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 …

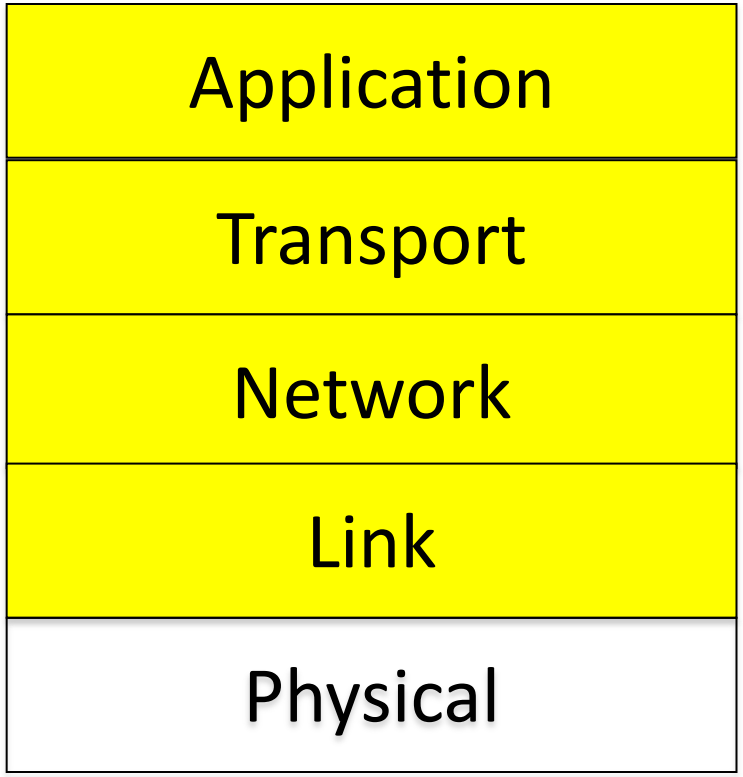
Final: 15:30PM - 17:30PM, Apr 30 (Tue)

- **@ 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
  - Teams link at course homepage, https://www.cs.purdue.edu/homes/chunyi/teaching/cs422-sp24/cs422-sp24.html

Internet protocol stack



Applications

… built on …

Reliable (or unreliable) transport

… built on …

Best-effort global packet delivery

… built on …

Best-effort local packet delivery

… built on …

Physical transfer of bits

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

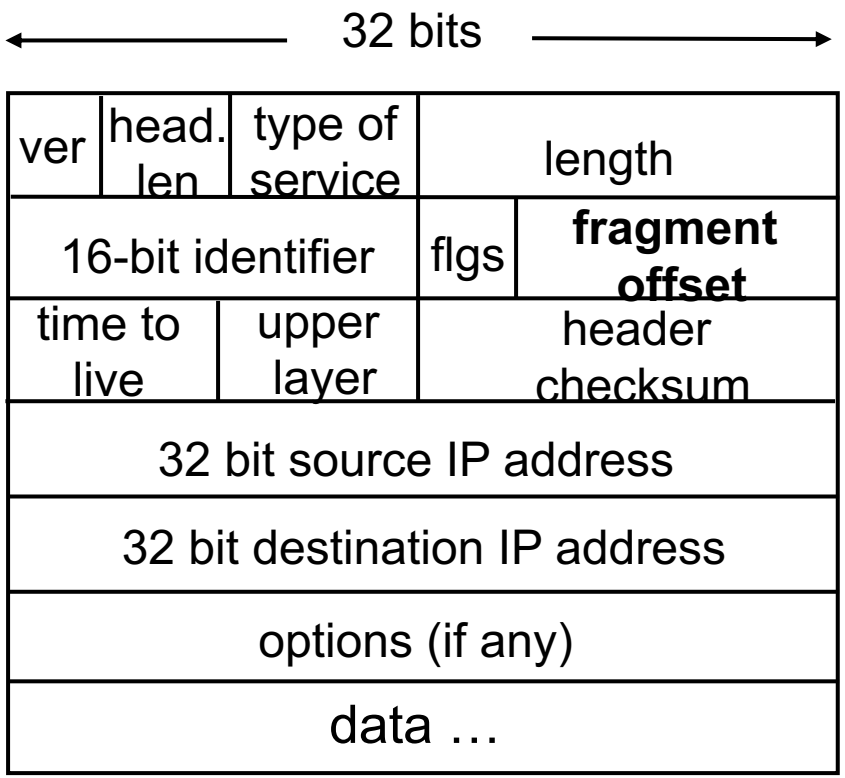
Ch4 + Ch5: Network layer

- Two functions on networking layer
  - **Routing (control-plane)**
  - **Forwarding (data-plane)**
  - Q: How do they work together?

