CS 168 — Introduction to the Internet
Summer 2025 — Final Exam

PRINT Your Name: ______________________________

PRINT Your Student ID: ______________________________

You have 170 minutes. There are 8 questions of varying credit. (100 points total)

Question:	1	2	3	4	5	6	7	8	Total
Points:	14	16	10	16	13	13	10	8	100

For questions with **circular bubbles**, you may select only one choice.

- ○ Unselected option (Completely unfilled)
- ◉ Don't do this (it will be graded as incorrect)
- ● Only one selected option (completely filled)

For questions with **square checkboxes**, you may select one or more choices.

- ■ You can select
- ■ multiple squares
- ☑ Don't do this (it will be graded as incorrect)

Anything you write outside the answer boxes or you ~~cross out~~ will not be graded. If you write multiple answers, your answer is ambiguous, or the bubble/checkbox is not entirely filled in, we will grade the worst interpretation.

Honor Code: Read the honor code below and sign your name.

> I understand that I may not collaborate with anyone else on this exam, or cheat in any way. I am aware of the Berkeley Campus Code of Student Conduct and acknowledge that academic misconduct will be reported to the Center for Student Conduct and may further result in, at minimum, negative points on the exam.

SIGN your name: ______________________________

Doodle credit: Andrea Lou

Q1 *Potpourri* **(14 points)**

Q1.1 (1 point) Consider TCP with congestion control, as seen in lecture. The window size should always be set to RTT $\times$ bandwidth to take advantage of the network capacity.

○ True ○ False ○ Not enough information

Q1.2 (2 points) Select all that apply. An end host participant in TCP, with no congestion control, has to maintain and update:

☐ Which packets have been sent and not acknowledged.

☐ How much longer is on the timer before a resend is needed.

☐ A buffer of received out of order packets.

☐ A buffer of all received packets.

☐ Congestion window size.

○ None of the above

Q1.3 (1 point) Assuming routers have a single FIFO buffer and are running TCP with congestion control, increasing the queue size at routers is always a good way to decrease network delays.

○ True ○ False ○ Not enough information

Q1.4 (1 point) A user only knows about one DNS recursive resolver, which goes down. At this point, the user cannot reach `www.google.com`.

○ True ○ False ○ Not enough information

Q1.5 (2 points) Select all of the following that Content Delivery Networks (CDNs) can help with.

☐ Loading private (i.e. `Cache-Control` header is set to private) user specific data quickly.

☐ Serving a small company's (does not own infrastructure) webpage fast and globally.

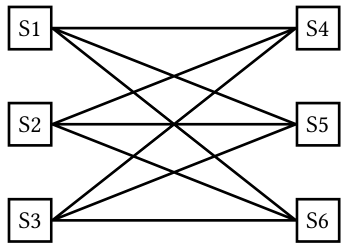
☐ Serving a large company's (owns infrastructure) webpage fast and globally.

☐ Reducing the need for network bandwidth.

☐ Reducing the load on the origin server.

○ None of the above

Q1.6 (2 points) What is the bisection bandwidth of the network shown below, with links of bandwidth B, and 6 total switches that each have 3 physical ports?



◯ B ◯ $5B$ ◯ $9B$

◯ $3B$ ◯ $6B$ ◯ Not enough information

Q1.7 (1 point) Encapsulation and decapsulation in datacenter networks can help with both multi-tenancy and managing virtualization.

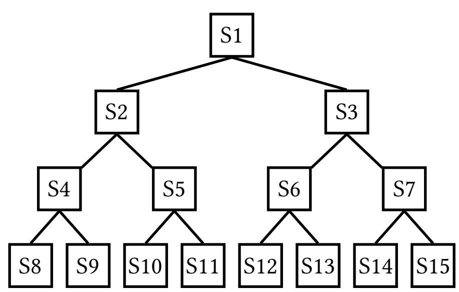
◯ True ◯ False ◯ Not enough information

Q1.8 (1 point) In a wide-area network with low-bandwidth links and non-zero queuing delay at routers, Remote Direct Memory Access (RDMA) can increase file transfer speed.

◯ True ◯ False ◯ Not enough information

Q1.9 (2 points) Consider the physical topology below. Calculate the average stretch (i.e. $\frac{\text{underlay hops}}{\text{overlay hops}}$) of an overlay ring topology designed for collective operations. Assumptions:

- All tree leaf nodes and the root node participate in the ring topology.
- Each physical and virtual link is cost 1.



◯ 28/9 ◯ 10/3 ◯ 9

◯ 5/3 ◯ 3 ◯ Not enough information

Q1.10 (1 point) Calculate the predicted Signal to Interference and Noise Ratio ($SINR_{dB}$) for a signal with a power of 10 Watts in a room with an average measured background noise of 200 mWatts and interference noise of 800 mWatts.

◯ 0.01 dB ◯ 20 dB ◯ 40 dB

◯ 10 dB ◯ 30 dB ◯ Not enough information

Q2 *TCP Congestion Control: No Fair!* **(16 points)**

Fairness in life (including on the Internet) is hard to define and quantify. In this **entire** question, you can assume that fairness means that all **flows** using a link will eventually converge to equal link bandwidth.

