CS422 Final Review

Spring 2024
Grading Policy

- Grade breakdown
  - Homework: 15%
  - Labs: 30%
  - Midterm: 25%
  - Final: 30%

- Check your grades at Brightspace
  - If questions, contact me no later than April 26 (Friday)

- Final grades will be curved ...
Final: 15:30PM - 17:30PM, Apr 30 (Tue)

- @ GRIS 103
- Bring your PUID
- Closed-book, closed-note ... (similar to your Midterm)
- No make-up exam
  - Exception only for emergency (with written document), according to University policy;
  - Contact me ASAP if any question
Extra Office hours next Monday

- 13:00PM – 14:00PM, April 29 Monday
- LWSN 2142E and/or @Teams
# Internet protocol stack

<table>
<thead>
<tr>
<th>Physical</th>
<th>Link</th>
<th>Network</th>
<th>Transport</th>
<th>Applications</th>
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<td>Reliable (or unreliable) transport</td>
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<td>Best-effort global packet delivery</td>
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<td>... built on ...</td>
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<td>Best-effort local packet delivery</td>
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<td>... built on ...</td>
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</tbody>
</table>

Source: Scott Shenker (UC Berkeley): slide 7 at The Future of Networking, and the Past of Protocols
https://www.youtube.com/watch?v=YHeyuD89n1Y&t=111s
One-page highlights

- Knowing **how** and **why** for each technique component
  - E.g., why four algorithms in TCP congestion control (slow start, congestion avoidance, fast retx/recovery, reset)?
  - E.g., why are there so many multiple access protocols? Which multiple access protocol fits in the targeted scenario?
  - E.g., Why is MAC address flat while IP address not?

- Knowing **how** different layers/protocols **work together**
  - The relationship between higher and lower layers
  - The order of different protocols
  - Example: synthesis
Two functions on networking layer
  • Routing (control-plane)
  • Forwarding (data-plane)
  • Q: How do they work together?

Per-router routing: Forwarding table
  • Datagram switching
    • Longest prefix match
    • How to denote an IP address?
      • CIDR: e.g. 233.1.1.0/24
IPv4 Datagram Format (20B header)

IP address allocation
- DHCP: how to get an IP address within a subnet?
- Address allocation for one subnet (address blocks)

IPv4 address runs out
- NAT (private IP address, port-IP translation)
- IPv6 (128 bits)
Ch4: Addressing & NAT

IPv4 crisis: run out of IP addresses --> IPv6

Organization 0
200.23.16.0/23

Organization 2
200.23.20.0/23

Organization 7
200.23.30.0/23

Fly-By-Night-ISP

“Send me anything with addresses beginning 200.23.16.0/20”

Internet

rest of Internet

local network (e.g., home network) 10.0.0/24

138.76.29.7

10.0.0.1 10.0.0.2 10.0.0.3 10.0.0.4

10.0.0.4

10.0.0.1

10.0.0.2

10.0.0.3

10.0.0.4

Send me anything with addresses beginning 200.23.16.0/20
How to generate forwarding tables at routers?

- IP address blocks/ranges in the table
- Routing algorithms:
  - Link-state
  - distance-vector
  - Q: How do they work? What are their difference?
- Routing protocols:
  - Intra-AS routing: OSPF (ISIS)
  - Inter-AS routing: BGP
  - How do they work together?
Ch5: Routing

- Intra-AS routing: e.g., OSPF within AS1?
- Inter-AS routing: eBGP and iBGP
  - AS PATH
  - How to select if multiple choices?
    - Policy first $\rightarrow$ short AS PATH $\rightarrow$ hot potato routing
Basic services in link layers
- Framing
- Link access (multiple access)
- Reliable transfer (link-level)
- Error detection and correction

Error detection and correction
- 2D parity code
- CRC (Q: how to calculate R, given D and G)

- Hint: \( A-B = A \ XOR \ B, A+B = A \ XOR \ B \)
Multiple Access Protocol

- Why?
  - Broadcast (shared) channel: collision without coordination

- How?
  - channel partitioning: TDMA, FDMA, CDMA
  - Random access: Slotted-ALOHA, ALOHA, CSMA, CSMA/CD, CSMA/CA
  - “taking turns”: Polling, token

- How to pick a proper multiple access protocol?
Ethernet CSMA/CD algorithm

- CSMA/CD
- After aborting, NIC enters binary (exponential) backoff:

802.11 CSMA/CA algorithm

- 802.11: no collision detection!
- avoid collisions (CA): $2^+ \text{ nodes transmitting at same time}$
- 802.11: CSMA - sense before transmitting
  - don’t collide with ongoing transmission by other node
- DIFS-DATA-SIFS-ACK: mandatory
- RTS-CTS-DATA-ACK
  - RTS-CTS: reserve channel (hidden terminal)
Ch6: link-layer framing & addressing

- **Framing**
  - Ethernet frame format
  - MAC address: 48 bit
    - Flat (how different from IP address?)
    - How to learn MAC address? (ARP)
- **Link layer: plug-and-play**
- **Ethernet Switch**
  - Switch forwarding table
  - How to map the interface and MAC address
  - **Self-learning**
    - When to flood
    - When to selective forward?
Ch6 + Ch7: From Ethernet to Wireless

- 
  - switch vs router: common and difference?
    - Switch (L2): **transparent** to hosts
      - N switches may be used in one subnet

- VLAN: virtualization over switch

- Wireless: WiFi + 4G (5G)
  - base station or WiFi AP: **relay**
  - Wireless characteristics
  - Much complex link layers ...
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A Vertical View & Beyond

Recall our synthesis example:
- Protocols/layers
- Nodes
  - @Hosts
  - @ routers
  - @ switches
  - @ DNS server,
  - @...

e.g., what happens @source host? In which order? How do they interact with other network equipment (following a protocol or function)?
Suppose you walk into LWSN, power on your laptop, connect to PAL3.0 (WiFi), open Youtube to watch a TED talk.

• What are all the protocol steps that take place in turn? Please introduce each step and protocols used as much as you can.
  
  CSMA/CA first or DHCP first? (CSMA/CA, why?)
  DNS earlier or TCP earlier? (DNS, why?)

• Please explicitly indicate in your steps how you obtain the IP and MAC address of a gateway router.
  Which address (IP address or MAC address) does your laptop know first? (IP address, why?)
Synthesis Example (More)

Refer to the lecture (at end of chapter 6)

@ Hosts

- DHCP
  - why? a valid IP first, regardless of applications
  - The rest is invoked by the application
    - Dependence $\rightarrow$ other protocols
      - e.g., WEB (URL) $\rightarrow$ DNS $\rightarrow$ UDP $\rightarrow$ IP $\rightarrow$ MAC address in Ethernet (or 802.11) $\rightarrow$ ARP
      - e.g., HTTP $\rightarrow$ TCP $\rightarrow$ the first TCP segment (three-way handshaking)
      - e.g., L2 delivery via WiFi $\rightarrow$ CSMA/CA

@ Routers (switches) [a network: a distributed system]
- Routing protocols (inter-AS, intra-AS) performed
- Self-learning performed
Any Question?
Contact me (chunyi@purdue.edu) or TAs (cs422-ta@cs.purdue.edu)

- Campuswire
- **Office hours next week**
  - 13:00PM – 14:00PM, April 29 Monday
  - @LWSN 2142E and/or @Teams

Several minutes on Course evaluation by April 28, 2024!

**Many thanks!**

Final: 15:30PM - 17:30PM, Apr 30 (Tue), GIS 103