CS118 Discussion 1B, Week 9

Boyan Ding

Outline

- About Quiz 2
- Lecture review:
    - Link layer
- Q & A

Quiz 2: last clarification

1. Chapter 3: It covers all aspects of TCP, including the segment structure, connection management (connection ID of the 4 tuple, connection setup and closing), TCP sockets, TCP reliable data transfer, and TCP congestion control algorithms (that are covered in the lecture slides and homeworks). On the TCP congestion control, skip the textbook and read the lecture slides (that describe all the algorithms) and the posted RFC5681 for further details if needed.

2. Chapter 4: The full chapter on data plane of the network layer will be covered. The focus will be on the IP datagram format (both IPv4 and IPv6), IP basic functions (addressing, prefix based forwarding, fragmentation and reassembly, etc.), NAT, and tunneling technique for transition from IPv4 to IPv6, DHCP.

3. Chapter 5: 5.1, 5.2 and 5.3 of 7th edition of the textbook. Equivalent, the focus is on link state routing algorithm, distance vector routing algorithm, and OSPF routing protocol (you can skip the hierarchical OSPF but focus on the basic version of OSPF).

For the above covered items, you should review the lecture slides and homeworks first, before you read through the textbook details.

Random access: slotted ALOHA

- Assumptions:
  - all frames same size
  - time divided into equal size slots (time to transmit 1 frame)
  - nodes start to transmit only slot beginning
  - nodes are synchronized
  - if 2 or more nodes transmit in slot, all nodes detect collision

Random access: slotted ALOHA

- suppose: N nodes with many frames to send, each transmits in slot with probability p
- Pr(given node has success in a slot) = p(1-p)^(N-1)
- Pr(any node has a success) = Np(1-p)^(N-1)
- max efficiency: find p* that maximizes Np(1-p)^(N-1)
- Take the limit of Np*(1-p*)^(N-1) as N goes to infinity, yields:
  - max efficiency = 1/e = .37

Random access: ALOHA efficiency

- Slotted ALOHA max efficiency = 1/e = .37
- Unslotted ALOHA max efficiency = 1/2e = .18

Quick question

- Consider a network with 9 nodes using slotted ALOHA. The probability that any node transmits is p at a given time.
- What is the probability that four nodes are transmitting?
- What is the probability that a specific node succeed to transmit a frame?

CSMA (carrier sense multiple access)

- Listen before transmit:
  - if channel sensed idle: transmit entire frame
  - if channel sensed busy, defer transmission
  - "don't interrupt others!"
- Channel busy?
  - 1-persistent CSMA: retry immediately
  - p-persistent CSMA: retry immediately with probability p
  - Non-persistent CSMA: retry after a random interval

CSMA/CD (collision detection)

- CSMA/CD: carrier sensing, deferral as in CSMA
  - collisions detected within short time
  - colliding transmissions aborted, reducing channel wastage
- collision detection:
  - easy in wired LANs: measure signal strengths, compare transmitted, received signals
  - difficult in wireless LANs: received signal strength overwhelmed by local transmission strength

CSMA/CD (collision detection)

- A: sense channel, wait if necessary, when channel is idle, transmit and monitor the channel
- If detect collision then {
  - abort and send jam signal;
  - update collision-count (n++);
  - delay for K slots (1 slot = 512bits transmission time) goto A
    - **chooses *K* at random from $\{0,1,2, \ldots, 2^m-1\}$.**
- } else {finish sending the frame; reset collision-count (n = 0)}
- collision detection: compare transmitted, received signal strengths

