CS335a: Computer Networks

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Deadline: 03/01/2026

SUBMISSION GUIDELINES

- **Your report should be in PDF format.**
- **Please submit your assignment via the e-learn platform.**
- **The maximum grade you can get is 120 with 20 out of the 120 points being BONUS.**
- **To prevent plagiarism, in each assignment series a random sample of students will be selected for further oral examination.**

Assignment 5: MAC Layer

Exercise 1 (20pts)

i) (5p) Explain the difference between **Error Detection** and **Error Correction**. Why might a link-layer protocol choose to only detect errors (and discard the frame) rather than correcting them? Provide an example scenario for each approach (detection vs. correction).

ii) (5p) Consider the following grid of data bits with **Even Parity**:

				Row Parity	
0	1	1	0	**0**	
1	1	0	1	**1**	
0	0	0	0	**0**	
1	0	1	1	**1**	
Col Parity	**0**	**0**	**0**	**0**	**0**

1. Suppose the bit at Row 2, Column 3, originally "0", is flipped to "1" during transmission.
2. Redraw the grid as received (with the error).
3. Explain exactly how the receiver detects the error and identifies which specific bit needs to be corrected using the row and column parity bits.

iii) (10p) Consider the data bit sequence D = 1 0 1 0 1 0 1 0 and the generator polynomial G = 1 0 0 1 (3 bits + 1).

1. Calculate the **CRC bits (R)** that the sender should append to the data.
2. Show your polynomial division steps clearly.
3. What is the final transmitted bit sequence?

Exercise 2 (25pts)

i) (5p) Compare channel partitioning protocols (**TDMA/FDMA**) with random access protocols (**ALOHA**, **CSMA**) in terms of:

1. Efficiency at low load.
2. Efficiency at high load.
3. Fairness.

ii) (10p) Suppose that nodes A and B are on the same 10 Mbps broadcast channel, and the propagation delay between the two nodes is 245 bit times. There is no other device on that channel. Nodes A and B send Ethernet frames at the same time. As we know the frames will collide. Assume that A and B choose different values of K in the **CSMA/CD** algorithm. Assuming no other nodes are active, can the retransmissions from A and B collide? For our purposes, it suffices to work out the following example. Suppose A and B begin transmission at t = 0 bit times. They both detect collisions at t = 245 bit times. Suppose KA = 0 and KB = 1. At what time does B schedule its retransmission? At what time does A begin transmission? **(Note: The nodes must wait for an idle channel after returning to Step 2—see protocol.**) At what time does A's signal reach B? Does B refrain from transmitting at its scheduled time?

iii) (10p) Consider N devices that use the (pure) **ALOHA** protocol to contend for a channel. The probability of retransmission probability is p. Show how to select p to optimize the utilization of the channel, considering that all N devices have a very large number of frames to transmit.

Exercise 3 (30pts)

i) (5p) Why do valid devices on the Internet need both a **MAC address** and an **IP address**? Describe a scenario where a device might change its IP address but keep its MAC address, or vice versa.

ii) (10p) Host A (IP: **192.168.1.10**, MAC: **AA:AA**) wants to send an IP datagram to Host B (IP: **192.168.1.20**, MAC: **BB:BB**). They are on the same **Ethernet LAN**. Host A's ARP table is empty.

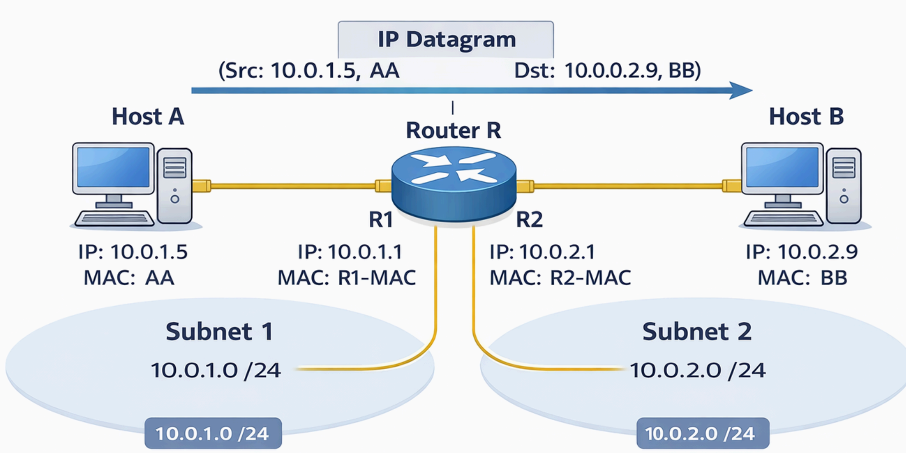
1. List the steps Host A takes to obtain Host B's MAC address.
2. Specify the source and destination MAC addresses of the ARP Request frame. Is this a broadcast or unicast frame?
3. Specify the source and destination MAC addresses of the ARP Reply frame.

iii) (15p) Consider the following topology:

- Host A (IP: **10.0.1.5**, MAC: **AA**) is on Subnet 1.
- Router R has interface R1 (IP: **10.0.1.1**, MAC: **R1-MAC**) facing Subnet 1 and interface R2 (IP: **10.0.2.1**, MAC: **R2-MAC**) facing Subnet 2.
- Host B (IP: **10.0.2.9**, **MAC: BB**) is on Subnet 2.

Host A sends an IP datagram to Host B. Describe the addressing in the frames at two distinct points:

1. **Frame 1 (Leaving Host A)**: What are the Source IP, Dest IP, Source MAC, and Dest MAC?
2. **Frame 2 (Leaving Router R towards Host B)**: What are the Source IP, Dest IP, Source MAC, and Dest MAC?
3. Why does the Destination MAC address change while the Destination IP address remains the same?