For subparts **Q2.1 to Q2.2**, fill in the blank to form the fairest congestion control adjustment algorithm.

Q2.1 (2 points) ______ Increase

◯ Additive ◯ Multiplicative

Explain your selection in approximately 15 words or less.

Q2.2 (2 points) ______ Decrease

◯ Additive ◯ Multiplicative

Explain your selection in approximately 15 words or less.

Q2.3 (1 point) In the TCP congestion control algorithm discussed in class, fairness depends on RTT.

◯ True ◯ False ◯ Not enough information

For subparts **Q2.4 to Q2.5**, imagine you are a greedy TCP developer who does not care about fairness. Which of the following adjustment algorithms gets you the most link bandwidth? Assume everyone else participating in the network is using the TCP congestion control algorithm from class.

Q2.4 (1 point) What algorithm should we use for the increase method?

◯ $\text{CWND} = \left(\frac{1}{2}\right) \times \text{CWND}$ ◯ $\text{CWND} = 1 + \text{CWND}$

◯ $\text{CWND} = 2 \times \text{CWND}$ ◯ $\text{CWND} = 10 + \text{CWND}$

◯ $\text{CWND} = 2 + \text{CWND}$ ◯ $\text{CWND} = \text{CWND} - 10$

Q2.5 (1 point) What algorithm should we use for the decrease method?

◯ $\text{CWND} = \left(\frac{1}{2}\right) \times \text{CWND}$ ◯ $\text{CWND} = \text{CWND} - 2$

◯ $\text{CWND} = \text{CWND} - 1$ ◯ $\text{CWND} = \lceil \log(\text{CWND}) \rceil$

◯ $\text{CWND} = \text{CWND} - 10$ ◯ $\text{CWND} = \left(\frac{1}{4}\right) \times \text{CWND}$

You have heard that using delay as an indication of congestion can sometimes result in better performance because adjustments occur before loss occurs. For subparts **Q2.6 to Q2.8**, consider the following delay based congestion control algorithm. Assume the topology does not change and RTT is in seconds.

- The `BaseRTT` is the accurate expected RTT with no queueing delay.
- Flow rate is calculated by $\frac{\text{CWND}}{\text{RTT}}$
- When the (expected flow rate − the measured flow) $\times$ `BaseRTT` is greater than 5, decrease CWND by 1
- When the (expected flow rate − the measured flow) $\times$ `BaseRTT` is less than 1, increase CWND by 1

Q2.6 (2 points) If all end hosts in the network use this delay based algorithm, bandwidth allocation is fair. Assume the `BaseRTT` is the same for all flows in the network.

○ True ○ False ○ Not enough information

Why? Explain your answer in approximately 20 words or less.

Q2.7 (2 points) If the `BaseRTT` for different flows is different, and all the end hosts in the network use the above delay based algorithm, bandwidth allocation is fair.

○ True ○ False ○ Not enough information

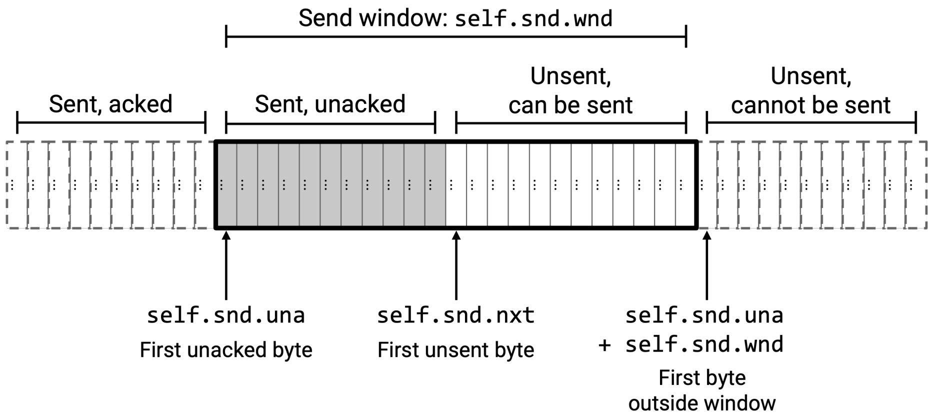
Why? Explain your answer in approximately 20 words or less.

Q2.8 (2 points) If only one flow in the network uses this delay based algorithm, and the rest of the flows use the TCP congestion control algorithm from class, bandwidth allocation is fair.

○ True ○ False ○ Not enough information

Why? Explain your answer in approximately 20 words or less.

Mini Project Quiz: For **Q2.9 to Q2.10**, consider the Transport Project 3 from class. The following project information is copied from the specification and included here for your reference and convenience:



The **TXControlBlock** object has the following relevant instance variables:

- **self.snd.iss**: Your initial sequence number.
- **self.snd.una**: The oldest unacknowledged sequence number that you sent.
- **self.snd.nxt**: The next sequence number you should send.
- **self.snd.wnd**: The current size of your send window, determined by how much buffer space the other side (recipient) has left.