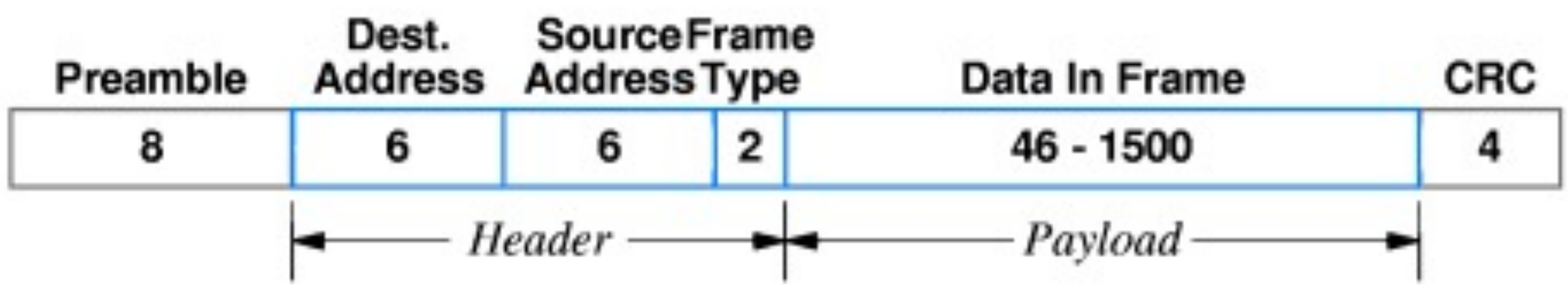
Ethernet

- Connectionless and unreliable protocol
  - Why doesn't Ethernet provide reliable data transfer?
- MAC protocol: CSMA/CD + exponential backoff
  - Can we use CSMA/CD in wireless network?
- Switch-based Ethernet
  - No real broadcast channel anymore
  - Self-learning algorithm: support plug-and-play
    - **Differences between routing table, switch table and ARP table?**

