Final

Friday, December 9, 2022 11:39 AM

Final Exam

ECE158A, Fall 2022

- This exam is to be taken under an honor code: By signing your name on this exam, you confirm that
  - you did not receive or provide aid and what you turn in is solely based on your individual work, AND
  - you treated the exam like a three-hour in-person exam where you limited your references to the course material and your own notes.
- The exam consists of 2 problems each with 4 sub-problems. Please show your work clearly to ensure you receive partial credits.
- Don't forget to write your name and PID.
- Good Luck!

....

1. Let us assume that your laptop is the only transmitter connected to the UCSD-PROTECTED wifi access point in the ECE building. Now assume another student in the building opens their laptop and have the option of selecting the same UCSD-PROTECTED access point versus another wifi access point, UCSD-ANS, that is set up in Prof Javidi's Adaptive Network Science Lab.

   Let us assume that both access points are running persistent slotted ALOHA MAC protocols where each packet only needs a time slot to be transmitted but with different transmission attempt probabilities. More specifically, your laptop is a node in the network that tries to sends its packet with probability p whenever it has a packet ready to send. The other student laptop, however, would try to send its packets with probability p whenever it has a packet ready to send and is connected to UCSD-PROTECTED while it would to send its packets with probability $q < p$ if it connects to UCSD-ANS. If both laptops are connected to the same access point and transmit at the same time, there is a collision (hence the packets need to be retransmitted).

(a) Assume that the other student chooses to connect to UCSD-ANS access point. What is the probabilities of successful transmission in a time slot for each laptop?

(b) Assume the other student chooses to connect to UCSD-PROTECTED access point. What is the probabilities of successful transmission in a time slot for each laptop?

(c) Let the packet arrival rate at each laptop's MAC queue be equal to $\lambda = \frac{1}{20}$. Compute and compare the mean waiting times under scenarios (a) and (b).

(d) Let us assume the other student transmits α percentage of the packets through UCSD-PROTECT and $1 - \alpha$ percentage through UCSD-ANS. Select α to ensure maxmin fairness.

(a) $\because$ My laptop $\rightarrow$ UCSD-Protected

Another laptop $\rightarrow$ UCSD-ANS

$\therefore$ no collision garanteed

$\therefore$ P(my successful transmission) $= p$

P(another's successful transmission) $= q$

(b) $\because$ both of us $\longrightarrow$ UCSD-Protected

$\therefore$ P(my successful transmission) $= p(1-p)$

P(another's successful transmission) $= (1-p)p$

(c) $\because$ the packet arrival rate $\lambda = \frac{1}{20}$ at any given time slot

each laptop tries to send packet at any given time slot with their own probability

$\therefore$ this model can be considered as M/M/1 Queue model.

part (a):

let T_1 be the mean waiting time for a packet in my laptop's queue

$$\therefore T_1 = \frac{1}{p - \frac{1}{20}} = \frac{20}{20p-1}.$$

let T_2 be ... ... in another laptop's queue

$$\therefore T_2 = \frac{1}{q - \frac{1}{20}} = \frac{20}{20q-1}$$

$\because q < p \quad \therefore T_2 > T_1$.

part (b):

let T_3 be ... ... in my laptop's queue

$$T_3 = \frac{1}{p(1-p) - \frac{1}{20}} = \frac{20}{20p(1-p)-1}.$$

let T_4 be ... ... in another laptop's queue.

$$T_4 = T_3 = \frac{20}{20p(1-p)-1}.$$

(d) at any given time slot,

$\rightarrow$ ANS.

$P(\text{transmit successfully}) = q$

$\rightarrow$ PROTECT

$P(\text{transmit successfully}) = p(1-p)$.

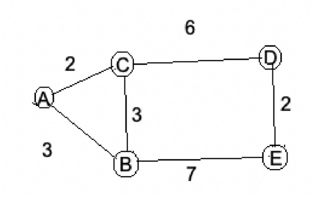
to ensure max-min fairness:

$$\alpha p(1-p) = (1-\alpha) q$$

$$\alpha(q + p(1-p)) = q. \quad \Rightarrow \quad \alpha = \frac{q}{q + p(1-p)}$$

2. (a) Consider the network shown in figure 1 where link costs (weights) are shown. Use Dijkstra's algorithm to find the shortest path from each node to destination node A.

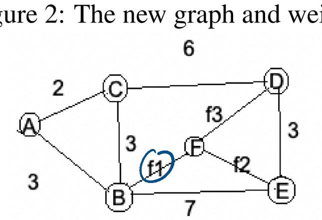
Figure 1: Graph and weights



(b) Assume the weight between E and D increases to 3 and we get an additional node F as you see in figure 2 with edges to nodes B, D, and E with costs f_1, f_2, f_3. What is the computational complexity if you re-run Dijkstra from scratch?

(c) Can you use the computations in part (a) to find the shortest path to destination node A more efficiently? What is the minimum number of additional computations needed to update the shortest path computations in a centralized manner.

Figure 2: The new graph and weights



$$\begin{cases} f_1 + f_3 + 2+3 < 2+6. \\ f_1 + f_2 < 7 \\ f_1 < 6. \end{cases}$$

(d) Put the value of $f_1 = f_2 = f_3 = 1$ and run the Bellman Ford algorithm using the values you found in part (a). How many steps does it take you to arrive at the solution?

(a)

step	N'	D(B), p(B)	D(C), p(C)	D(D), p(D)	D(E), p(E)
0	A	3, A	2, A	∞	∞
1	AC	3, A		6, C	∞
2	ACB			6, C	7, E
3	ACBD				2, E
4	ACBDE				

(b) in (b), $\because$ there is a new node.

$\therefore$ the complexity $= O(6^2)$.

(c) Yes. By centralized manner, the complexity can be reduced from $O(n^2)$ to $O(n\log n)$ where n is the number of nodes.

$\because$ node B and C are neighbours of node A.

$\therefore$ they don't need to be updated after adding node f.

$\therefore$ only nodes D, E, f needs to be updated.

$\therefore$ min additional computations $= 3$.

(d) By running the Bellman Ford algorithm, only $6-1=5$ steps required.