Midterm Review

EECS 122

University of California
Berkeley

Topics

- Network Architecture
  - Network hierarchy
  - Layering
  - Performance
- Link Layer
  - Ethernet
  - Wi-Fi
- Network Layer
  - Addressing
  - Routing

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Review: Network

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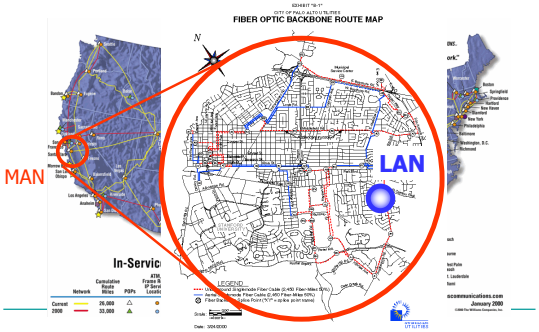
Review: Network



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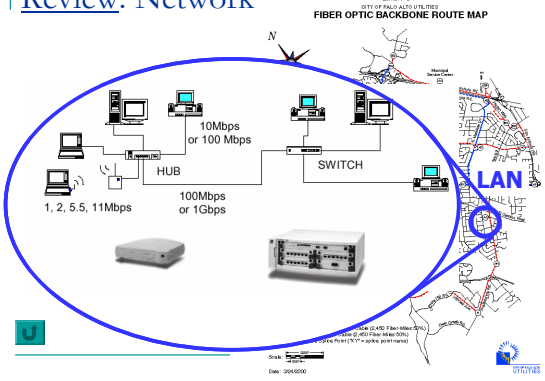
Review: Network



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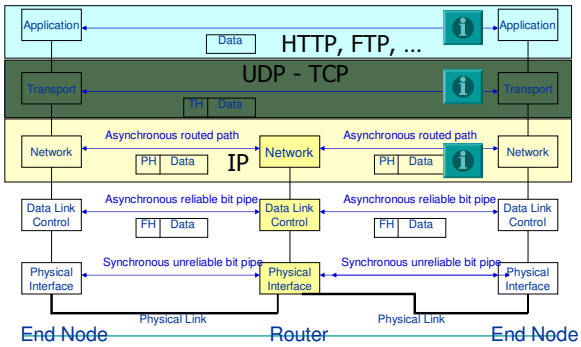
Review: Layers & Protocols



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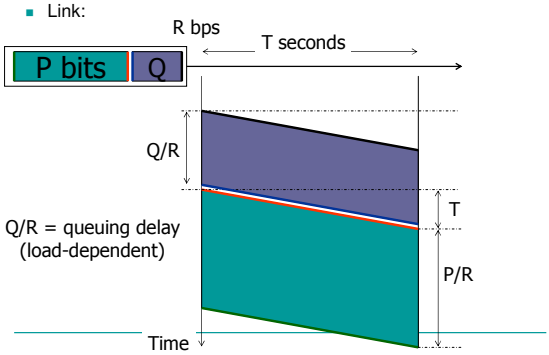
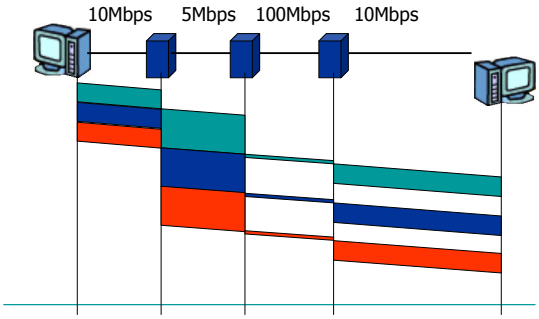
Timing: Queuing

- Link:



Timing: Store & Forward - Multiple

- System:

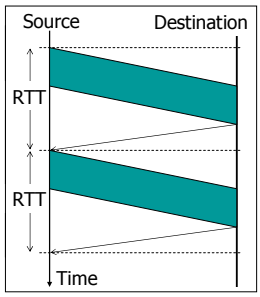


Performance Metrics

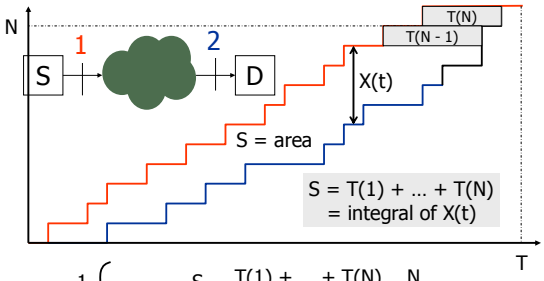
- Throughput
- Delay
- Jitter

Connection Throughput

- Connection:
  - Send W bits (window size)
  - Wait for ACKs
  - Repeat
- Assume that the round-trip time is RTT seconds
- Throughput = W/RTT bps
- Numerical Example:
  - W = 64KBytes = 512 kbits
    = 512x1,024 = 524,288 bits
  - RTT = 200ms
  - Throughput = W/T = 2.6Mbps