MAC address

- MAC address allocation by IEEE (who assigns IP?)
- MAC address is flat -> portability (IP address is ___?)
- Format: 48 bit address
  - AA-BB-CC-DD-EE-FF
  - Broadcast address: FF-FF-FF-FF-FF-FF

Ethernet Frame



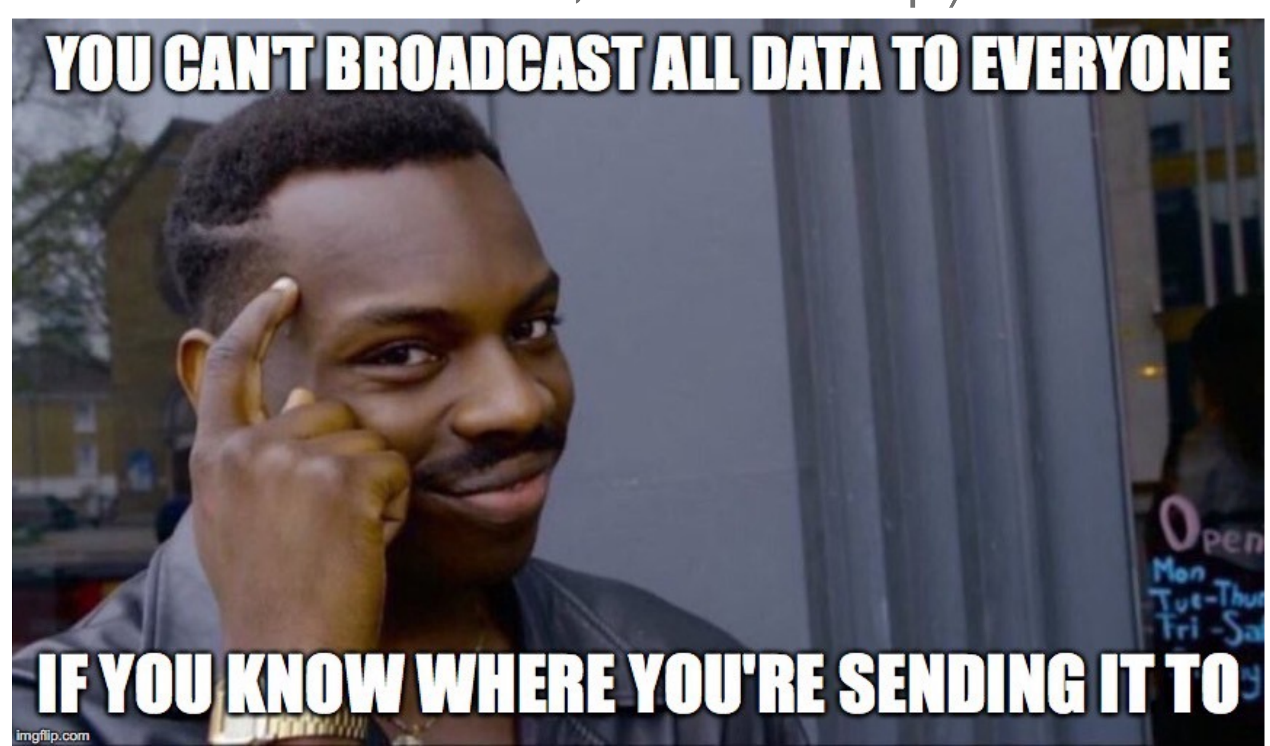
- Min frame size: 64 Bytes
  - why? (to reliably detect collisions)
- Max frame size: 1514 Bytes
  - why? (to fair share the media)