If you receive a TCP segment **seg**, you can extract these fields from its header:

- **seg.seq**: The sequence number.
- **seg.ack**: The ack number.
- **seg.win**: The advertised window (how much buffer space is left on the other side).

Q2.9 (2 points) Calculate the amount of unsent data bytes which can be sent.

◯ **remaining = self.snd.iss |PLUS| self.snd.wnd |MINUS| self.snd.nxt**

◯ **remaining = self.snd.nxt |PLUS| self.snd.wnd |MINUS| self.snd.una**

◯ **remaining = self.snd.una |PLUS| self.snd.wnd |MINUS| seg.seq**

◯ **remaining = self.snd.una |PLUS| self.snd.wnd |MINUS| self.snd.nxt**

Q2.10 (1 point) In the **check_ack** function, we should only call **self.handle_accepted_ack** if the ACK number in the received segment corresponds to a packet that was sent but has not yet been acknowledged. Which of the following correctly bounds a sent, but unacked packet?

◯ **self.snd.una |LT| seg.ack and seg.ack |LE| self.snd.nxt**

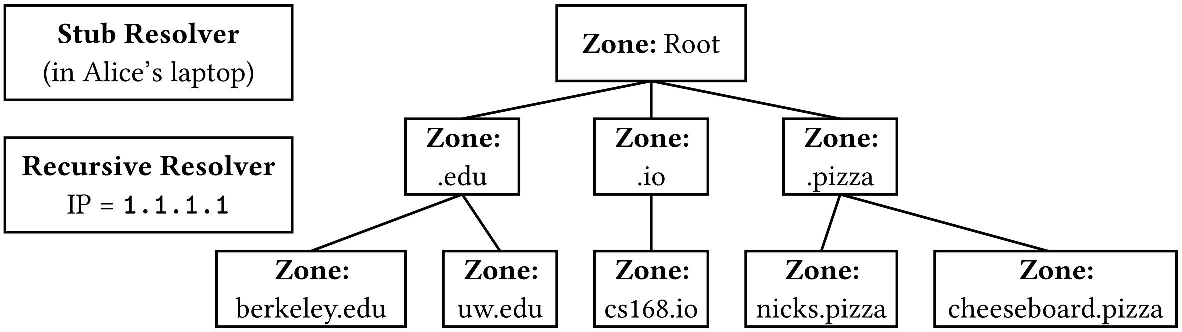
◯ **self.snd.una |LT| seg.ack and seg.ack |LT| self.snd.nxt**

◯ **self.snd.una |LE| seg.ack and seg.ack |LE| self.snd.nxt**

◯ **self.snd.una |LE| seg.ack and seg.ack |LT| self.snd.nxt**

Q3 *DNS: Resolving... The Best Local Pizza* **(10 points)**

Consider the following DNS name server hierarchy, stub resolver, and recursive resolver. Each box in the server hierarchy represents a zone. Alice, a CS168 student, is typing URLs into her browser.



Q3.1 (1 point) What protocol helps the stub resolver learn the IP address of the recursive resolver?

○ DHCP ○ DNS ○ ARP ○ BGP

Q3.2 (2 points) Starting with empty caches everywhere, Alice searches for **`www.nicks.pizza`**. How many queries must the recursive resolver make to get the IP address for **`www.nicks.pizza`**?

○ 1 ○ 2 ○ 3 ○ Not enough information

Q3.3 (2 points) Continuing from **Q3.2** (i.e. caches not cleared), Alice searches for **`www.cheeseboard.pizza`**. How many queries must the recursive resolver make to get the IP for **`www.cheeseboard.pizza`**?

○ 1 ○ 2 ○ 3 ○ Not enough information

Q3.4 (2 points) Alice orders pizza from the best of the two places and heads to Soda to meet her friends. She attaches her laptop to the WiFi network and searches **`www.cs168.io`** in her browser. How many queries must the recursive resolver make to learn the IP of **`www.cs168.io`**?

○ 1 ○ 2 ○ 3 ○ Not enough information

Subparts **Q3.5 to Q3.7**: Alice is searching for Connie's webpage in the CS168 site. The stub resolver makes a request to the recursive resolver. Who sends each of the following records to the recursive resolver?

Q3.5 (1 point) **Record:** `connie.cs168.io A 192.160.161.188`

○ Root name server ○ `.io` name server ○ `cs168.io` name server

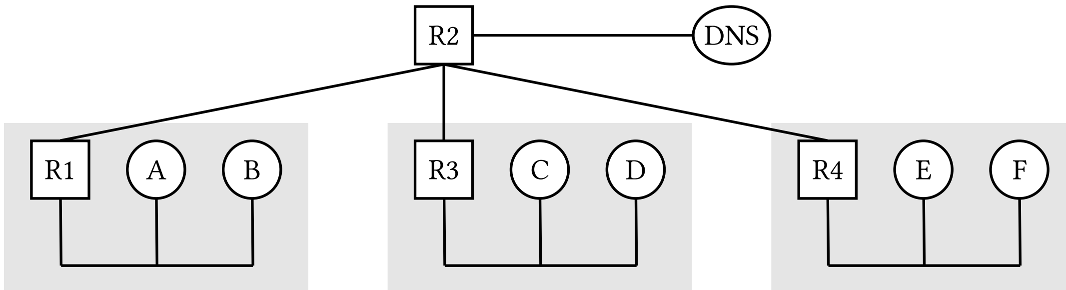
Q3.6 (1 point) **Record:** `cs168-dns.io A 192.160.162.189`

