ECE/CS 438: Communication Networks **Spring 2023**

Homework 4

Handed Out: April 23rd, 2023 *Due: 11:59pm, April 30th, 2023*

TA: Lily Pan

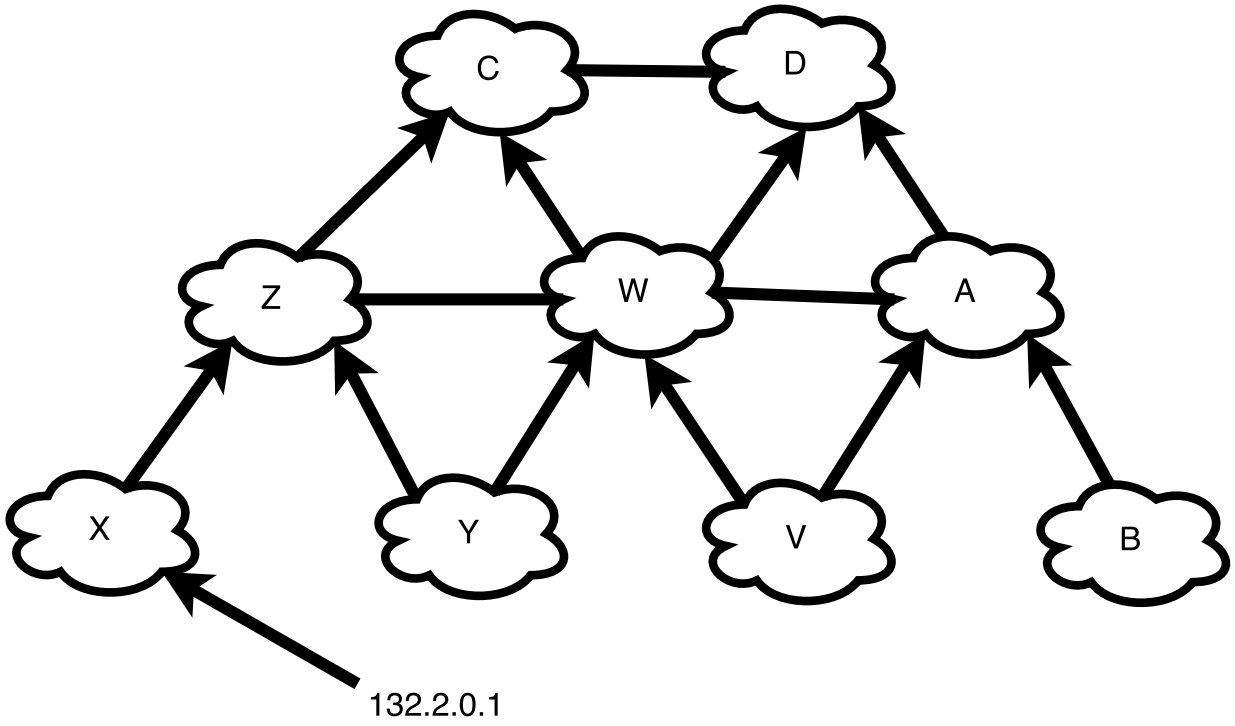
- Homework assignments must be submitted online through GradeScope. Hard copies are not accepted. Please submit a pdf file to GradeScope (`https://www.gradescope.com`). You can either type your solution or scan a **legible** hand-written copy. We will not correct anything we do not understand. Contact the TAs via Piazza if you face technical difficulties in submitting the assignment. Note: Please select your page(s) for each question during submission on GradeScope; Otherwise, your submission will not be graded.
- Homework assignments can be done in groups of two, but only one person needs to submit on GradeScope. Remember to include your partners name in the solution and on GradeScope by editing "Group Members". It is your responsibility that your partner's name is included. For detailed instruction please refer to (`https://youtu.be/rue7p_kATLA`).
- You can use Piazza to find a partner. We highly recommend working in groups. You will not get extra credit for working alone.
- Please use Piazza and come to office hours if you have questions about the homework. Failure to understand the solutions will be the student's fault.
- While we encourage discussion within and outside of the class, cheating and copying is strictly prohibited. Copied solutions will result in the entire assignment being discarded from grading at the very least and a report filed in the FAIR system. It is also your responsibility to ensure that your partner obeys the academic integrity rules as well.