Ethernet CSMA/CD

- 1. NIC receives datagram from network layer, creates frame
- 2. If NIC senses channel idle, starts frame transmission. If NIC senses channel busy, waits until channel idle, then transmits.
- 3. If NIC transmits entire frame without detecting another transmission, NIC is done with frame !
- 4. If NIC detects another transmission while transmitting, aborts and sends jam signal
- 5. After aborting, NIC enters binary exponential backoff:

Switch

- Examine each incoming frame's MAC address, forward to the destination LAN if dest. host is on a different LAN
- store-and-forward
- switch table: self-learning algorithm
    - (MAC address of host, interface to reach host, timestamp)



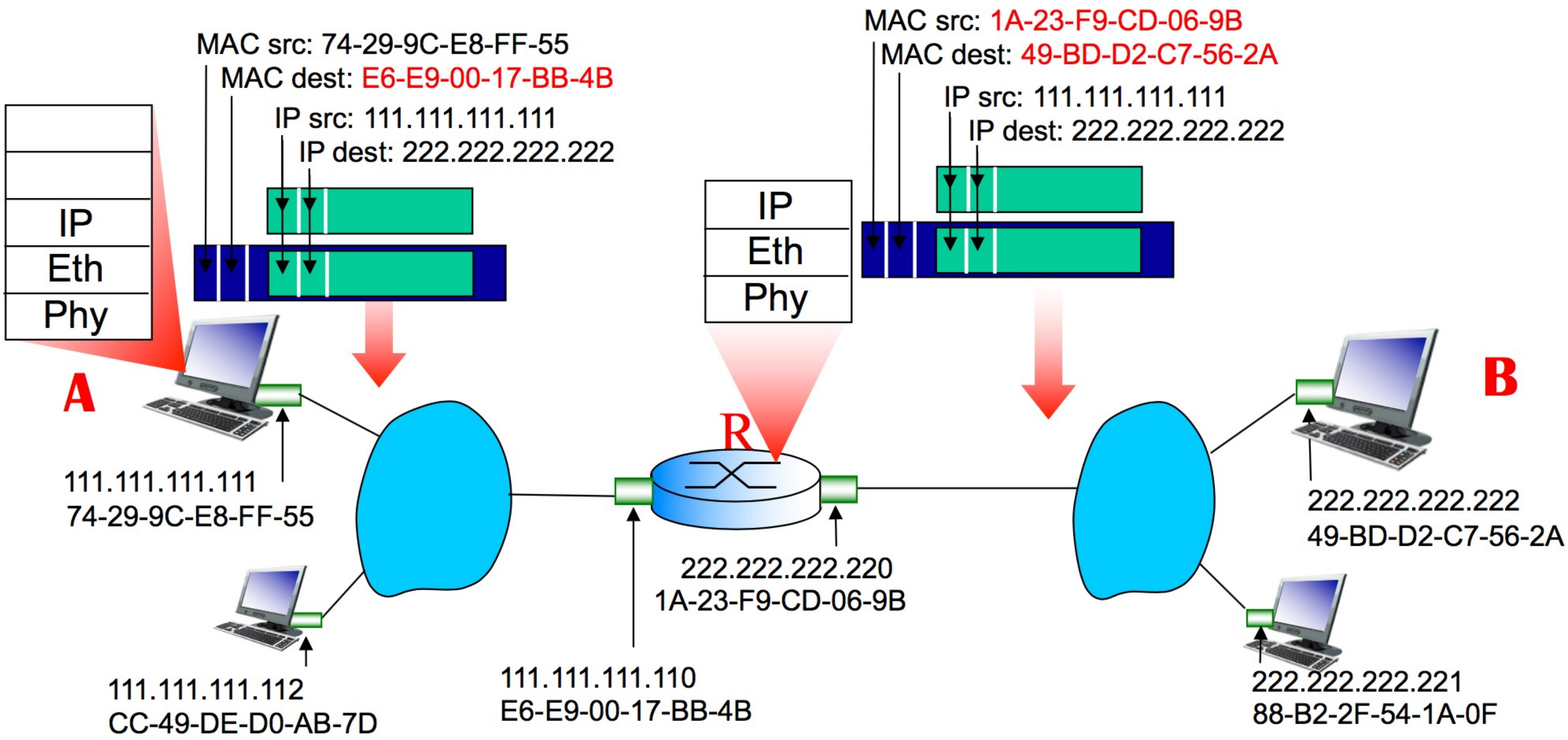
ARP: address resolution protocol

- How to determine interface's MAC address, knowing its IP address?
- ARP table: each IP node (host, router) on LAN has table
  - IP/MAC address mappings for some LAN nodes:
  - <IP address; MAC address; TTL>
  - called PnP (plug-and-play)
  - soft-state design: information deletes itself after certain time unless being refreshed

ARP: send an IP packet in the same subnet

- A wants to send IP packet to B, but B’s MAC address not in A’s ARP table.
- A broadcasts ARP query packet, containing B's IP address (all nodes on LAN receive ARP query)
  - dest MAC address = FF-FF-FF-FF-FF-FF
- B receives ARP packet, replies to A with its (B's) MAC address
  - frame sent to A’s MAC address (unicast)
- A caches IP-to-MAC address pair in its ARP table until information becomes old (times out)