○ Root name server ○ `.io` name server ○ `cs168.io` name server

Q3.7 (1 point) **Record:** `cs168.io NS cs168-dns.io`

○ Root name server ○ `.io` name server ○ `cs168.io` name server

Q4 *End-to-End: Three's a Crowd* **(16 points)**



In this question, consider this network topology containing three different subnets.

Routers R1, R2, and R3 are using NAT with Port Address Translation.

There is one DNS resolver with IP 8.8.8.8 in the network, labeled DNS. Everyone uses this DNS resolver.

1. R1's private address is 1.1.1.1, and its public address is 192.1.1.1.
   It can allocate the addresses 1.1.1.2, 1.1.1.3, and so on, to the hosts in its subnet.
2. R3's private address is 3.3.3.1, and its public address is 192.3.3.3.
   It can allocate the addresses 3.3.3.2, 3.3.3.3, and so on, to the hosts in its subnet.
3. R4's private address is 4.4.4.1, and its public address is 192.4.4.4.
   It can allocate the addresses 4.4.4.2, 4.4.4.3, and so on, to the hosts in its subnet.

Q4.1 (1 point) Suppose host A joins the network, with all caches empty and no active connections.
In Host A's DHCP Discover request, what is the source IP address?

- ○ 0.0.0.0
- ○ 1.1.1.1
- ○ 1.1.1.2
- ○ 255.255.255.255

Q4.2 (1 point) Which best explains the source port Host A uses when sending a DHCP request?

- ○ Host A uses source port 67 since that's what all hosts use as source ports for DHCP.
- ○ Host A uses the source port that was burned within its hardware.
- ○ Host A picks a random source port.
- ○ Host A doesn't need to add a source port when sending a DHCP request.

For the remainder of this problem, suppose all six hosts have completed the DHCP handshake, in alphabetical order, one after the other, and have been assigned IP addresses respectively.

Q4.3 (2 points) At this point, which addresses does A know? Assume hosts process all broadcast packets.

- ☐ B's private IP
- ☐ R1's public IP
- ☐ R1's private IP
- ☐ DNS's IP

Q4.4 (2 points) Suppose A knows B's IP and wants to send a unicast packet to B. What will A do first?

- ◯ Make a DNS request, which ultimately returns B's MAC Address.
- ◯ Make an ARP request, which ultimately returns B's MAC address.
- ◯ Make an ARP request, which ultimately returns R1′s MAC address.
- ◯ Send the packet to B immediately since they're within the same subnet.

Q4.5 (2 points) Suppose A knows D's IP and wants to send a unicast packet to D. What will A do first?

- ◯ Make a DNS request, which ultimately returns D's MAC Address.
- ◯ Make an ARP request, which ultimately returns D's MAC address.
- ◯ Make an ARP request, which ultimately returns R1′s MAC address.
- ◯ Send the packet to C immediately since they're within the same subnet.

Q4.6 (2 points) Suppose E sends a DNS request to the DNS resolver. Write the **destination IP in the DNS response packet** from this DNS request.

[ ]

Q4.7 (2 points) Suppose C and D each send a packet to F. Select the true statement.

- ◯ R3 forwards both packets to R2 without modifying any of the headers for either packet.
- ◯ R3 always uses a randomized source port number for C's and D's packet before sending to R2.
- ◯ R3 drops one of the packets due to possible ambiguity when F sends a packet.
- ◯ R3 forwards a packet with C's source port and a packet with D's (different) source port to R2.

Now, suppose E sends a packet to A, and a packet to B.

Q4.8 (1 point) Can E assign the same source port for both of these packets?

◯ Yes ◯ No

Q4.9 (2 points) Can D start a direct TCP connection to E? Explain in approximately 20 words or fewer.

[ ]

Q4.10 (1 point) If F knows E's MAC address, can F send packets to E even if E gets a new IP address?

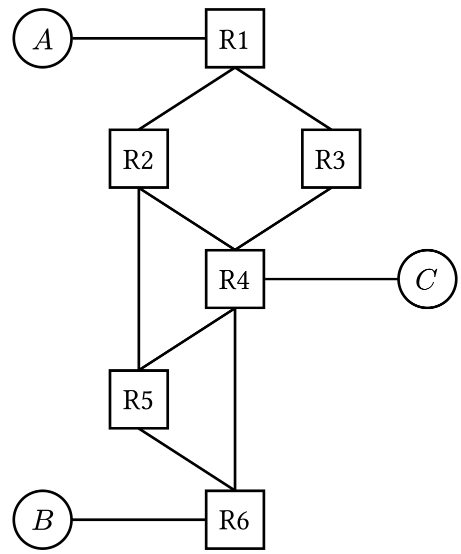
◯ Yes ◯ No

Q5 *STP: Standard STP* **(13 points)**

Consider running the Spanning Tree Protocol (STP) for the network topology to the right.