1 BGP Policy - 6 Points

Fig. 1 represents relationship between ASes. The vertices are individual ASes and edges are links between them and IP is the prefix from AS X. Also suppose that arrows represent customer-provider relationships where the customer points to its provider. An edge without arrows represents a link between peers.

1. Suppose all ASes follow local preference rules that enforce *valley-free* paths: any path must follow a sequence of zero or more provider links, followed by at most one peer link, followed by a sequence of customer links. An AS will route through the *valley-free* path with the least number of hops. List the routes that each AS will follow to reach X in a *valley-free* manner.
2. Suppose AS Y does not like AS W. Using only BGP, is it possible for AS Y to implement a policy stating that "traffic outbound from my AS should not cross W "? If it is possible, show that Y can still reach all ASes using *valley-free* paths that do not cross W. If it is not possible, show that there exists an AS such any *valley-free* path from Y must go through W.
3. Suppose AS W does not like AS X, and therefore decides to not forward any traffic from X. Can AS X deal with this change? If it can, show that X can find *valley-free* paths to all ASes that do not cross W. If it cannot, show that there exists an AS such any *valley-free* path from X must go through W.

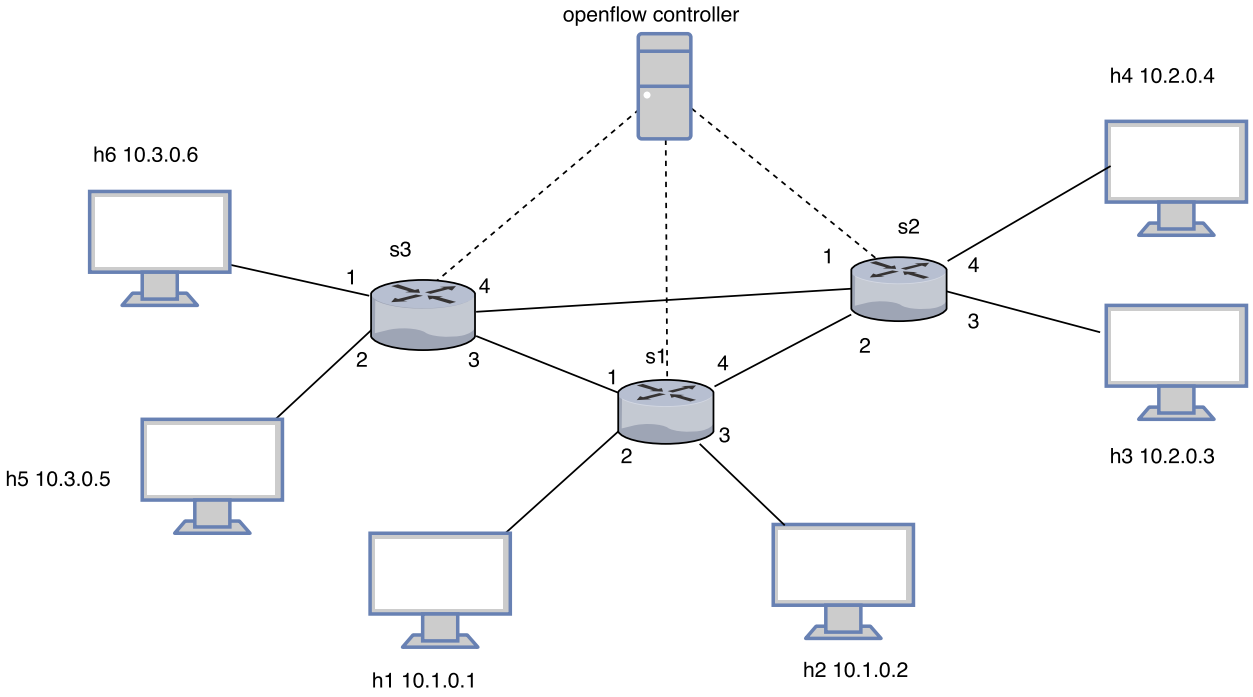
Figure 1:



2 SDNs - 12 Points

Consider the SDN OpenFlow network shown below in Fig. 2. Suppose we want switch s2 to function as a firewall. Specify the flow table in s2 that implements the following firewall behaviors. Specify a different flow table for each of the four firewalling behaviors below. The flow table should only consider delivery of datagrams destined to h3 and h4. You do not need to specify the forwarding behavior in s2 that forwards traffic to other routers. The flow table should show the matching rule and the action taken.

Figure 2:



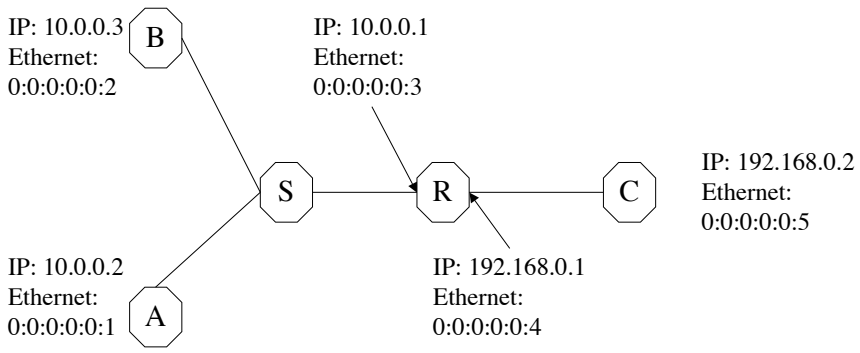
1. Only traffic arriving from hosts h2 and h5 should be delivered to hosts h3 or h4.
2. Only TCP traffic is allowed to be delivered to hosts h3 or h4.(i.e., that UDP traffic is blocked.)
3. Only traffic destined to h4 is to be delivered (i.e., all traffic to h3 is blocked.)
4. Only UDP traffic from h6 and destined to h3 is to be delivered. All other traffic is blocked.

3 Synthesis - 16 Points

Given the diagram below in Fig.3, list the packets that will be sent when A makes a TCP connection to C on port 1234. S here is a learning switch; R is a router. Assume that all the switching tables and ARP caches are empty. Assume that A allocates port 54321 for this connection. For each packet, list:

- Ethernet source and destination address
- IP source and destination address
- Packet type (ARP / TCP)
- TCP source and destionation ports, flags
- Which host sent the packet
- Which link(s) the packet will be sent on (e.g., A–S, R–C)

Figure 3:



Fill the Table 1 as your answer.

Table 1: Answer of "Synthesis"

	Ethernet		IP		TCP				
Type	Src	Dst	Src	Dst	Src	Dst	Flags	Sender	Link
ARP	0:0:0:0:0:1	FF:FF:FF:FF:FF:FF	10.0.0.2	10.0.0.1	N/A	N/A	N/A	A	A-S

4 Error Detection - 16 Points

Consider the following bit stream (16 bits) to be transmitted over a given link in a local area network: "11110011 10001001".

1. Parity Check
   (a) What is the value of the error-check field for the case of single parity scheme? Assume even parity, i.e. number of 1's should be even after adding the parity bit.
   (b) Assuming two-dimensional parity using a 4×4 array , how many parity bits will be added to the bit stream?
   (c) Show the resulting two dimensional parity bits assuming even parity.
   (d) Find an example of a pattern of 3 errors that cannot be detected using two-dimensional parity. Explain your answer.
   (e) List one advantage and one disadvantage of two-dimensional parity over single parity.
2. Cyclic Redundancy Checksum.