ARP: send an IP packet across subnets



ARP: send an IP packet across subnets

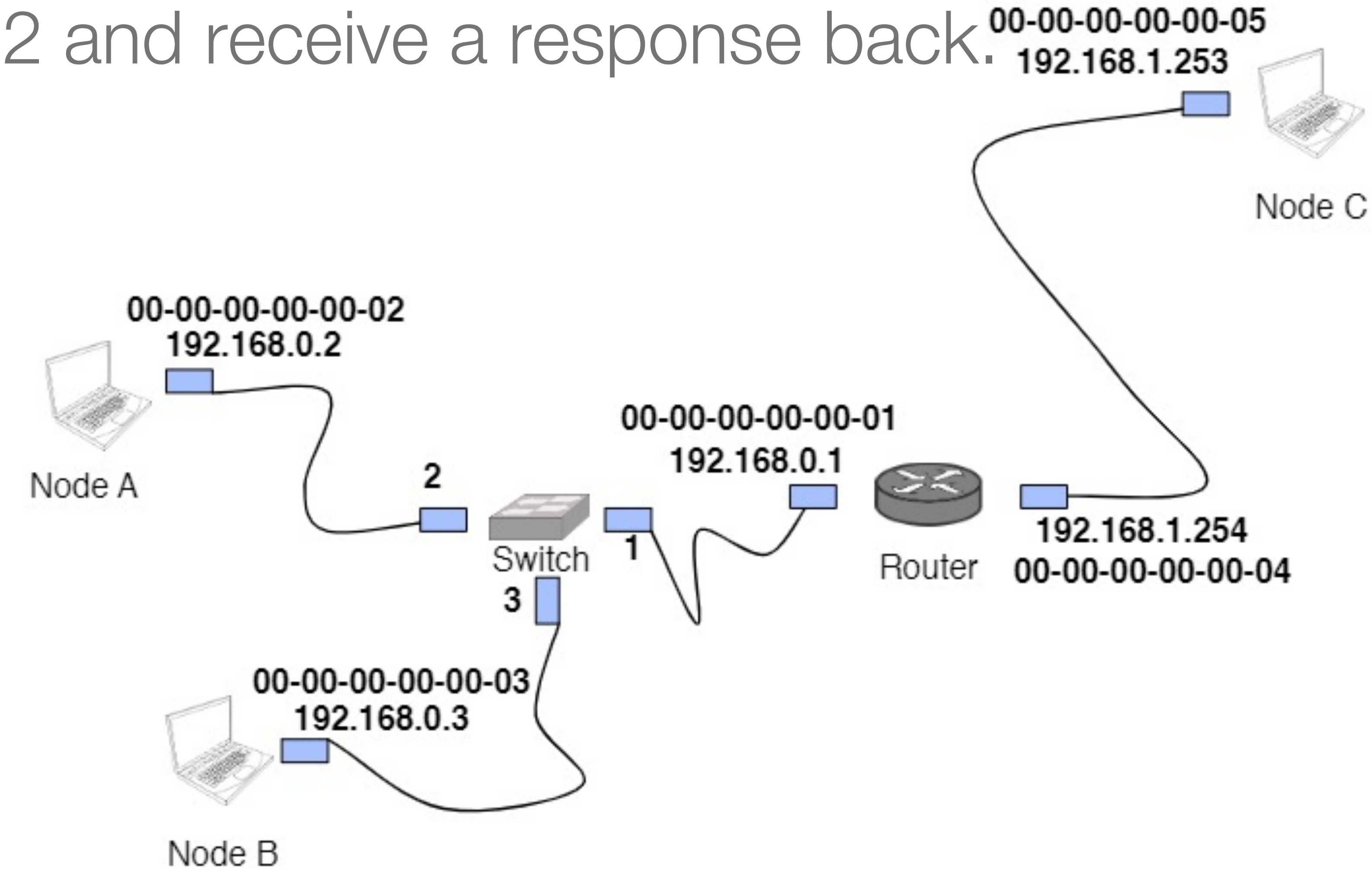
- Find an entry in the **routing table**
- If entry is saying that packet can be sent directly
  - Lookup MAC for destination IP in **ARP table**
- If entry is saying that packet should be set to the gateway
  - Lookup MAC for the gateway's IP in **ARP table**
- Create frame with the found MAC and original IP packet as a payload
- Send the frame

ARP: send an IP packet across subnets (cont'd)

- Router or node receives the frame, as it is destined to it
- Router removes Ethernet header, finds IP destination address
    - If IP is itself, deliver to transport layer and higher layers
    - If IP is not self and node is router, repeat the previous steps (lookup routing table, lookup ARP, ...)

