**Fundamentals Of Information Science** **2022 Spring**

Homework8

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# Problem 1.

Carl Coder implements a simple slotted Aloha-style MAC for his rooni's wireless network. His room has only two backlogged nodes, A and B. Carl picks a transmission probability of $2p$ for node A and $p$ for node B. Each packet is one time slot long and all transmissions occur at the beginning of a time slot.
(a) What is the utilization of Carl's network in terms of $p$ ?
(b) What value of $p$ maximizes the utilization of this network, and what is the maximum utilization?
(c) Suppose node $A$ and node $B$ can freely choose their transmission probabilities $p_A$ and $p_B$. How to choose $p_A$ and $p_B$ such that the throughput achieved by A is three times the throughput achieved by B and the utilization of his network is maximized.

**Solution.**

(a)
The probability that each time slot transmission is effective is:

$$\begin{aligned} P_{success} &= p(1-2p) + 2p(1-p) \\ &= 3p - 4p^2 \end{aligned}$$

Suppose there are N time slots,the utilization of Carl's network is:

$$\begin{aligned} U &= \frac{NP_{success}}{N} \\ &= 3p - 4p^2 \end{aligned}$$

(b)

$$U = 3p - 4p^2$$
$$\frac{dU}{dp} = 3 - 8p$$
$$let \frac{dU}{dp} = 3 - 8p = 0, we\, can\, get\, that\, when\, p = \frac{3}{8}, the\, utilization\, is\, max$$
$$p_0 = \frac{3}{8} \qquad U_{max} = \frac{9}{16}$$

(c)
According to the meaning of the question, we can get:

$$P_A(1-P_B) = 3P_B(1-P_A)$$
$$P_B = \frac{P_A}{3-2P_A}$$

The utilization is:

$$U = P_A + P_B - 2P_AP_B$$
$$U = \frac{4(P_A - P_A^2)}{3 - 2P_A}$$

$$\frac{dU}{dp} = \frac{2P_A^2 + 6P_A - 3}{(3 - 2P_A)^2}$$

Let $\frac{dU}{dp} = 0$,we can get:

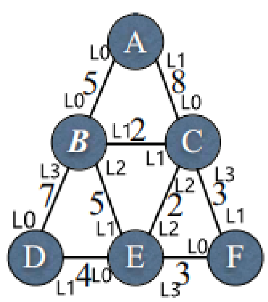
$$P_A = \frac{3 - \sqrt{3}}{2} \qquad P_B = \frac{\sqrt{3} - 1}{2}$$

At this time, utilization takes the maximum value:

$$U_{max} = 0.5359$$

## Problem 2.

Consider the the network shown in the following figure, Each node implementa Dijkstra's shortest paths algorithm using the link costs shown in the picture.




(a) Initially, node $D$ 's routing table contains only one entry, for itself. When $D$ runs Dijkstra's algorithm, in what order are nodes added to the routing table? List all possible answers.
(b) Now suppose the link cost for one of the links changes but all costs remain nonnegative. For each change in link cost listed below, state whether it is possible for the route at node $C$ (i.e., the link used by $C$ ) for any destination to change, and if so, name the destination(s) whose routes may change.

i. The cost of link (B, D) increases:
ii. The cost of link (B, D) decreases:
iii. The cost of link (B, E) increases:
iv. The cost of link (B, E) decreases:

**Solution.**

we can get two possibilities:

| Step | u | Nodeset | A | B | C | D | E | F | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | [A,B,C,D,E,F] | $\infty$ | $\infty$ | $\infty$ | 0 | $\infty$ | $\infty$ | ? | ? | ? | – | ? | ? |
| 1 | D | [A,B,C,E,F] | $\infty$ | 7 | $\infty$ | 0 | 4 | $\infty$ | ? | L0 | ? | – | L1 | ? |
| 2 | E | [A,B,C,F] | $\infty$ | 7 | 6 | 0 | 4 | 7 | ? | L0 | L1 | – | L1 | L1 |
| 3 | C | [A,B,F] | 14 | 7 | 6 | 0 | 4 | 7 | L1 | L0 | L1 | – | L1 | L1 |
| 4 | B | [A,F] | 12 | 7 | 6 | 0 | 4 | 7 | L0 | L0 | L1 | – | L1 | L1 |
| 5 | F | [A] | 12 | 7 | 6 | 0 | 4 | 7 | L0 | L0 | L1 | – | L1 | L1 |
| 6 | A | [] | 12 | 7 | 6 | 0 | 4 | 7 | L0 | L0 | L1 | – | L1 | L1 |