Assume the IDs are ordered according to the router labels. For example, R4 has a lower ID than R5.

For the first two subparts, option "R1, to R2" means "the port from R1 going to R2," and likewise for other options. Assume ties are broken by choosing the router with the lowest ID. Assume all the links have a cost of 1.



Q5.1 (2 points) Select all Root Ports.

- ☐ R1, to R2
- ☐ R1, to R3
- ☐ R2, to R1
- ☐ R2, to R4
- ☐ R2, to R5
- ☐ R3, to R1
- ☐ R3, to R4
- ☐ R4, to R2
- ☐ R4, to R3
- ☐ R4, to R5
- ☐ R4, to R6
- ☐ R5, to R2
- ☐ R5, to R4
- ☐ R5, to R6
- ☐ R6, to R4
- ☐ R6, to R5

Q5.2 (2 points) Select all Blocked Ports.

- ☐ R1, to R2
- ☐ R1, to R3
- ☐ R2, to R1
- ☐ R2, to R4
- ☐ R2, to R5
- ☐ R3, to R1
- ☐ R3, to R4
- ☐ R4, to R2
- ☐ R4, to R3
- ☐ R4, to R5
- ☐ R4, to R6
- ☐ R5, to R2
- ☐ R5, to R4
- ☐ R5, to R6
- ☐ R6, to R4
- ☐ R6, to R5

Q5.3 (2 points) Select all true statements.

- ☐ The Designated Ports in the network should be all the ports not selected in the above subparts.
- ☐ A link can only be disabled when both connected routers agree to disable it.
- ☐ Blocked ports lead to routers that are further away from the root.
- ☐ After disabling links with STP, the resulting topology will contain no cycles.
- ○ None of the above

Suppose STP has converged. Regardless of your answers to the previous subparts, assume that the following 3 links are disabled (also shown in the diagram to the right):

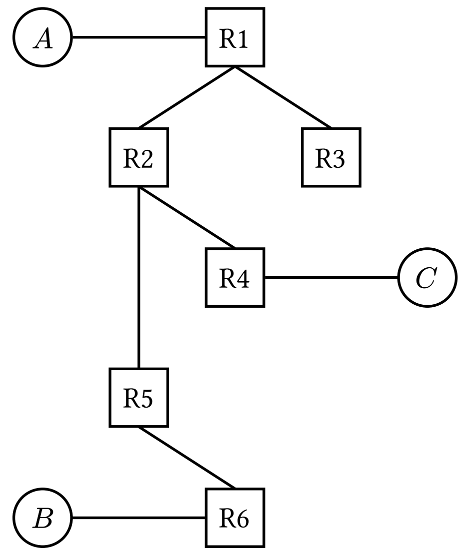
- R3-to-R4
- R4-to-R5
- R4-to-R6

Switches R1 to R6 are all learning switches.

At the start, the only entry in all forwarding tables is a valid least-cost next-hop to host B.

For each of the remaining subparts, a host will attempt to send a packet to another host.

The packets are sent one after the other. In other words, forwarding table entries created in one subpart carry over to later subparts.



Q5.4 (1 point) A sends a packet to B.

Which of the following will most likely occur from this packet being sent?

◯ Every switch floods the packet to all neighbors, eventually reaching host B.

◯ The packet goes from A to R1 to R2 to R5 to R6 to B, without reaching any other routers.

◯ The packet goes from A to R1 to R2 to R4 to C, thus never reaching B.

◯ A sends the packet to R1 who proceeds to drop it, thus never reaching B.

Q5.5 (2 points) B sends a packet to A.

Select all switches that will receive the packet.

☐ R1 ☐ R2 ☐ R3 ☐ R4 ☐ R5 ☐ R6

Q5.6 (2 points) A sends a packet to C.

Select all switches that will receive the packet.

☐ R1 ☐ R2 ☐ R3 ☐ R4 ☐ R5 ☐ R6

Q5.7 (2 points) C sends a packet to B.

Select all switches that will receive the packet.

☐ R1 ☐ R2 ☐ R3 ☐ R4 ☐ R5 ☐ R6

Q6 *Datacenters: Making a Mega Datacenter* **(13 points)**

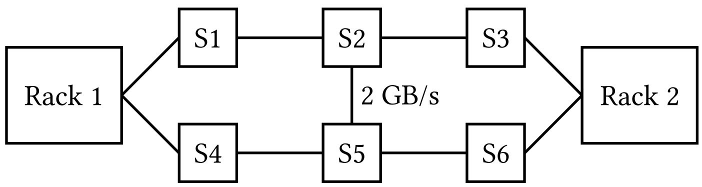
Paola is building a datacenter and is considering a few possible designs.

Q6.1 (3 points) Which topologies supports Rack 1 sending data to Rack 2 at 2 GB/s? Select all that apply.