   The given bit stream is to be protected by a CRC code using the CRC-8 generator "100100110".
   (a) Calculate the CRC bits using modulo 2 long division. Show the steps of your calculation.
   (b) What is the resulting bit stream to be transmitted?
   (c) How does the receiver know if an error has occurred in the transmitted bit stream?
   (d) Suppose that the leftmost bit of the transmitted bit stream is inverted due to noise on the transmission link, what is the result of the receiver's CRC check? Show the steps of your calculation.
3. Checksum

   Given the following bit stream sequence in hexadecimal representation: "0x7E 0xFF 0xAA 0xC8 0xEC 0x05".

   Determine the 16 bit Internet checksum of the given sequence by dividing it into into segments of size 16 bits and calculating the 1's complement sum. Show the steps of your calculation.

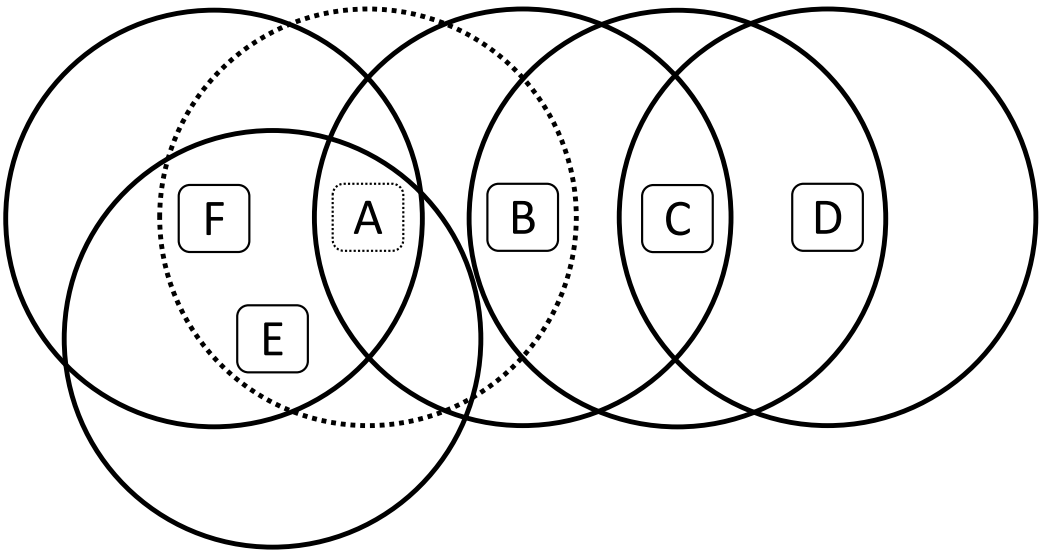
5 Channel Contention - 8 Points

Suppose nodes A and B are ready to send a packet. In the i^{th} round after $(i-1)$ collisions have already occurred, the two nodes can wait $0, 1, \ldots, 2^{i-1}-1$ slots until the next attempt, all 2^{i-1} choices having equal probability.

1. Find the probability q_i of a collision in the i^{th} round, given that there are collisions in the previous $(i-1)$ rounds (i.e., $q_1 = 1$, $q_2 = \frac{1}{2}$), for all $i \geq 1$.
2. Find the probability p_i that exactly i rounds are needed for the first success, and compute $p_1, p_2, \ldots, p_4$.
3. Now assume that after the first collision, node A "wins" the backoff and transmits successfully. After it is finished, both nodes try to transmit again (A has an infinite amount of traffic to send), causing a collision. Now compute the probability that A wins the channel for the next packet.

6 Wireless - 12 points

In the diagram below, each wireless node is shown along with its transmission radius. E.g., A's transmission radius is the circle with the dashed line.



