput:
  - 37%@G=1.0 (slotted ALOHA)
  - 18%@G=0.5 (ALOHA)



ALOHA improvements

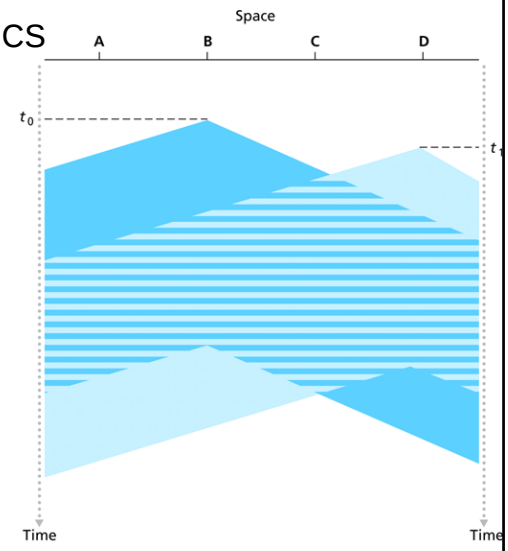
- How can we improve ALOHA?

ALOHA improvements

- How can we improve ALOHA?
  - Don't send when somebody else has already started
  - Stop when interference is already happening
    - » Why do we need to do that if we don't start sending when somebody else sends?
- Carrier Sensing (CS)
  - Listen on channel
  - Only send when nobody else is transmitting
- Collision Detection (CD)
  - Listen to own transmission on channel
  - If garbled then stop transmitting

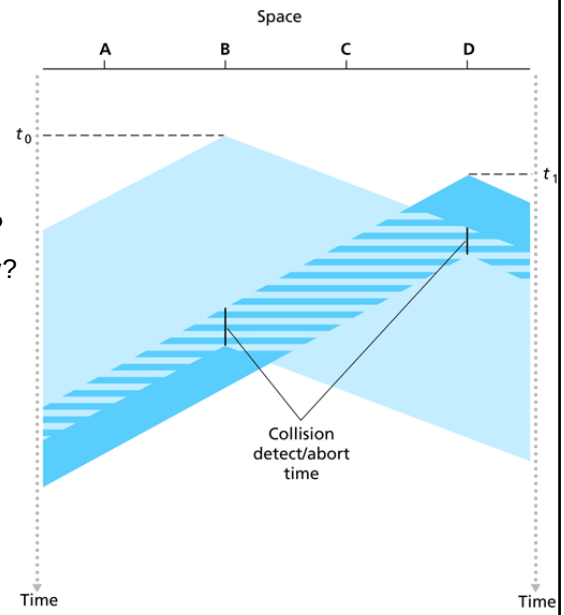
CSMA collision

- Collisions occur despite CS
  - Space-time diagram
- Propagation causes problems



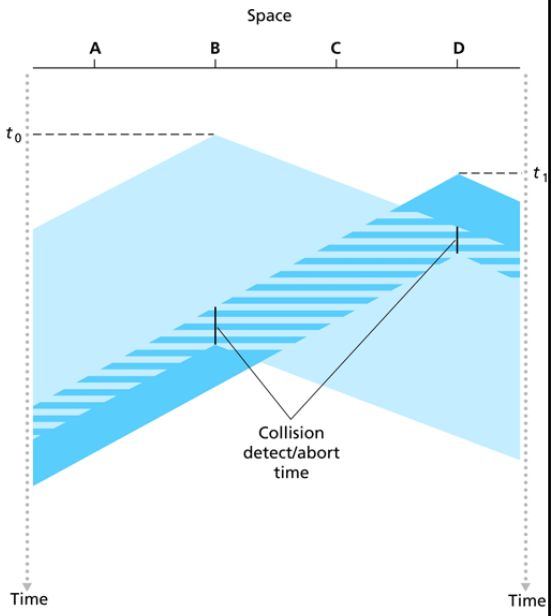
CSMA/CD

- Collision detection reduces useless transmissions
- How can we guarantee that collision is detected?
  - Why is this necessary?