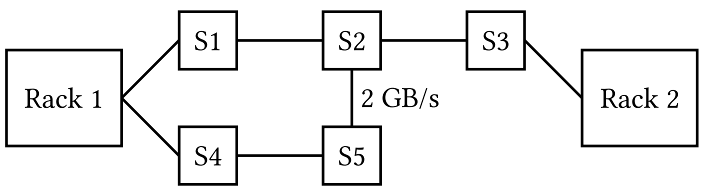
Unmarked edges have a bandwidth of 1 GB/s.

☐ Topology 1 ☐ Topology 2 ☐ Topology 3

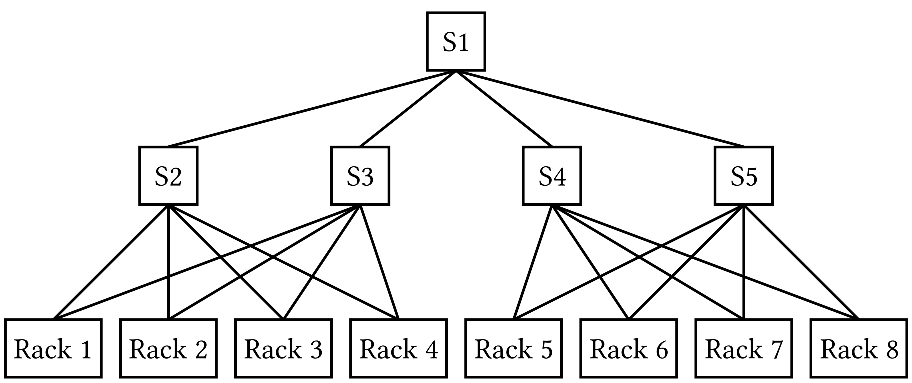
Topology 1:

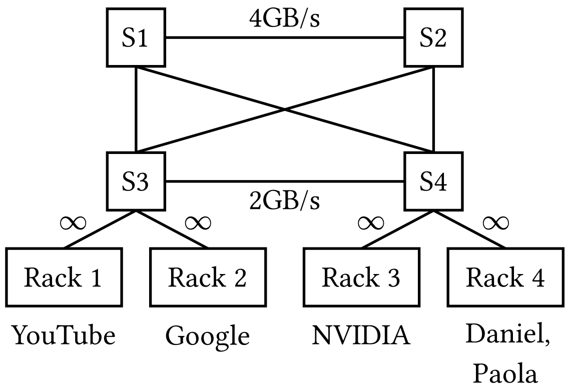


Topology 2:



Topology 3:





Paola builds a datacenter with an underlay and overlay (as seen in lecture).

Each rack has a virtual switch that interfaces with the virtual machine(s) on that rack.

The links from a rack to a switch have infinite bandwidth.

Q6.2 (2 points) What is the bisection bandwidth?

[ ] GB/s

Q6.3 (2 points) Daniel downloads a large YouTube video (100+ GB).
Select all true statements about using traffic engineering to transfer this large video.

- ☐ Sending the traffic across multiple paths could make the transfer faster.
- ☐ Sending the traffic across multiple paths could overwhelm the receiver (Daniel).
- ☐ It is possible for Daniel to receive the video at rate 6 GB/s.
- ○ None of the above

Q6.4 (2 points) All of the switches are busy processing Daniel's data transfer. At the same time, Paola wants to download a small 30-second YouTube video.

Select all protocols that could help Paola load the video before Daniel's transfer is done.
Consider each answer independently.

- ☐ TCP
- ☐ OpenFlow API Flow Tables
- ☐ Packet Priorities
- ☐ Encapsulation and Decapsulation
- ☐ Equal Cost Multi-Path Routing (ECMP)
- ☐ Constrained Shortest Path First (cSPF)

Q6.5 (2 points) Paola adds a new VM, Meta, to Rack 1. Which devices need to update their forwarding table? Select all that apply.

- ☐ VMs sending data to Meta
- ☐ Switches S3 and S4
- ☐ VMs sending data to YouTube
- ☐ Rack 1's virtual switch
- ☐ Switches S1 and S2
- ○ None of the above