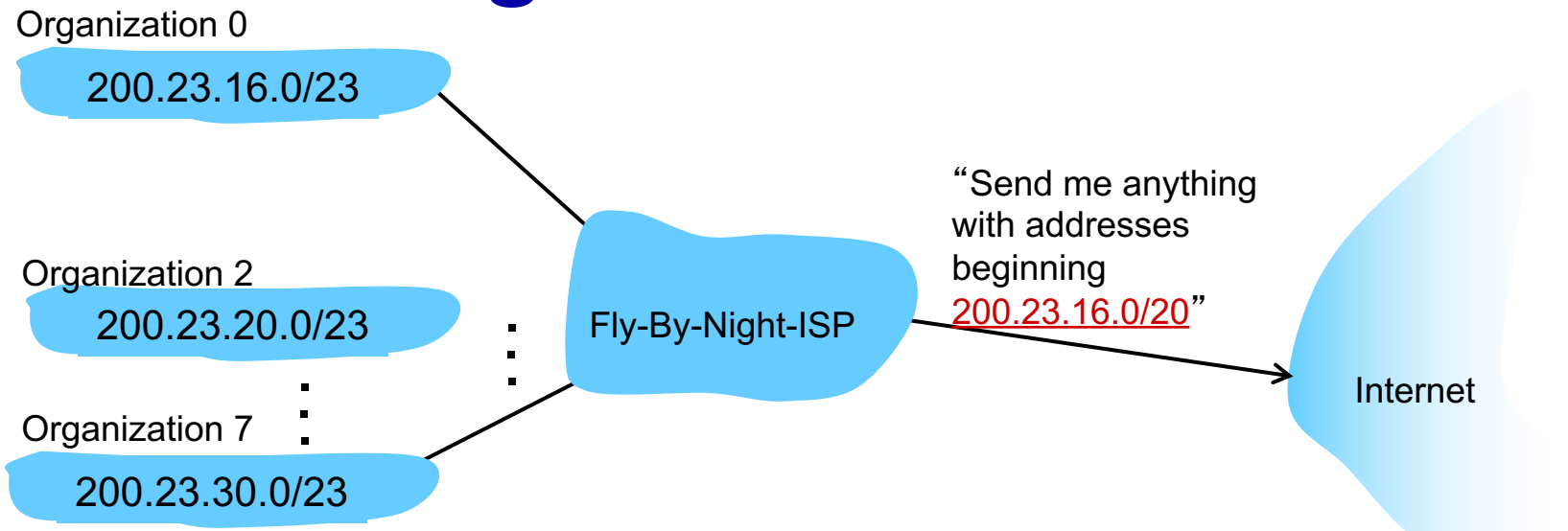
- Per-router routing: **Forwarding table**
  - Datagram switching
    - **Longest prefix match**
    - How to denote an IP address?
      - CIDR: e.g.233.1.1.0/24

Ch4 + Ch5: Network layer (contd.)