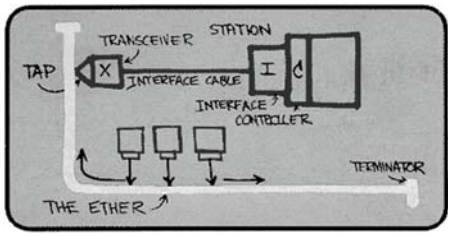
CSMA/CD

- How can we guarantee that collision is detected?
  - Packet must be at least as long as twice the propagation delay between stations with maximum separation
- 10 Mbps Ethernet
  - Packet length:
    - » 64 bytes
  - Maximum distance:
    - » 2.5 km



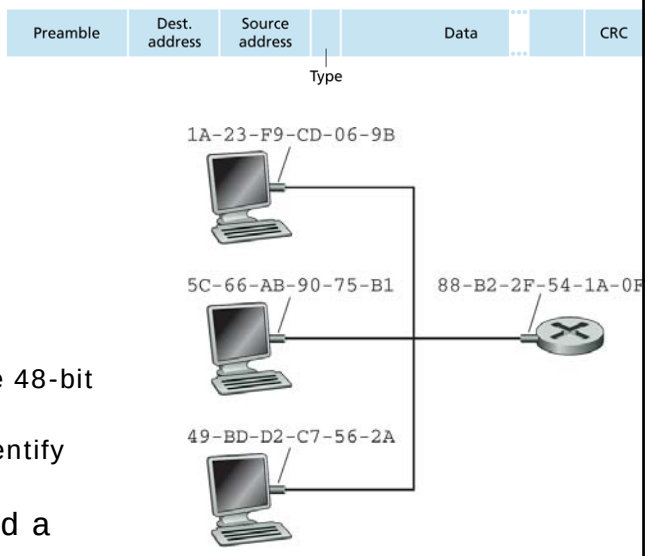
Ethernet

- IEEE 802.3 protocol
- CSMA/CD
  - Station listens and transmits when cable idle
  - If collision occurs, then station backs off and retries
- Truncated exponential backoff
  - Wait for random number of 512 bit-times
  - After c collisions: uniform distribution over $[0...2^{\min\{c,10\}}-1]$
  - After 16 collisions: transmission aborted
- Limitations
  - Max 2.5km of cable, thus RTT limited to 51.2μs
  - Corresponds to 64 bytes @ 10Mbps



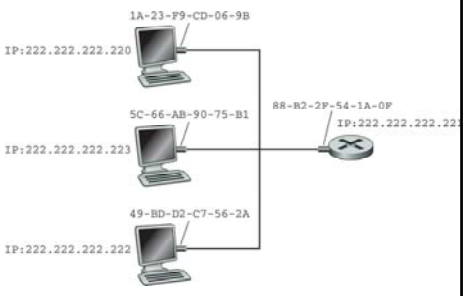
Ethernet

- Frame format:
  - Preamble synchronized receiver
  - Type identifies network layer protocol
  - CRC for error detection
- Addressing
  - Globally unique 48-bit address
  - First 24 bits identify vendor
- How can we find a destination?



Address Resolution Protocol

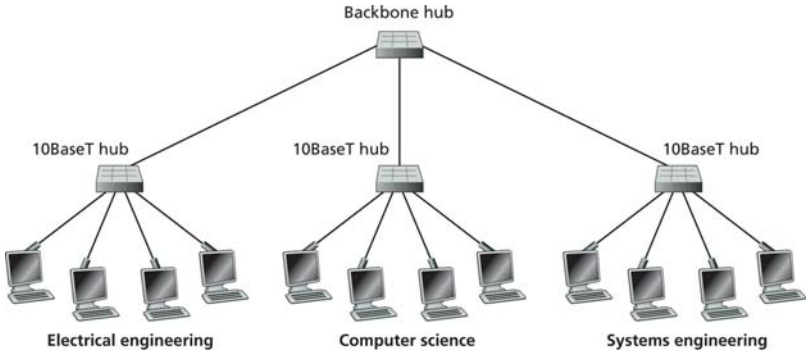
- Problem: what is Ethernet address of destination?
- ARP protocol
  - Broadcast of request for Ethernet address of given IP address
  - Response from anybody
- ARP table maintains entries
  - Timeout ensures adaptation to reconfigurations



IP Address	MAC Address	TTL
222.222.222.221	88-B2-2F-54-1A-0F	13:45:00
222.222.222.223	5C-66-AB-90-75-B1	13:52:00