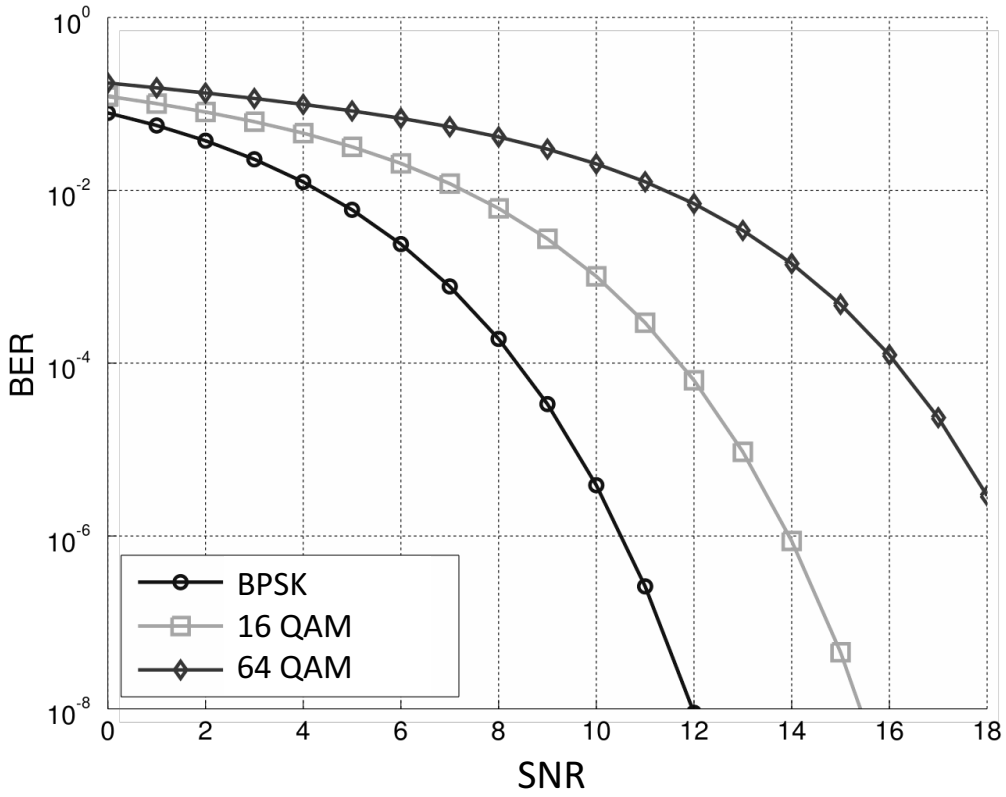
1. List all the hidden terminals in the above wireless network?
2. The network uses CSMA/CA. When B wants to transmit to A it sends an RTS and A replies with a CTS to reserve the channel. Is this guaranteed to avoid collisions, explain why or why not?
3. In 802.11, after node A receives the data packet successfully, it sends an ACK message. Why is it necessary to send an ACK message?
4. Suppose the nodes F, A, B, C, D are equally spaced by a distance of d. Assume all nodes are identical and transmit at same power level on the same frequency. Also assume the signal attenuates based on free space pathloss model.

   A is transmitting to B while C is transmitting to D. Compute the SINR of C's signal at D in the following cases?

   (a) The noise power at D is zero.

   (b) The noise power at D is not zero and in the absence of any interference, the SNR of C's signal at D is 18.

5. Consider the BER vs SNR curve for different modulation schemes.



(a) The SNR of a wireless link is 12 dB. Which of the above modulation schemes should be used to maximize bit rate while ensuring the BER is less than 10^{-6}?

(b) Given the above choice of modulation scheme, compute the bit rate assuming the bandwidth is 10 MHz?

(c) Given the above choice of modulation and SNR, what is the probability of packet loss assuming the packet length is 1500 bytes and no error correction is used? (Note: In the absence of error correction, a packet is lost if any bit in the packet is in error.)