Practices

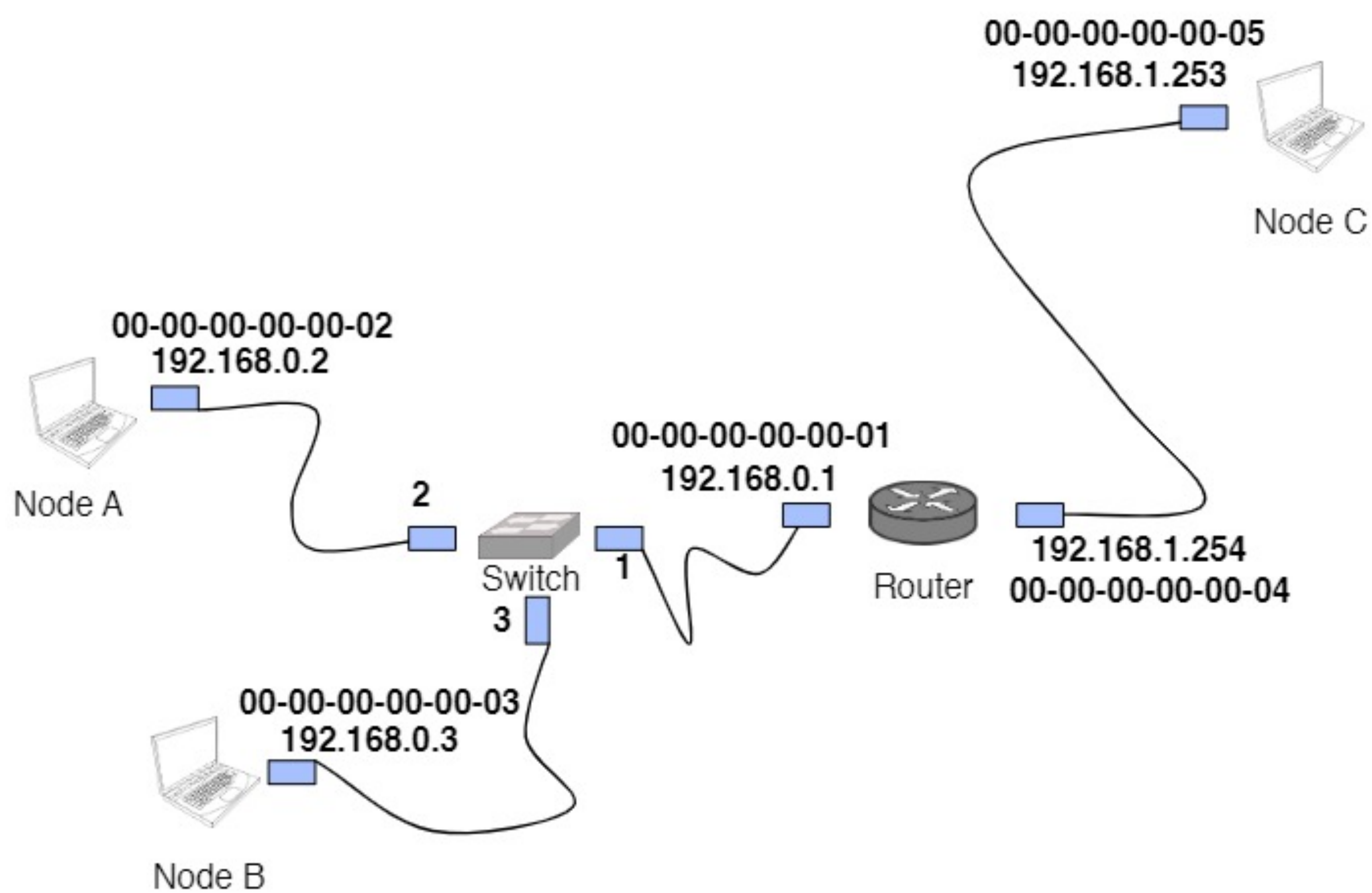
Assume that routing tables are properly configured and the network just started (i.e., all ARP caches and switch tables are empty), fill the following table to enumerate Ethernet frames (in chronological order) needed for node B to send an IP packet to 192.168.0.2 and receive a response back.



frame #	dst MAC addr	src MAC addr	device(s) that can get the frame, excluding the sender	new entries added into the switch's table (if any)