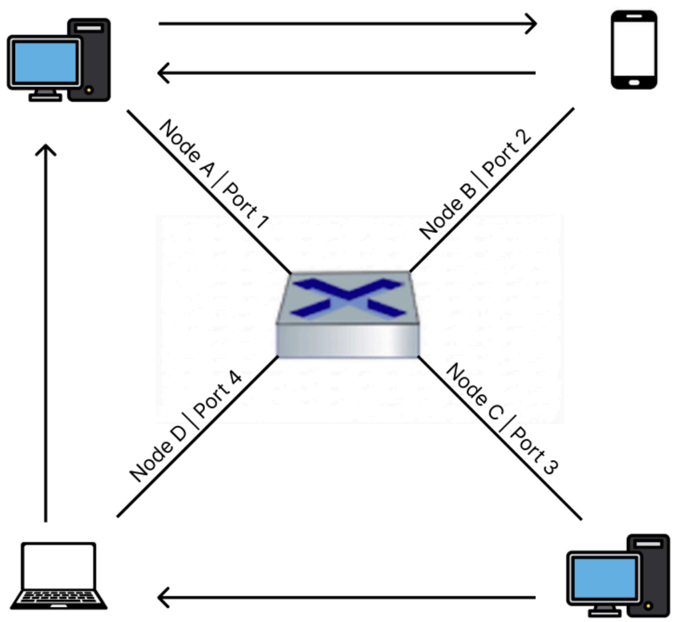
Exercise 4 (25pts)

i) (10p) Consider a switch with 4 ports (1, 2, 3, 4). The switch table is initially empty.

- Node A is on Port 1.
- Node B is on Port 2.
- Node C is on Port 3.
- Node D is on Port 4.

Trace the switch table state and the switch's forwarding actions for the following sequence of frames:

1. A sends a frame to B.
2. B replies with a frame to A.
3. C sends a frame to D.
4. D sends a frame to A.



ii) **(5p)** Compare Link-Layer Switches and Network-Layer Routers in terms of:

1. Protocol layer processed.
2. Handling of broadcast traffic (do they forward broadcasts by default?).
3. Topology structure (loops allowed vs. prevented).

iii) **(5p)** Compare **DNS**, **ARP**, and **DHCP** in terms of:

1. **Mapping Function:** Briefly describe what identifier each protocol resolves from and what it resolves to.
2. **Operational Scope:** Which of these protocols can operate globally across the Internet, and which are strictly limited to the local network? Explain the technical reason why the local protocols cannot traverse routers.

(iv) **(5p)** Ethernet switches are capable of building their forwarding tables automatically, without network administrator intervention.

1. When a frame arrives at a switch interface, what specific piece of information does the switch extract to populate its table? What mapping does it create?
2. If the switch finds no entry in its table for the frame's Destination MAC address, what action does it take?
3. Why do these table entries typically have a timer (TTL) after which they are deleted?

Exercise 5 (20pts)

i) (8p) A common misconception is that when you communicate with a web server (like google.com), your computer needs to know Google.com''s MAC address. In this task, you will prove that Link Layer addressing is strictly local.

1. Open your terminal/command prompt.
2. Find your Default Gateway IP address:
   - Windows: **ipconfig** (Look for "Default Gateway").
   - Mac/Linux: **netstat -nr | grep default** or **ip route**.
3. Ping your Gateway (e.g., ping 192.168.1.1) to ensure the Link Layer connection is active.
4. Ping a Remote Server (e.g., ping 8.8.8.8 or ping www.mit.edu).
5. Immediately run **arp -a** to view your Link Layer Neighbor Table.

Questions:

1. Look at your ARP table. You should see an entry (MAC address) for your Default Gateway's IP. Provide a screenshot and write it down.
2. Look for an entry for the Remote Server's IP (e.g., **8.8.8.8**). Is it there?
3. Explain your findings. When your computer creates the Ethernet frame destined for Google (**8.8.8.8**), which Destination MAC address does it use in the Ethernet header? The MAC of Google's server or the MAC of your Gateway? Why?

ii) (6p) The first 24 bits (3 bytes) of a MAC address are known as the **Organizationally Unique Identifier (OUI)** and identify the manufacturer of the network card.
Run ipconfig /all (Windows) or ifconfig / ip link (Linux/macOS) on your machine.

1. Identify the Physical Address (MAC) of your active network adapter (Wi-Fi or Ethernet). Screenshot the result, and write it down.
2. Use an online **OUI** Lookup tool (e.g., wireshark.org/tools/oui-lookup) to search for the first 3 bytes of your MAC address. Who is the manufacturer of your network interface card (e.g., Intel, Realtek, Apple)?
3. Why is it important that OUIs are globally unique?

iii) (6p) Consider the following output from a Linux netstat -i command on a busy server:

Iface	MTU	RX-OK	RX-ERR	RX-DRP	RX-OVR	TX-OK	TX-ERR
eth0	1500	24050	0	0	0	23000	0
eth1	1500	85000	450	200	50	84000	5

1. Which interface (**eth0** or **eth1**) is experiencing physical layer or link layer issues?
2. **RX-ERR** often indicates "Cyclic Redundancy Check (CRC)" failures. What does a CRC failure tell you about the physical integrity of the cable or signal?
3. **RX-DRP** (Dropped packets) often increases when the driver/buffer is overwhelmed. Is this a physical cable fault or a system performance bottleneck? Explain briefly.

For this exercise, provide screenshots wherever you think it's necessary. Make sure your answers clearly indicate which section and question they correspond to.