EECS 563 Spring 2024

Review Test 2

Internet Protocols

- IPv4 – packet header
  - Source/Destination Address-32 bits
  - TTL
  - ToS
  - Header check
  - Fragmentation/reassembly

Internet Protocols

- Addressing IPv4
  - Net_Id, Host_Id
  - a.b.c.d format
  - /X
    - Subnetwork mask
    - Address range/network
    - # hosts/network
  - Subnetworks

Internet Protocols

- Header check sum Not equal 0→ drop packet
- TTL=1 and when decrement TTL= 0 then → drop packet & send ICMP packet to source
- Forwarding→ Router actions upon arriving packet
- Using the forwarding table: Longest Prefix Match

Dest Network	Next Hop	Interface
192.1.1.0/24	Router 7	Fiber1
237.5.0.0/16	Router 9	Eth3
Default	Router 8	Fiber2

Internet Protocols

- ICMP
- DHCP
- DNS
- ARP (PHY/Layer 2/MAC and IP Addresses)
- Tunneling
- NAT

Internet Protocols

- Routing→ gather information and build the forwarding tables
  - Issues
    - How to learn the network topology?
    - How to share information?
    - How to define "distance"?
    - What shortest path algorithm to use?
    - How to respond to failures?
    - How to respond to congestion?
- Exhaustive Search

Internet Protocols

- Routing hierarchy
  - AS & between AS's
    - Within one AS uses IGP, example OSPF
    - Between AS's uses EGP, example BGP
  - ASN (32 bits)
  - EGP's need to consider cooperation among competing entities, BGP policies are based on business relationships
- Source Routing

Internet Protocols

- IPv6
  - Addresses → 128 bits
    - 4BF5:AA12:0216:FEBC:BA5F:039A:BE9A:2176
  - Header
    - TTL becomes a Hop Limit
    - No header checksum
    - No Fragmentation
    - Flow label
    - Traffic Class
  - Transition IPv4 to IPv6
    - Dual stacks
    - Tunneling

MAC

- Scaling & trade-offs WRT:
  - rate (b/s),
  - number of users, and
  - size (km)
- Deterministic (Polling)
  - Operation (why called deterministic)
  - MTHT
  - Calculate effective rate & efficiency

MAC

- Random Access
  - Collision process
    - Time vulnerable to collision

      Time vulnerable to collision ↑ then S_{max} ↓
    - Detecting Collisions
  - Time
    - Unslotted
    - Slotted
  - Role of backoff process

MAC (Random Access-continued)

- Types (all can be slotted/unslotted)
  - ALOHA (for unslotted S_{max}=18%, for slotted S_{max}= 36%)
    - Vulnerable to collision ~L/R sec (not function of τ)
  - CSMA
    - Vulnerable to collision ~τ sec
    - p-persistent (1-persistent)
    - Non-persistent
    - CSMA/CD

$$a = \frac{\tau}{\frac{L}{R}} \text{ where } \tau = \text{End-to-End Propagation Time}$$

$$\text{As } a \uparrow \quad S_{Max} \downarrow \text{ and as } a \to 1,\ S_{Max} \to ALOHA$$

- Leads to specification of Min/Max Packet size

MAC

- Collision Free Protocols
- Centralized Reservation Systems
  - In upstream - send requests to transmit
    - Use part of cycle time (contention slots) to send requests
    - Use random access to share contention slots
  - Receive grants to transmit in the downstream
  - No contention in downstream
  - If no grant in downstream then assume collision for the request, backoff and resend request in upstream
  - Vulnerable to collision ~ contention slot time

MAC

Maximum Throughput for Centralized Reservation Systems
(No contention for reservation slots)

$$S_{\max} = \frac{1}{1 + \frac{v}{Xk}}$$

R = Link rate (b/s)
L = packet size (bits) assume fixed length
v= minislot size (sec)
M = Number of stations
X = L/R (sec) = clocking time
k = number of packet transmissions reserved with ONE reservation message

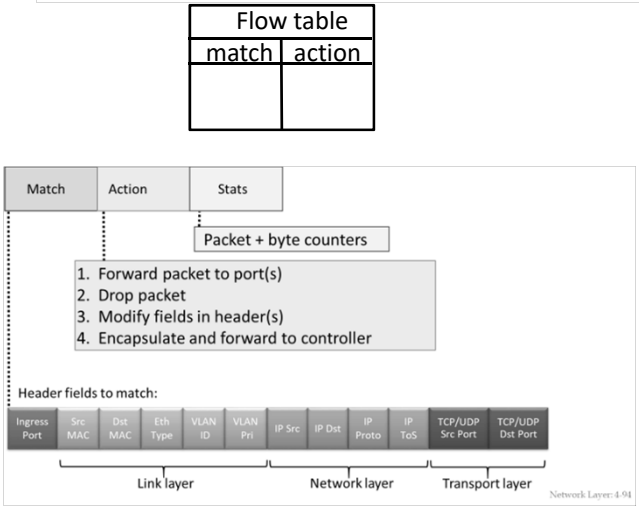
Maximum Throughput for Centralized Reservation Systems
(Using Aloha for access to reservation slots)

$$S_{\max} = \frac{1}{1 + \frac{2.7v}{X}}$$

Ethernet

- IEEE 802.3
  - Evolution
    - Bus
    - Hub
    - Switch
    - 10 Mb/s → 100 Gb/s
  - Role of CSMA/CD its use when there is a collision domain
- VLANs