Little's Result



$$\frac{1}{T}\int X(t)dt = \frac{S}{T} = \frac{T(1) + \ldots + T(N)}{N} \cdot \frac{N}{T}$$

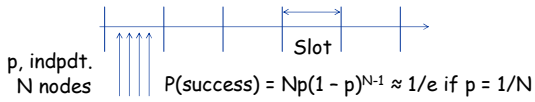
→ Average occupancy = (average delay)x(average arrival rate)

Ethernet

- Random Multiple Access
- Switching
- Bridged Ethernet
- 802.11

Random Multiple Access

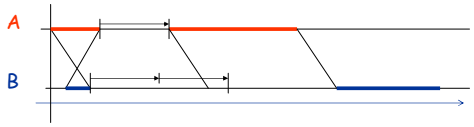
- How to share a channel?
  - Multiple Access ≠ Multiplexing
- ALOHA: First random multiple access system
  - Efficient for many users, each with low utilization
  - Try; If collide, wait random time then repeat (CD)
  - Analysis: Slotted Aloha efficiency ≈ 1/e = 36%



Random Multiple Access

Ethernet: First version – CSMA/CD

- Wait until channel is idle; try; if collide, stop, wait, repeat
- Idea: CS should improve efficiency if fast enough
- Wait random multiple of 512 bit times (exponential back off)
- Analysis: Efficiency ≈ 1/(1 + 5a), a = PROP/TRANS



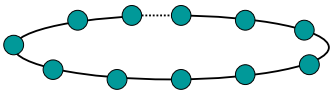
Switching

Ethernet: Later versions – Switched

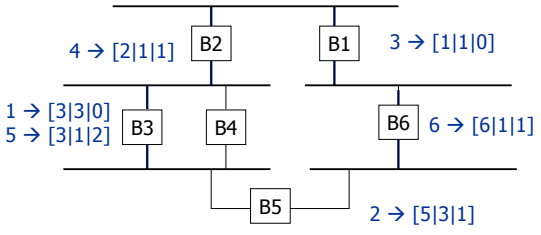
- Larger aggregate throughput
- VLANs: partition in disjoint logical LANs
- Link Aggregation
- Each port is in its own collision domain
  - as opposed to a hub where all ports are in the same collision domain
- Fast, GE, 10GE
  - Improved modulation schemes

Bridged Ethernet

- Flat Addressing
- Learning
  - Watch source addresses
- Avoiding Loops
  - Spanning Tree Protocol
  - (ID, presumed root ID, distance to presumed root ID)
  - Note: Not very efficient; Not very fast



Spanning Tree Example



Format: [my ID | presumed root ID | distance to presumed root]

Ethernet

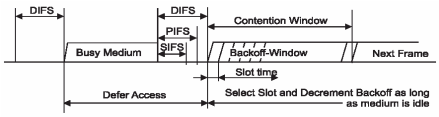
- Service?
- Operations: Addresses, MAC, Hub, Switch, Learning, Spanning Tree
- MAC: Why not Aloha?
- Why Switch?
- Why Loops?

802.11

- a - 5GHz, up to 54Mbps
- b - 2.5GHz, up to 11Mbps
- g - 2.5GHz, up to 54Mbps
- MAC: CSMA/CA with or without RTS/CTS
  - Distributed (DCF):
    - CSMA/CA using different Interframe Gaps
    - maintain network allocation vector
  - Centralized (PCF): access point polls nodes

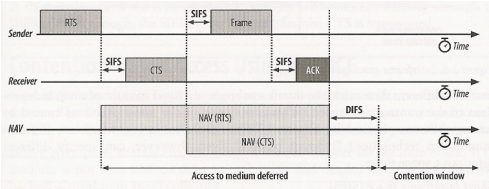
802.11 MAC

- If medium is idle for DIFS interval after a correctly received frame and backoff time has expired, transmission can begin immediately
- If previous frame contained errors, medium must be free for EIFS
- If medium is busy, access is deferred until medium is idle for DIFS and exponential backoff
- Backoff counter is decremented by one if a time slot is determined to be idle
- Unicast data must be acknowledged as part of an atomic exchange



