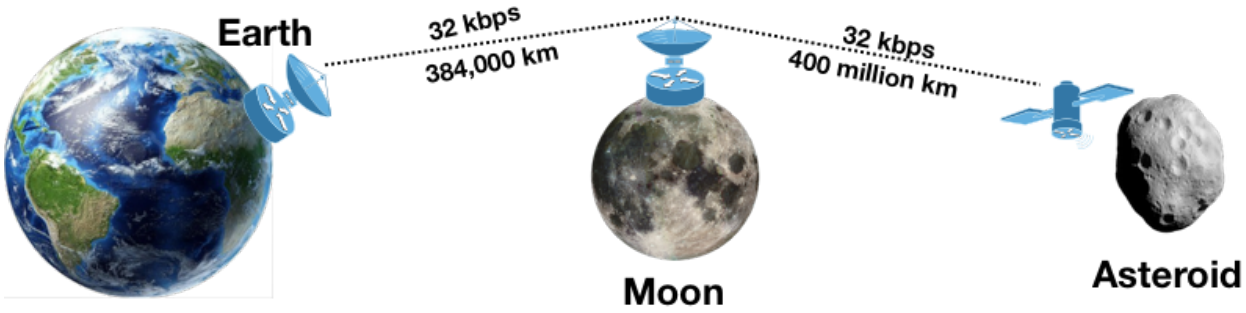
15-441/641 Homework #2
Due February 1, 2019 at 5PM to Gradescope
V 1.1 1/26/2019

Part 1: Latency and Packet Forwarding Warmup

The year is 2040. You are a distinguished CMU alum, now Vice President of Engineering at an asteroid mining company (asteroid mining is a major industry in 2040). You manage a network from Earth to the Asteroid; packets are sent first to an intermediary store-and-forward router on the Moon before being sent onwards to the Asteroid. Assume that the speed of light is 300,000 km/sec.



1. (4 pts) How long does it take to transmit at 1500 byte message on Earth? That is, from when Earth starts signaling the first bit to when it finishes signalling the last bit, how long does this take?

2. (4 pts) How long does it take for a 1500 byte message to be transmitted from Earth to the Moon? That is, from when Earth starts signalling the first bit, to when the Moon receives the last bit, how long does this take?

3. (4 pts) How long does it take for a 1500 byte message to be transmitted from the Earth to the Asteroid? That is, from when Earth starts signalling the first bit, to when the Asteroid receives the last bit, how long does this take? (Don't round!)

4. (4 pts) Your CEO is frustrated that this communication is taking too long! He suggests you upgrade your infrastructure to new radio technology that transmits at 100Mbps. Do you think that this upgrade is a good idea? Why or why not? What about 1Gbps?

Part 2: Latency and Packet Forwarding Challenge

You have a sender and a receiver, Alice and Bob, connected by a path of Z links (and $Z - 1$ switches), each with a link capacity of B bps and a propagation delay of 2ms. The maximum packet size across this network is D bits, h of which are reserved for the header, leaving at most p for the payload ($p = D - h$). Alice wants to send an M-bit file to Bob. Assume M is evenly divisible by p.

1. (3pts) Derive an equation showing how long it takes Alice to send an M-bit file to Bob over this network, assuming the network is packet-switched with store-and-forward switches.

2. (3pts) 'Cut through routing' is an alternative to store-and-forward where a switch waits for the first h bits of a packet to arrive, and then begins transmitting the packet on the next link immediately (even if the last bits of the packet haven't arrived yet). Derive an equation showing how long it takes Alice to send an M-bit file to Bob over this network, assuming the network is packet-switched with cut-through switches.

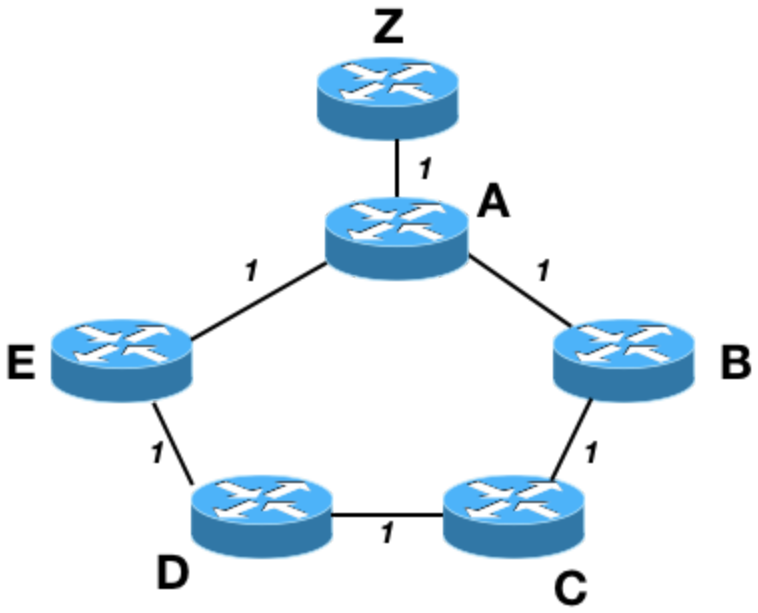
3. (3pts) Let's assume our network uses circuit switching. When Alice wants to send a file to Bob, she first sends one 'setup' packet of exactly k bits (for k < D, with k total bits in the packet including both header and payload) to B (requesting as much capacity as possible) and all of the switches act like normal store-and-forward switches. After Bob receives the setup packet, a 'circuit' has been established and the switches no longer use store-and-forward: a bit coming in on a switch immediately moves to the output port at the switch. Bob sends the k bit packet back to Alice, and then Alice is free to begin transmitting her file with no headers attached. Derive an equation showing how long it takes Alice to sends an M-bit file to Bob over this network, which is circuit switched.

4. (4pts) Let k=100 bytes, Z = 8, B = 50Mbps, D = 1550 bytes, and h = 50 bytes.
    a. (2pts) Which of the above networks will transmit a 3000 byte file fastest?

    b. (2pts) Which of the above networks will transmit a 30MB file fastest?

Part 3: Distance Vector Routing Warmup

Consider the following network where each router uses a Distance Vector Algorithm to manage routing. All routers implement Split Horizon/Poison Reverse. Each router releases a Distance Vector to its neighbors every 10 seconds, in lock step -- all at the same time.



1. (5 points) Fill in the DV table for A node after all routes have stabilized :

	Via B	Via E	Via Z
To B			
To C			
To D			
To E			
To Z			

2. (5 points) Fill in the DV table for D after all routes have stabilized.

	Via C	Via E
To A		
To B		
To C		
To E		
To Z		

3. (2 points) How many seconds does it take for all nodes in the network to discover their best routes?

4. (2 points) How many seconds does it take for all routes to stabilize (both best and backup paths)?

Part 4: Distance Vector Routing Challenge

1. (1 point) You are managing the above network, when node Z goes down entirely. You find that your network enters a “count to infinity” pattern. You read about hold down timers as a potential solution (combined with Split Horizon/Poison Reverse). When a node hears any announcement that a path to a node has gone down, it sets a “hold down timer”. First, it voids all routes to the downed node. Then*, it ignores any DV updates to the network that claim that the route is reachable until the timer expires.* After the timer expires, it accepts new updates normally.

   What is the minimum duration you should set your hold-down timer for in this network in order to avoid Count-to-Infinity?