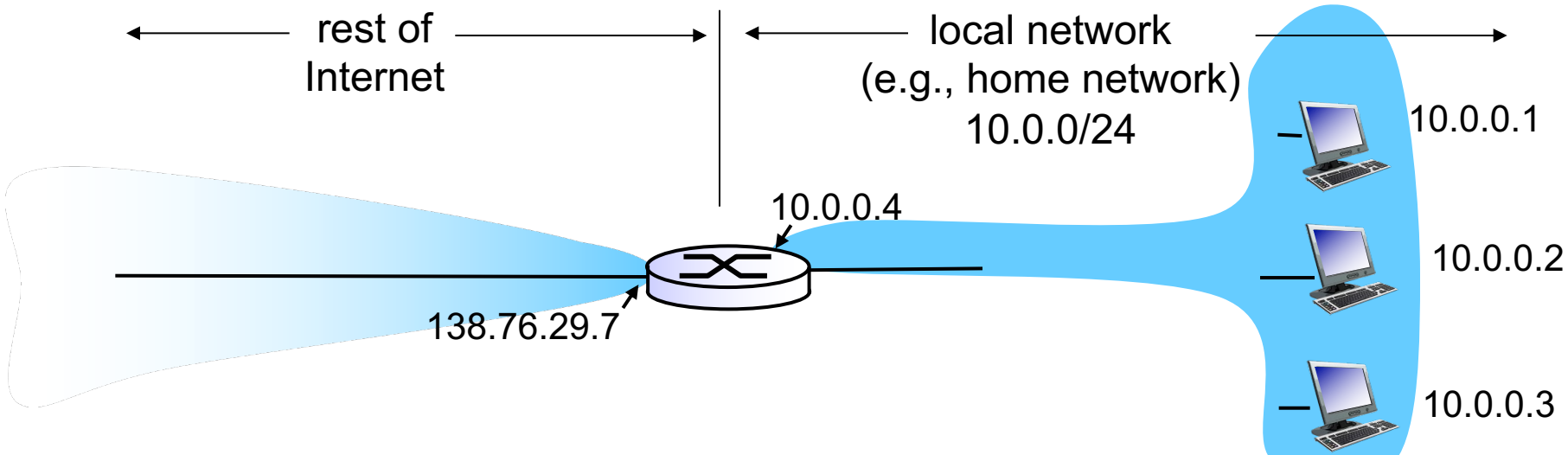
- **IPv4 Datagram Format** (20B header)
- **IP address allocation**
  - DHCP: how to get an IP address within a subnet?
  - Address allocation for one subnet (address blocks)
- IPv4 address runs out
  - NAT (private IP address, port-IP translation)
  - IPv6 (128 bits)



Ch4: Addressing & NAT

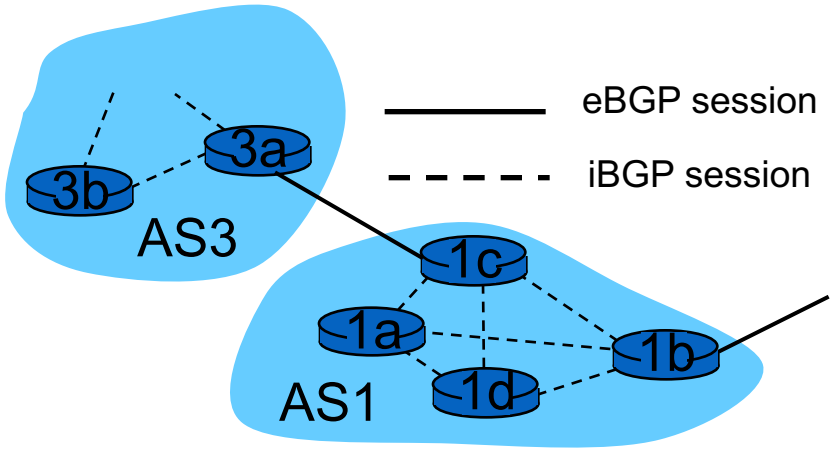


IPv4 crisis: run out of IP addresses --> IPv6



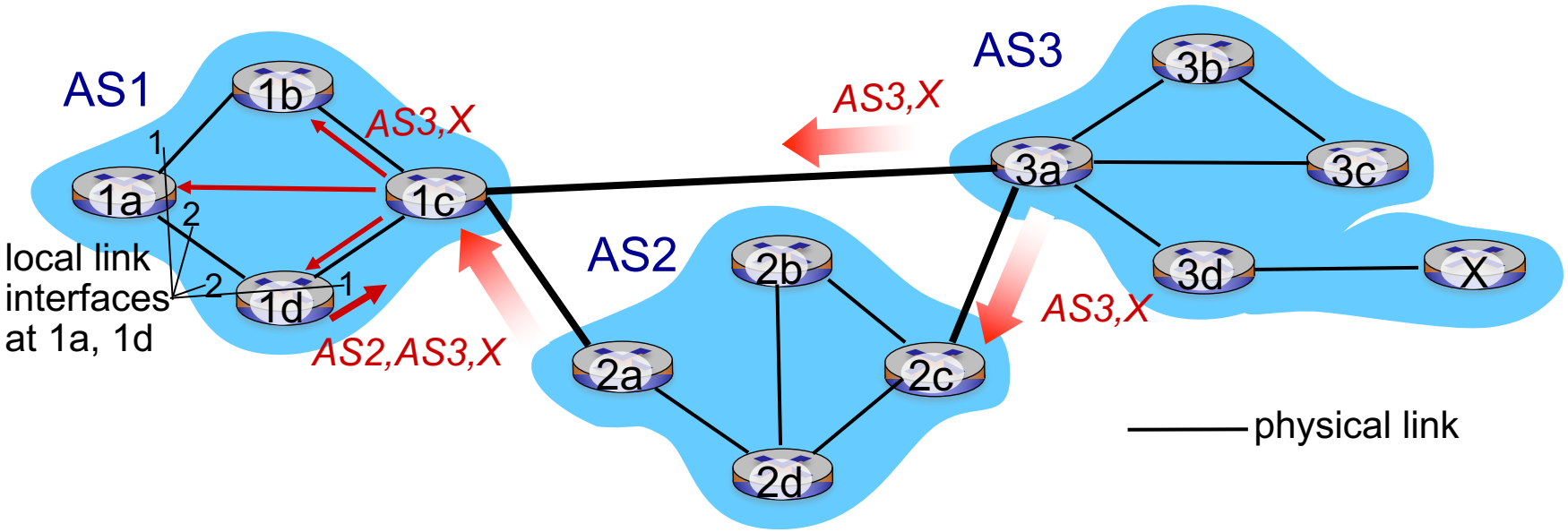
Ch4 + Ch5: Network layer (contd.)