Generalized Forwarding



- Actions include:
  - Send packet to selected output port (physical)
  - Drop the packet
  - Modifying a field in the header (there are restrictions)
- Action is based on any fields in the packet header
- Generalized forwarding is used in Software Defined Networks (SDNs)

Network Elements

- Repeater
- Bridge
- Switch
- Router
  - Layer 2 Switch
  - Layer 3 Switch
  - Layer 4 Switch
  - Layer "Any" Switch

Wireless Networks

- Issues
  - Noise
  - Signal Fading
  - Hidden terminal
- IEEE 802.11
  - RTS/CTS
  - Infrastructure mode
  - Ad hoc mode

4G/5G cellular networks

- UE
- Base Station (eNode B)
- Address in SIM (Subscriber Identity Module)
- All IP
- MAC: request/grant reservation “like” protocol
- Handoff
- Mobility: visiting other networks

Cable Networks

- Cable Networks
  - DOCSIS
  - Access protocol
    - Centralized Reservation Systems
  - CM, Headend, CMTS
- Satellite Networks
  - GEO
  - LEO

DLC

- Goal→ point-to-point error free link
- Functions
  - Framing→ Flags & bit stuffing
  - Error recovery (ARQ)
  - Flow control

DLC

- Sliding window flow control
  - n bits/SN in packet header
  - Max window →N= 2^n-1
  - N=1 → Stop and Wait
  - When to retransmit?
    - Timeout
    - NAK
  - What to retransmit?
    - Uses SN
    - Go-back-N
    - Selective Repeat

DLC

- Piggybacking, ACKs in the reverse path
- Frame structure
  - Building up fields in the header
  - Components of the packet header
- HDLC & PPP

DLC

- Performance

$$\eta = \frac{R_{eff}}{R}$$

$$R_{eff} = \frac{\#bits}{\text{Time to tx } \#bits}$$

* Understand assumptions behind these equations

N_{RTT} = # Frames in RTT

- Stop&Wait*

$$\eta_{stop\ \&wait} = \frac{1}{1+\frac{2\tau R}{n_f}} = \frac{1}{1+N_{RTT}}$$

- Sliding window*

$$\eta_{Sliding\ Window} = \begin{cases} 1 \text{ if } N \geq \frac{2\tau R}{n_f}+1 \\ \frac{N}{1+\frac{2\tau R}{n_f}} \text{ if } N < \frac{2\tau R}{n_f}+1 \end{cases}$$

Small Window Case

$$\frac{N}{1+N_{RTT}}$$

DLC

- Control the source rate by limiting the window size
- Open Loop Control
  - DE bit
  - Token bucket
    - Average rate
    - Maximum burst size

Transport Layer

- Port & sockets
- UDP
- TCP
  - Error free end-to-end communications
  - Connection oriented
  - Header checksum →covers data and header
  - SN and advertised window in **Bytes**

Transport Layer - TCP continued

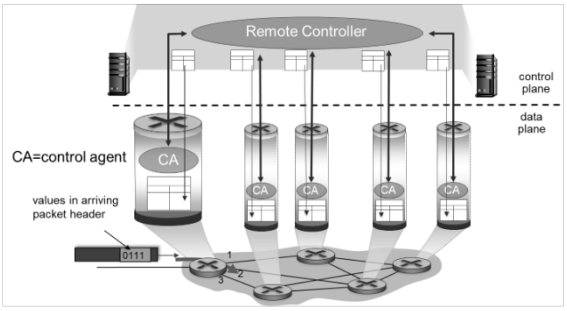
- Session setup/teardown
- Estimate RTT → set time out
- Window management for flow control
- Adaptive window for congestion control
  - Assumes loss due to congestion
  - Action on loss (timeout or duplicate ACKS)
  - Phases
    - Slow start
    - Congestion avoidance
    - Threshold between the slow start and congestion avoidance phases
- AQM and RED

MPLS

- Internet mechanism to support VC for aggregate flows
- Language of MPLS
  - Label
  - FEC
  - LDP
  - LSR
  - LSP
- Enables
  - Traffic Engineering
  - QoS for FEC
- Restoration and Protection

Software defined networking (SDN)

- Control plane functions external to data-plane switches
- Programmable control applications, e.g., routing and load balancing in the "remote controller"
- Flow table loaded from "remote controller" using OpenFlow protocols and standard API's



At the conclusion of this class the students are expected to:

- Understand the basics of network protocols,
  - Datagram/virtual circuit switching,
  - Access control (MAC),
    - (Including DOCSIS, IEEE 802.11, 4G/5G)
  - Data link control,
  - IP (including forwarding, generalized forwarding, and supporting protocols),
  - Routing,
  - Transport protocols
  - **Resulting in an understanding of how the Internet works.**
    - (Including AQM, MPLS, SDN's)