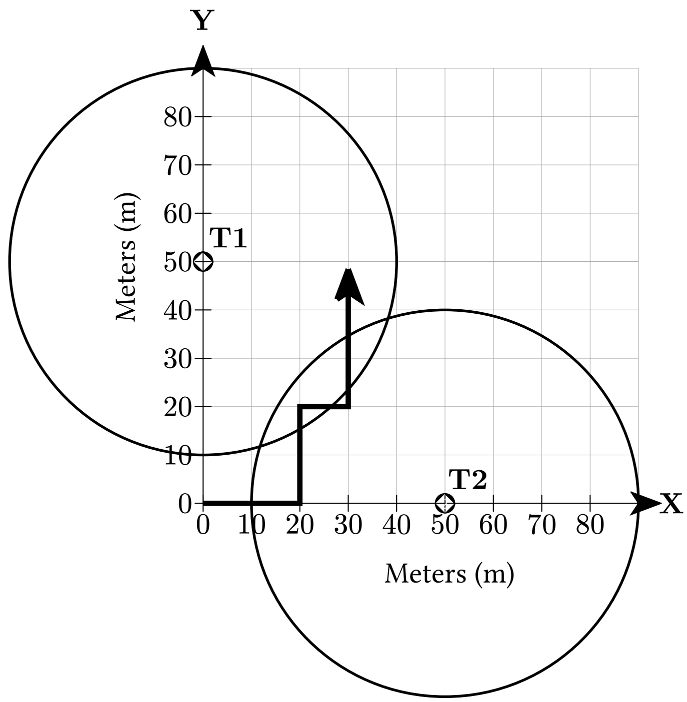
Q6.6 (2 points) Google wants to communicate with NVIDIA with very small latency. How could Paola update the datacenter to achieve this? There may be multiple answers.

Q7 *Wireless: Stuck in the Middle* **(10 points)**

There are two wireless terminals (T1 and T2) constantly attempting to send location information on the same frequency to V, a mobile autonomous vehicle. V has a wireless receiver and attempts to receive data from the terminals (T1 and T2). V follows the path starting from $(x, y) = (0, 0)$ and ending at $(30, 50)$.

Assumptions for Subparts Q7.1 to Q7.3:

- The vehicle (V) maintains a velocity of 10 m/s.
- T1 is located at $(0, 50)$. T2 is located at $(50, 0)$.
- Each terminal (T1/T2) has a transmit range of 40 m.
- There is no background noise or interference.
- If there are wireless collisions at T1,T2, or V, they cannot receive data.
- T1,T2, and V use **CSMA**.
- The vehicle starts moving from $(0, 0)$ at $t = 0$.



Q7.1 (2 points) At $t = 2$, which of the following is true?

- ☐ V can receive data from T1
- ☐ V can receive data from T2
- ☐ T1 and T2 can exchange data
- ☐ Hidden terminal causes collisions
- ☐ Exposed terminal stops a transmit
- ○ None of the above

Q7.2 (2 points) At $t = 4$, which of the following is true?

- ☐ V can receive data from T1
- ☐ V can receive data from T2
- ☐ T1 and T2 can exchange data
- ☐ Hidden terminal causes collisions
- ☐ Exposed terminal stops a transmit
- ○ None of the above

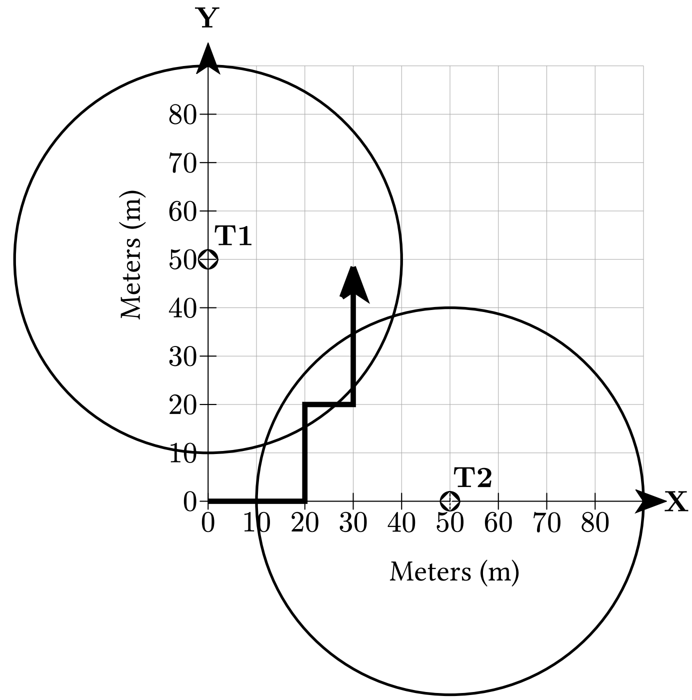
Q7.3 (2 points) At $t = 7$, which of the following is true?

- ☐ V can receive data from T1
- ☐ V can receive data from T2
- ☐ T1 and T2 can exchange data
- ☐ Hidden terminal causes collisions
- ☐ Exposed terminal stops a transmit
- ○ None of the above

The assumptions and diagram are reprinted below. The only change is CSMA → MACA.

Assumptions for Subparts Q7.4 and Q7.5:

- The vehicle (V) maintains a velocity of 10 m/s.
- T1 is located at $(0, 50)$. T2 is located at $(50, 0)$.
- Each terminal (T1/T2) has a transmit range of 40 m.
- There is no background noise or interference.
- If there are wireless collisions at T1,T2, or V, they cannot receive data.
- T1,T2, and V use **MACA**.
- The vehicle starts moving from $(0, 0)$ at $t = 0$.



Q7.4 (2 points) To fix the hidden terminal and exposed terminal problem, MACA is implemented instead of CSMA. What assumption must be made to fix the exposed terminal problem?

