CS118 Discussion 1B

Link layer, Multiple Access, Ethernet

Week 8

Zhiyi Zhang (zhiyi@cs.ucla.edu)

Link Layer

Network Stack: A better understanding

- Application
  - Where app message is generated
    - HTML request and response, DNS request and response, etc.
- Transport
  - Where the message is prepended the transport header for process-wide identification (multiplexing and demultiplexing)
    - HTML request is from process whose port is 12345 and to the process whose port is 80
- Network
  - Where the packet is delivered across the Internet, host to host
    - From sender’s LAN to sender’s AS to other ASes to target network’s LAN
- Link
  - Where packet is transmitted in each link, hop to hop
    - From router1’s interface 1 to the shared link then to router2’s interface 2

Link Layer

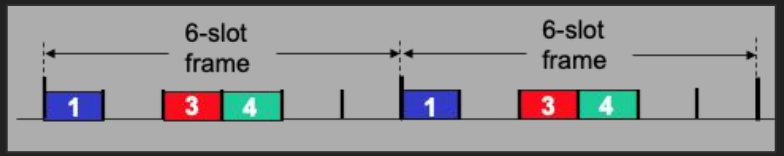
- Services provided by the link layer
  - Data framing
  - Error detection, correction - CRC (cyclic redundancy check)
  - Multiple access handling
  - Link layer addressing
- Typical link layer protocols for LAN (local area network, e.g., your home, office)
  - Ethernet
  - VLANs
  - WiFi

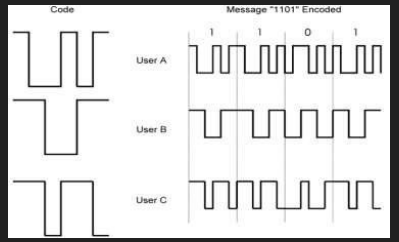
Packet Delivery at the Link Layer

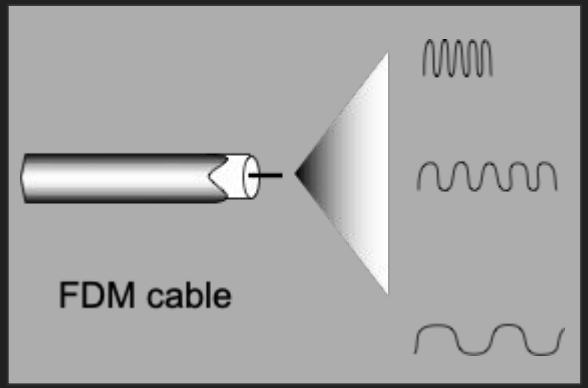
- Basic communication models (also applies to other layers)
  - Unicast
    - A sends to B
    - E.g., TCP, UDP unicast
  - Broadcast
    - A sends to the rest hosts in the network
    - E.g., DHCP discovery (over UDP)
  - Multicast
    - A sends to a group of hosts in the network
    - E.g., IGMP (Internet Group Management Protocol) + DVMRP (Distance Vector Multicast Routing Protocol)

Multiple Access Protocol over Broadcast Media

- Channel partitioning
  - FDMA: partition frequency
  - TDMA: partition time
  - CDMA: partition code
- Random access
  - Aloha
  - Slotted Aloha
  - CSMA
  - CSMA/CD - wired link
  - CSMA/CA - wireless link
- Taking turns
  - Token ring







Aloha vs Slotted Aloha

- Suppose N nodes with enough frames to send, each transmit with probability P
- Aloha
  - Pr(a given node can send out the message) = $p(1-p)^{2(N-1)}$
  - Pr(a node can send out the message) = $Np(1-p)^{2(N-1)}$
- Slotted Aloha
  - Pr(a given node can send out the message) = $p(1-p)^{N-1}$
  - Pr(a node can send out the message) = $Np(1-p)^{N-1}$
- To get max efficiency, find a p that maximize the equation, when N goes to infinity, we get max efficiency to be 1/e = 0.37 v.s. 1/(2e) = 0.18

Carrier Sense Multiple Access (CSMA)

- Listen before transmit: only send when idle
- What if busy
  - Retry immediately
  - Retry immediately with a probability
  - Retry after a random time interval
- Collision is possible
  - Because of the propagation delay, a sending host can be hidden to the listener
- To reduce bandwidth waste after collision
  - CSMA/CD (collision detection): abort transmission when detecting collision, used more in wired network because collision can easily be detected
  - CSMA/CA (collision avoidance): better ensure the channel is clear, used more in wireless network because collision cannot be detected

Ethernet

Ethernet Overview

- Service: connectionless , unreliable (best effort) data delivery
- Multiple Access Solution: CSMA/CD + exponential backoff
- MAC addresses are identifiers used in Ethernet
- Switch are used in Ethernet
  - ARP
  - Self learning strategy to be plug-and-play

Ethernet Multiple Access Protocol

- NIC creates frames after it receives datagram from the network layer
- If the channel is idle, starts frame transmission; if it’s busy, wait until the channel is idle again then transmit.
- If NIC transmits the whole frame successfully, we are done; if another transmission is detected (collision), abort the transmission, send jam signal, and run exponential backoff

MAC address

- Assigned by the manufacture (eventually assigned by IEEE)
- Burned in NIC ROM
- MAC address flat -> portable
  - IP is structured -> fit into the network topology, not portable
- Format: 48 bits address
  - AA-BB-CC-DD-EE-FF
  - Broadcast address: FF-FF-FF-FF-FF-FF

ARP: Address Resolution Protocol

- A mapping between the IP address and the MAC address
- ARP table: check with arp -a
  - IP address
  - MAC address
  - TTL
- When a host/router is about to send the packet, the adapter needs to get the MAC address for the next hop who is physically connected to the sender
- Broadcast based
  - **Broadcast** the query: who knows the MAC address of this IP?
  - Reply with **unicast**: this IP's MAC address is blabla

A host send out a packet

- What’s the destination IP address?
  - If same network
    - Look up the corresponding MAC address and send out the packet
  - If not within the same network
    - Look up the gateway router’s MAC address and send out the packet

Switch

- Forward frame based on its destination MAC address
- Store and forward
- No “routing” equivalent
  - Use self learning to establish the forwarding table
- Different from a router
  - Router forwards by IP address, cross networks, network layer
- Different from a hub or a repeater
  - Repeater: repeat bits from the incoming link to all other links
  - Hub: link layer packet received from the incoming link to all other links

Open to Quiz 2, Homework, Project 2 questions