

1/ Alice and Bob are standing at the opposite ends of a long dark tunnel.

A convoy of enemy vehicles are going to arrive at the tunnel from Alice's end, and she needs to communicate to Bob the number of vehicles (which can be any number). The only means of communication is a flashlight that Alice has, and this flashlight is visible on the other end. Design a protocol that Alice can use to communicate the number of enemy vehicles to Bob.

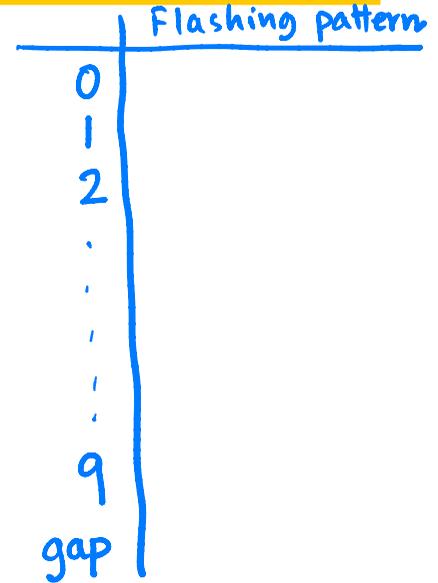
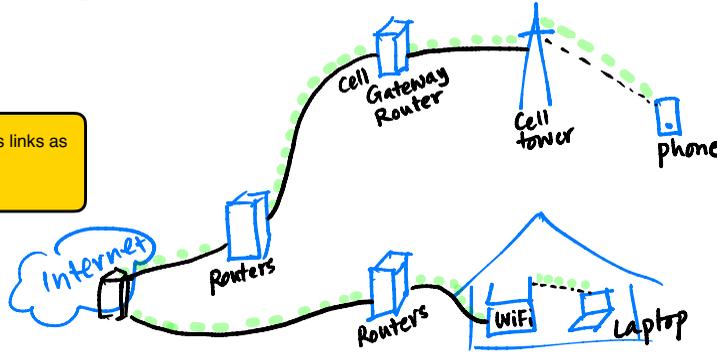
Hints: Alice needs to create some flashing pattern for each digit, and also needs to ensure that Bob can recognize the start of each digit. Remember that Alice and Bob can design the protocol in advance, so Bob knows how to interpret whatever Alice does with the flashlight by following the rules for the protocol.

2/ Order the following technologies in chronological order of their invention (as discussed in class)

VLSI ... Main frame computers ... PCs ... Internet ... Electricity ... Ethernet

③ ② ④ ⑥ ① ⑤

3/ Draw wired links as solid lines ... and wireless links as dashed lines ... to connect all the laptops and smartphones to the Internet



4/ Ronaldo has his WiFi access point plugged into the west wall of his apartment. This wall is shared with his neighbor Messi who is always playing games on the Internet. On the east side of Ronaldo's apartment is a large empty playground. If Ronaldo wants to maximize his Internet speed, then the best location to sit with his laptop is:

- (A) near the east wall because ...
- (B) near the west wall because ...
- (C) neither, because it depends on ...
- (D) doesn't matter because ....

$$\frac{\text{West}}{50 + 5}$$

$$\frac{\text{East}}{5 + 5}$$



$$\text{SINR} = \frac{\text{Signal power}}{\text{Int} + \text{Noise}}$$

Pick one and complete the argument.

5/ In a small neighborhood of 10 houses, WiFi transmission in any house can be "overheard" at any other house. Every WiFi exchange takes one-thousandth of a second to complete, before some other WiFi exchange can begin. Assume all packets are 500 bits.

Assuming perfect round robin scheduling, how much bandwidth (in bits per second) can each house get? Show your work. Writing a product or similar mathematical expression is sufficient for your answer.

6/ When I drive away from my home, my phone cannot connect to my home WiFi after some time because ...

- (A) My phone's WiFi radio experiences more noise once they go out of the home environment
- (B) My phone's WiFi radio sleeps off once it is moving ~~X~~
- (C) My phone's WiFi radio does not get the WiFi signal anymore because the phone is too far from home.
- (D) My phone's WiFi radio always gets the WiFi signal but cannot distinguish this weak signal from noise anymore. ✓

7/ Transmit power = 360 Watts at a range of 1 meter, Noise = 5 Watts, Interference = 15 Watts, SINR needed for success = 2. What is the communication range of this wireless communication technology in meters? Hint: first, set up an equation (show work), then solve it.

$$\text{SINR} \geq 2$$

$$\frac{360}{r^2} = 2 \Rightarrow \frac{360}{r^2} = 40$$

$$r^2 = 9 \quad \therefore r = 3$$

(T)  $\rightarrow$   $\text{SINR} \geq 2$       (R)  $N=5$   
 $I=15$

$$\text{SINR} = \frac{\text{Received Power}}{\text{Int} + \text{Noise}} = 2$$

8/ Ronaldo has his WiFi access point plugged into the west wall of his apartment. This wall is shared with his neighbor Messi who is always playing games on the Internet. However, Messi is on a different frequency than Ronaldo.