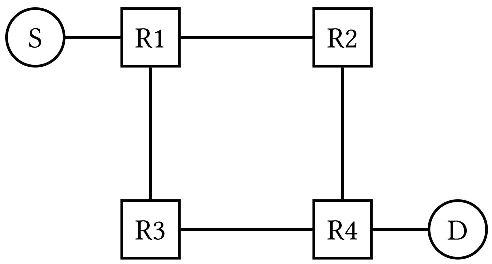
- ◯ RTS/CTS is sent directly after data transfers finish.
- ◯ CTS can be heard over data broadcasts.
- ◯ The contention window is doubled on failure.
- ◯ ACKs are implemented for reliability.
- ◯ It is not possible to fix the exposed terminal problem.

Q7.5 (2 points) With MACA, the first terminal to send a successful RTS/CTS exchange will likely succeed in most future exchanges, and the other terminal will be unable to send data. This is an issue since the vehicle should get data from both terminals. Explain how to fix this. Please answer in approximately 20 words or less.

Q8 *Project 1: Traceroute Storm* **(8 points)**

In this question, Host S runs traceroute on the network topology below. All links cost 1.

Unless otherwise specified, you can assume no network errors occur (e.g., no packet drops, no corruption, no additional duplication beyond the behavior described, etc).



- R1 has IP address 1.1.1.1.
- R2 has IP address 2.2.2.2.
- R3 has IP address 3.3.3.3.
- R4 has IP address 4.4.4.4.
- D has IP address 100.0.0.1.

Instead of keeping a routing table, each router **floods** every packet it receives, by forwarding a copy of that packet out of every outgoing port, including the one you received the packet from. If a router creates a new packet to be sent, that packet is also forwarded out of every outgoing port.

End hosts do not flood packets across the network. If a packet is flooded to them, they do not forward it elsewhere.

Host S runs traceroute with destination D, sending 1 probe at each TTL. The result is a list of sublists:

`[[____], [____], [____], [____]]`
(1) (2) (3) (4)

Q8.1 (1 point) Which IP(s) are in the first sublist (1)? Select all that apply.

☐ 1.1.1.1 ☐ 2.2.2.2 ☐ 3.3.3.3 ☐ 4.4.4.4 ☐ 100.0.0.1

Q8.2 (1 point) Which IP(s) are in the second sublist (2)? Select all that apply.

☐ 1.1.1.1 ☐ 2.2.2.2 ☐ 3.3.3.3 ☐ 4.4.4.4 ☐ 100.0.0.1

Q8.3 (1 point) Which IP(s) are in the third sublist (3)? Select all that apply.

☐ 1.1.1.1 ☐ 2.2.2.2 ☐ 3.3.3.3 ☐ 4.4.4.4 ☐ 100.0.0.1

Q8.4 (1 point) Which IP(s) are in the fourth sublist (4)? Select all that apply.

Assume that all reply packets received at each TTL are processed and added to the list, i.e. we don't return early after finding the destination.

☐ 1.1.1.1 ☐ 2.2.2.2 ☐ 3.3.3.3 ☐ 4.4.4.4 ☐ 100.0.0.1

Subparts Q8.5 to Q8.8: Assume the following:

- When a router creates a new packet, the TTL on that new packet is always set to 3.
- A duplicate is a probe response that reveals an IP that S has already added to the current sublist.
- All probes and responses at a given TTL are processed before moving onto the next TTL, so there are no badly-delayed duplicates.
- If S receives a packet with TTL 1, it still processes that packet.

As a reminder, each router **floods** every packet it receives. End hosts do not flood packets across the network. If a packet is flooded to them, they do not forward it elsewhere.

For instance, if R4 was sending a response to a traceroute request from S, it would flood this packet to all of its neighbors: R2, R3, and D. Each of its neighbors would then flood the packet to each of their neighbors, **including** R4.

Q8.5 (1 point) How many duplicates are discarded by S when building the first sublist (1)?

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

Q8.6 (1 point) How many duplicates are discarded by S when building the second sublist (2)?

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

Q8.7 (1 point) Suppose that we re-run traceroute (still from S to D), now sending 3 probes at each TTL instead of 1 probe.

Does the resulting list of sublists change?

○ Yes, the result is different and unpredictable on each run.

○ Yes, the result is different, but the same on every run.

○ No, the result is still the same on every run.

Q8.8 (1 point) Suppose that we re-run traceroute from S, but now to a destination that is not connected to the network. We still send 1 probe at each TTL.

What does the resulting list of sublists look like at higher TTLs?

○ `[..., [], [], [], [], ...]`

○ `[..., [1, 4], [2, 3], [1, 4], [2, 3], ...]`

○ `[..., [1, 2, 3, 4], [1, 2, 3, 4], [1, 2, 3, 4], ...]`

○ `[..., [1], [2], [3], [4], [1], [2], [3], [4], ...]`

○ `[..., [4], [4], [4], [4], ...]`

○ `[..., [1], [1], [1], [1], ...]`

Comment Box

Congrats for making it to the end of the exam! Leave any thoughts, comments, feedback, or doodles here.

Nothing in the comment box will affect your grade.