802.11 Virtual Carrier Sensing

- Virtual Carrier Sensing using Network Allocation Vector (NAV)



802.11

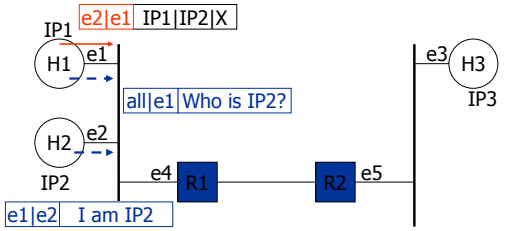
- Why not CSMA/CD?
- Objectives of new MAC?
- Why RTS/CTS?
- How does NAV work?
- Why different IFS?
- Why more than 2 addresses?
- Why different PHYs?
- Why multiple channels?

Layers: IP – Internet Protocol

- Internetworking
- Addressing
  - Class-Based
  - Classless: CIDR
- Routing

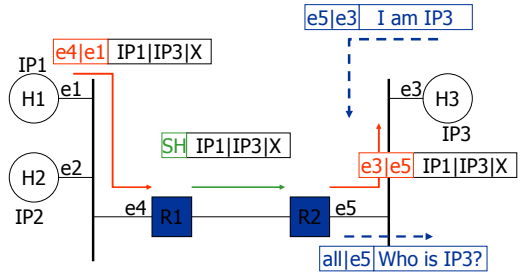
Internetworking

Direct Delivery



Internetworking

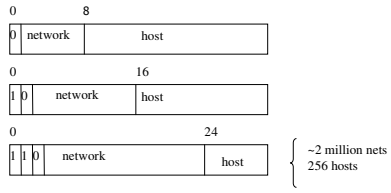
Indirect Delivery



Note: Fragmentation may be required at R1

Class-base Addressing

- Addressing reflects internet hierarchy
  - 32 bits divided into 2 parts:
  - Class A
  - Class B
  - Class C



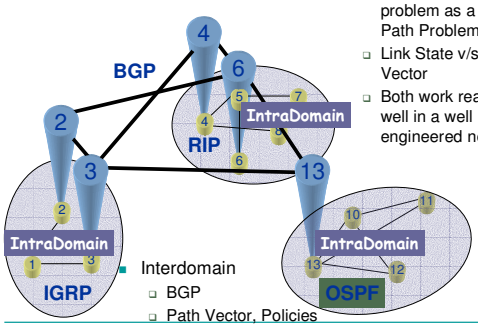
Classless Internet Domain Routing

Suppose fifty computers in a network are assigned IP addresses 128.23.9.0 - 128.23.9.49

- Range is
  01111111 00001111 00001001 00000000
  to 01111111 00001111 00001001 00110001
- They share the first 26 bits of 128.23.9.0:
- Convention: 128.23.9.0/26 = prefix
- There are 32-26=6 bits for the 50 computers
  - 2^6 = 64 addresses

IP: Routing

- Intradomain
  - Formulate the routing problem as a Shortest Path Problem
  - Link State v/s Distance Vector
  - Both work reasonably well in a well engineered network



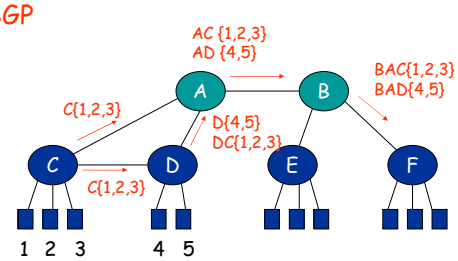
- Interdomain
  - BGP
  - Path Vector, Policies

Route Computation

- Dijkstra: Link State
  - Use a flooding protocol to discover the entire topology
  - Find the shortest paths in order of increasing path length from node i.
- Bellman Ford: Distance Vector
  - $D(i,d) = \min_{j \in N(i)} \{c(i,j) + D(j,d)\}$
- BGP: Path Vector
  - Policy routing: Receive and advertise entire routes
  - AS numbers describe the path to a CIDR address

Network Structure

BGP



Transit; Peering Agreements; Customer-Provider

IP

- Service?
- Operations: Addresses, Routing
- Glue L2/L3: ARP
- Addressing: Why CIDR? How? Why DHCP, NAT?
- Routing: Why Domains? Why different algorithms? Pros/Cons of each algorithm?

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Check List

- Network hierarchy
- Layering
- Performance: Timing & Metrics
- Layer 2
- Ethernet MAC
- Wi-Fi MAC
- Repeaters, hubs, bridges, switches, routers
- Internet addressing
- Routing

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