On the east side of Ronaldo's apartment is a large empty playground. There are no other WiFi transmission in that neighborhood.

If Ronaldo wants to maximize his Internet speed, then the best location to sit with his laptop is:

- (A) near the east wall because ...
- (B) near the west wall because ...
- (C) neither, because it depends on ...
- (D) doesn't matter because ....

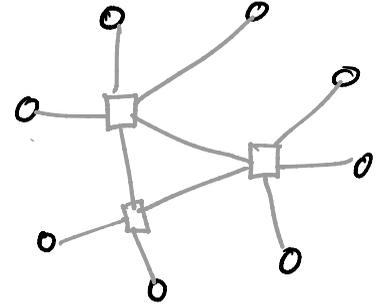
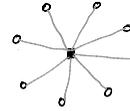
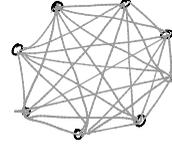
Pick one and complete the argument.

9/ Suppose you read in the newspaper: "Verizon is planning to buy a large spectrum from the television service providers, because TV business is no longer profitable". Can you explain this in your own words. What is Verizon trying to do?

using 1 router

10/ Imagine 8 computers located on a circle

- (a) connect them to form a clique (i.e., every computer directly connected to every other computer)
- (b) connect them to form a star topology ... which is a 2 level hierarchy.
- (c) you have 3 routers ... find a good way to connect them hierarchically.



11/ Fill in the blanks:

- (a) A router's forwarding table has two columns, namely \_\_\_\_\_
- (b) When a packet arrives, the router uses the packet's *destination IP address* to find which interface the packet should be forwarded.
- (c) The \_\_\_\_\_ populates the forwarding table at each router.
- (d) The routing algorithm takes \_\_\_\_\_ as the input and outputs the \_\_\_\_\_
- (e) A network graph is composed of two important components: \_\_\_\_\_ and \_\_\_\_\_
- (f) The Internet edge stores all the data, while the Internet core \_\_\_\_\_ these data.

12/ Donald suggests the following idea as an alternative to DNS. Argue why this is NOT a good design choice:

Instead of having separate DNS servers, how about we store the name-to-IP-address-mapping at every router.

This way, when my laptop sends a packet to CNN.com, the first router that gets the packet can replace CNN.com with the corresponding IP address and then forward the packet. That will completely eliminate the delay caused by DNS resolution.

13/ Explain in your own words the meaning of the phrase: "The transport protocol's task is to offer a reliable service over an unreliable network".

1/ Ans: One possibility

0: 1 second ON, 1 second OFF  
1: 1 second ON, 2 seconds OFF  
2: 1 second ON, 3 seconds OFF  
...  
9: 1 second ON, 10 seconds OFF

New digit: 2 seconds ON, 1 second OFF

2/ Ans: Electricity ... Main frame ... VLSI ... PCs ... Ethernet ... Internet

4/ Ans: [A] because ... the signal power and the interference power decrease proportional to the distance from the west wall, however the noise remains the same. So the SINR ratio is maximum near the west wall.

5/ Ans: 1000 packets can be transmitted in a second ... and 10 houses share this bandwidth in a round robin manner. So each house gets to transmit 100 packets in a second. Since each packet is 500 bits, we have  $500 \times 100$  bits transmitted per second. So each house gets  $50,000$  bits/second bandwidth = 50kbps.

6/ Ans: [D] Recall that a signal travels out of your WiFi access point all the way into deep space and reaches the moon in 1.25 seconds and Mars in 10 minutes. So it certainly reaches your car on earth. The problem is that the signal becomes weaker than noise by the time it reaches your car, hence your phone's WiFi radio is not able to decode the bits in that signal.

7/ Ans:  $(360/r^2) / (15 + 5) = 2$

Solve for r.

This means  $r^2 = 360 / 40 = 9$

Thus  $r = 3$

Communication range is 3 meters

8/ Ans: [A] because Messi does not interfere with Ronaldo and hence to maximize SNR, Ronaldo should be as close to the west wall as possible.

9/ Ans: This means that the frequencies that TV service providers were using are now being handed over to Verizon since they can use these frequencies to send Internet data to phones and other wireless devices.

10/ Ans: Connect 3 adjacent computers with a router, and then connect the 3 routers to a 4th router.

11/ (a) Destination IP address, Interface number  
(b) Destination IP address  
(c) Routing algorithm  
(d) network graph ... least cost path  
(e) nodes and links  
(f) delivers or routes or forwards or carries or trans

12/ Many reasons why this is not a good design.

For instance:

(a) all routers will need to have a huge memory to store all the mapping  
(b) If UIUC changes its own server's IP address, it needs to tell this to all routers in the world  
(c) For every incoming packet, the first router needs to spend a lot of time resolving the name to IP address. That's a traffic jam at the router.

13/ The transport protocol is keeping track of which packets are getting delivered successfully and which ones are failing, and accordingly doing the needful to repair the failed transmissions. Importantly, the protocol does not assume that packets will not fail, but is still trying to make sure that a reliable service can be established on top of an unreliable packet delivery service.