- **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?**



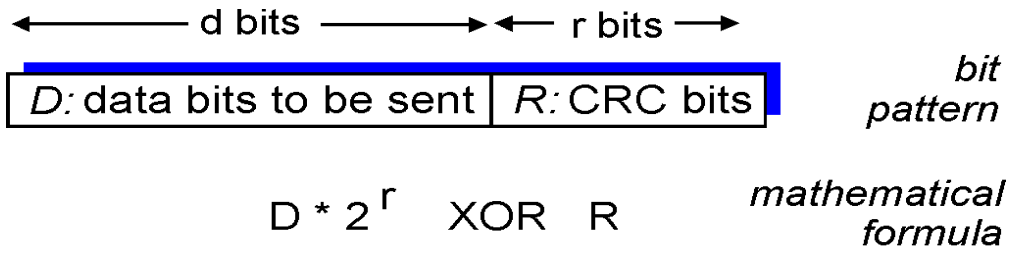
Ch5: Routing

- Intra-AS routing: e.g, OSPF within AS1?
- Inter-AS routing: eBGP and iBGP
  - AS PATH
  - How to select if multiple choices?
    - **Policy first → short AS PATH → hot potato routing**



Ch 6: Link layer + Ch 7 Wireless (partly)

- 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

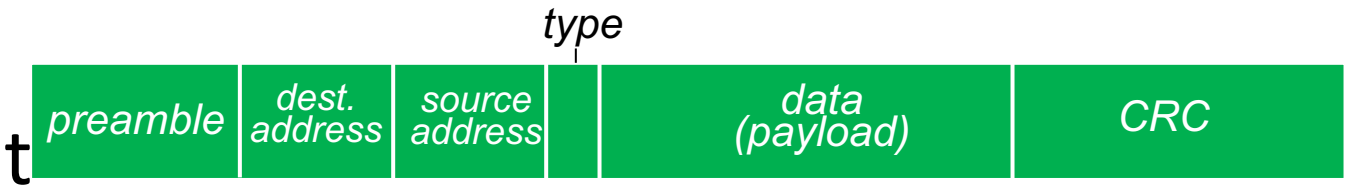
- CSMA/CD
- After aborting, NIC enters *binary (exponential) backoff:*

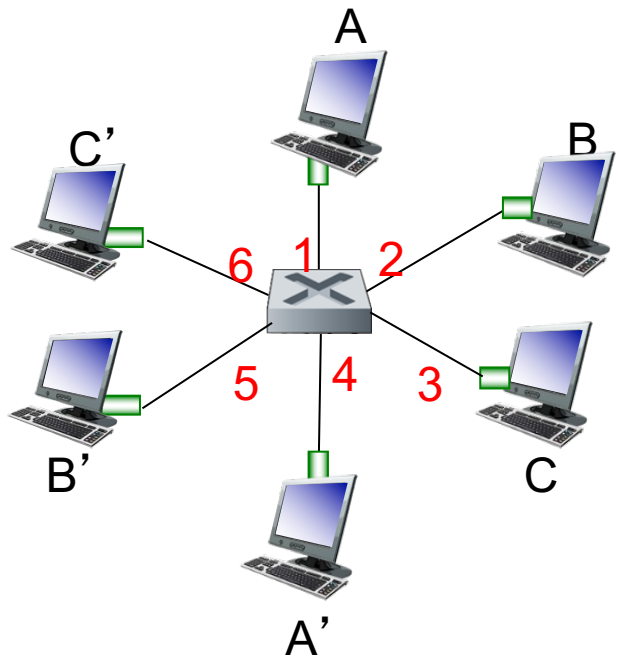
802.11 CSMA/CA algorithm

- 802.11: *no* collision detection!
- avoid collisions (CA): 2^+ 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?