| Step | u | Nodeset | A | B | C | D | E | F | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | [A,B,C,D,E,F] | $\infty$ | $\infty$ | $\infty$ | 0 | $\infty$ | $\infty$ | ? | ? | ? | – | ? | ? |
| 1 | D | [A,B,C,E,F] | $\infty$ | 7 | $\infty$ | 0 | 4 | $\infty$ | ? | L0 | ? | – | L1 | ? |
| 2 | E | [A,B,C,F] | $\infty$ | 7 | 6 | 0 | 4 | 7 | ? | L0 | L1 | – | L1 | L1 |
| 3 | C | [A,B,F] | 14 | 7 | 6 | 0 | 4 | 7 | L1 | L0 | L1 | – | L1 | L1 |
| 4 | F | [A,B] | 14 | 7 | 6 | 0 | 4 | 7 | L1 | L0 | L1 | – | L1 | L1 |
| 5 | B | [A] | 12 | 7 | 6 | 0 | 4 | 7 | L0 | L0 | L1 | – | L1 | L1 |
| 6 | A | [] | 12 | 7 | 6 | 0 | 4 | 7 | L0 | L0 | L1 | – | L1 | L1 |

(1)DECBFA
(2)DECFBA

(b)
(i) if the cost of link(B,D)increases,the routes for C remain unchanged.
(ii)if the cost of link(B,D)decreases,When it decreases to less than 4, the shortest path from C to D changes from CED to CBD,so the routes for C changed
(iii)if the cost of link (B,E)increases,the route for C remain unchanged
(iv) if the cost of link (B,E)decreases,when it decrease to zero,the route CBED and CED have the same cost,so the route for C may change.

## Problem 3.

Consider the the network in Problem 2. If the network implements the distance-vector protocol, describe how the routing table at node $D$ changes after each step of integration. Given the network topology, how many steps are sufficient for the distance-vector protocol to converge (i.e., every node can find the shortest paths to its destinations).

**Solution.**

Round 1:

'D':(None,0)

Round 2:

'B':('L0;,7)
'D':(None,0)
'E':('L1',4)

Round 3:

'A':(L0,12)
'B':('L0,7)
'C':('L1',6)
'D':(None,0)
'E':('L1',4)
'F':('L1',7)

we can get at Round 3,Node D find the shortest path,but for Node E,it doesn't find the shortest paths.for E: Round 1:

'E':(None,0)

Round 2:

'B':('L1,5)
'C':('L2',2)
'D':('L0',4)
'E':(None,0)
'F':('L3',3)

Round 3:

'A':(L2,10)
'B':('L2,4)
'C':('L2',2)
'D':('L0',4)
'E':(None,0)
'F':('L3',3)

Round 4:

'A':(L2,9)
'B':('L2,4)
'C':('L2',2)
'D':('L0',4)
'E':(None,0)
'F':('L3',3)

so Node E need 4 steps to find the shortest paths,the distance-vector protocol to converge need 4 steps.

## Problem 4.

Annette Werker conducts tests between a server and a client using the sliding window protocol described in this chapter. There is no other traffic on the path and no packet loss. Annette finds that:
(1) With a window size $W_1 = 50$ packets, the throughput is 200 packets per second.

(2) With a window size $W_2 = 100$ packets, the throughput is 300 packets per second.
Annette finds that even this small amount of information allows her to calculate several things, assuming there is only one bottleneck link. Calculate the following:
(a) The minimum round-trip time between the client and server.
(b) The average queueing delay at the bottleneck when the window size is 100 packets.
(c) The average queue size when the window size is 100 packets.

**Solution.**

(a)The minimum round-trip time:

$$\begin{aligned} RTT_{min} &= W_1/200 \\ &= 0.25s \end{aligned}$$

(b,c)

$$B \cdot RTT_{min} = 75$$

because $W_2 > B \cdot RTT_{min}$,we can get:

$$W_2 = B \cdot RTT_{min} + Q$$

$$Q = 25$$

According to Little's Law(i.e.Q=B • D), the average delay D at the bottleneck is:

$$D = \frac{Q}{B} = \frac{1}{12}(seconds)$$