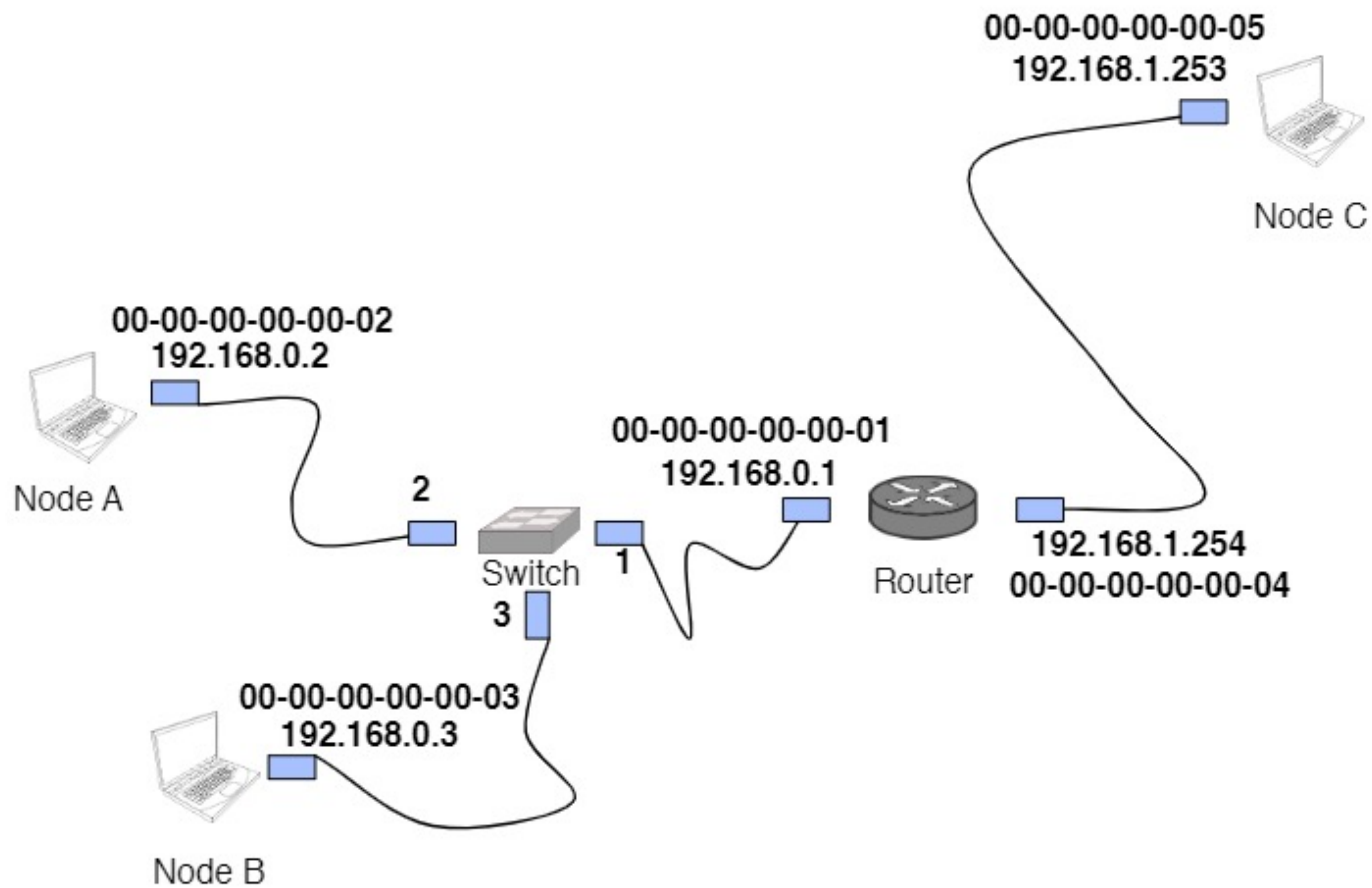
Practices

frame #	dst MAC addr	src MAC addr	device(s) that can get the frame, excluding the sender	new entries added into the switch's table (if any)
1	FF-FF-FF-FF-FF-FF	...-03	Switch, A, Router	addr: ...-03, interface:3
2	...-03	...-02	Switch, B	addr: ...-02, interface:2
3	...-02	...-03	Switch, A	
4	...-03	...-02	Switch, B	