LAN Architecture

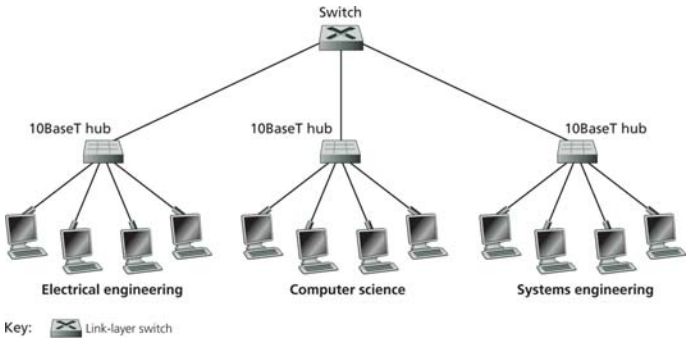
- LAN consists of several segments
- Hub connections maintain collision domain



LAN Architecture

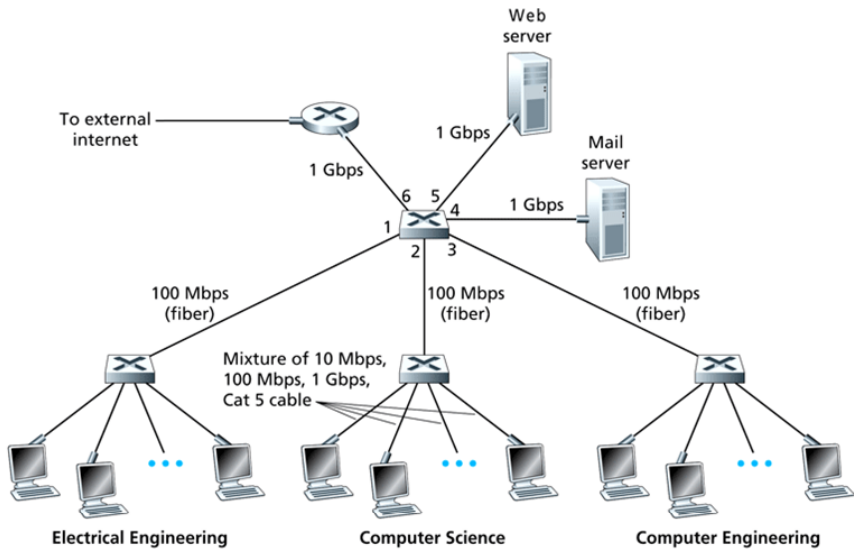
- Switches separate collision domains
- Filtering and forwarding
  - Switch "knows" where frame should go
  - Switch table

Address	Interface	Time
01-12-23-34-45-56	2	9:39
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
....	....	....



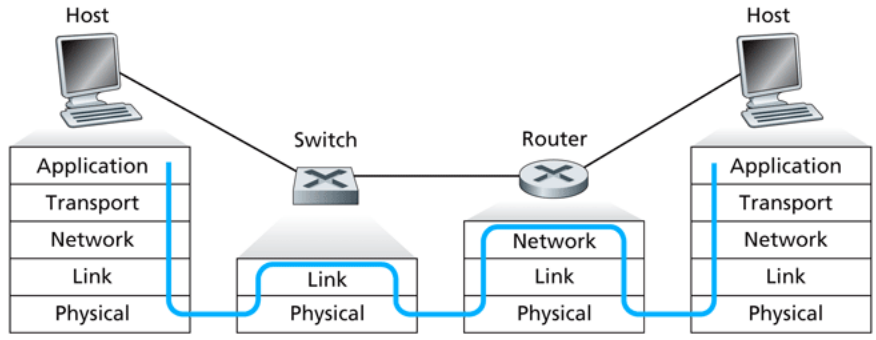
LAN Architecture

- Example with heterogeneous links



Network Architecture

- Comparison of LAN switches and routers



Assignments

- Read
  - kc claffy, Greg Miller, and Thompson Kevin, “The nature of the beast: Recent traffic measurements from an internet backbone,” in Proc. of 1998 INET Conference, Geneva, Switzerland, June 1998.
- Have a look at
  - http://www.caida.org
- SPARK
  - Assessment quiz