switch with six interfaces (1,2,3,4,5,6)

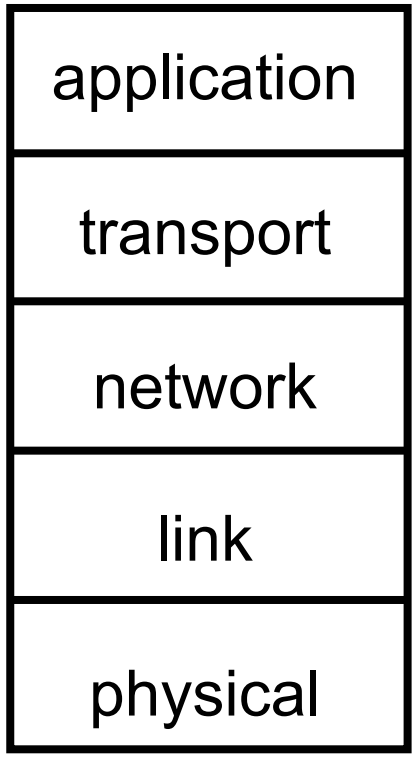
Ch6 + Ch7: From Ethernet to Wireless

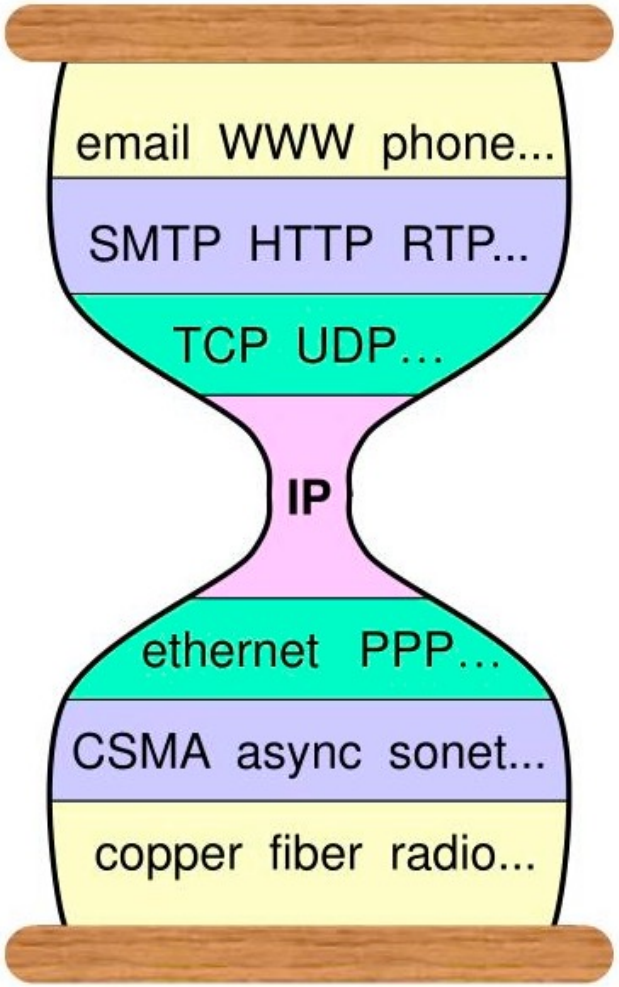
- switch vs router: common and difference?
  - Switch (L2): **transparent** to hosts
    - N switches may be used in one subnet
- VLAN: virtualization over switch
- Wireless: WiFi + 4G (5G)
  - base station or WiFi AP: relay
  - Wireless characteristics
  - Much complex link layers …

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

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)?

Another Synthesis **Example**

- 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 → other protocols
    - e.g., WEB (URL) → DNS → UDP → IP → MAC address in Ethernet (or 802.11) → ARP
    - e.g., HTTP → TCP → the first TCP segment (three-way handshaking)
    - e.g., L2 delivery via WiFi → 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