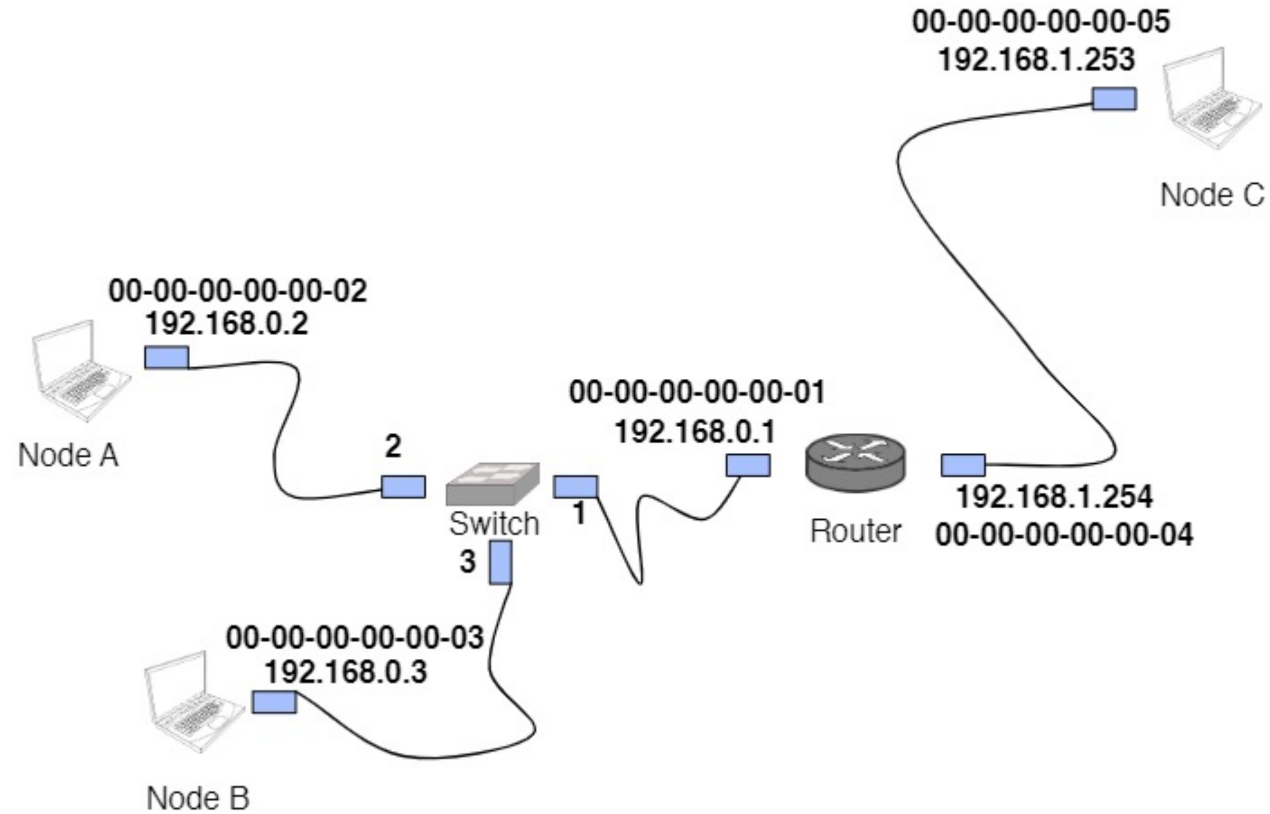


Practices

Assume that the previous operation is done, fill the following table to enumerate Ethernet frames (in chronological order) for node B to send a packet to 192.168.1.253 and receive a reply.



Practices



frame #	dst MAC addr	src MAC addr	device(s) that can get the frame, excluding the sender	new entries added into the switch's table (if any)
1	FF-FF-FF-FF-FF-FF	...-03	Switch, A, Router	
2	...-03	...-01	Switch, B	addr: ...-01, interface:1
3	...-01	...-03	Switch, Router	
4	FF-FF-FF-FF-FF-FF	...-04	C	
5	...-04	...-05	Router	
6	...-05	...-04	C	
7	...-04	...-05	Router	
8	...-03	...-01	Switch, B	

Router vs. Switch

- Both are store-and-forward devices
  - routers: network layer devices (examine IP headers)
  - switches: link layer devices (examine Ethernet headers)
- Circuit-switch network: connection should be established before forwarding the data
  - At each hop, the circuit path is marked as a label
  - Data forwarding is based on label: **O(1) complexity**
  - **Vulnerable to link/node failures**
- Packet-switched network: connectionless, packets are forwarded based on IP header
  - Longest prefix matching: **O(N) complexity**
  - **Robust to link/node failures**
- **Can we take advantage of both, while preventing any vulnerabilities?**

Tables we learnt

- Routing table
- Forward table
- ARP table

Tables we learnt

- Routing table

  IP address (prefixes), next hop, TTL

- Forward table

  MAC address, interface, TTL

- ARP table

  IP address; MAC address; TTL

Network devices

- Repeater: PHY layer
  - bits coming in one link go out all other links at same rate
- Hub: link layer
  - packets coming in one port/link, go out all other ports/links
- Switch: link layer