**Homework 3 Problems**

Due: Monday, 6 May 19

1. Consider the network with nodes A, B, C, D, E, and F as shown below.



The network carries traffic from four sessions, with arrival rates, λS, for each session indicated in the table below. Note, for example, that traffic for session ACE originates at node A, traverses links (A,C) and (C,E) and exits the network at node E.

|  |  |
| --- | --- |
| *Session* | *λS (pkts/min)* |
| ACE | 100 |
| ADE | 200 |
| BCEF | 500 |
| BDEF | 600 |

Arrivals for each session are Poisson. Packet lengths are exponentially distributed with mean of 1,000 bits. The capacity of each link in the network is 50,000 bits per second. Assume that propagation delay is negligible.

1. For each of the seven links, what is the expected delay for packets traversing that link, including time in queue and transmission time? [Hint: The arrival rate at link (A,C) is 5/3 packets/s and the expected delay for link (A,C) is 0.0207 s.]
2. For each of the seven links, what is the expected number of packets at each link, including packets being transmitted and in queue? [Hint: The expected number of packets at link (A,C) is 0.0345.]
3. For the network, what is the expected delay for a packet from any session to traverse the network from source to destination? [Hint: The answer is 0.0749 s.]
4. For each of the four sessions, what is the expected delay for a packet to traverse the network from source to destination? [The expected delay for packets from session ACE is 0.046 s.]
5. Consider a computer system as shown below. There are two job classes A & B entering the system with arrival rate of  jobs/sec and  jobs/sec. A class A job makes 10 visits to the cpu and 9 to the disk before exiting the system. Similarly Job B makes 5 visits to the CPU and 4 visits to the disk. The service times are as follows

Job A: Cpu time 0.1 sec per visit Disk service time 0.3 sec per visit

Job B: Cpu time 0.4 sec per visit Disk service time 1.0 sec per visit

Calculate the throughput (e.g. XA,CPU), utilization (e.g. UB,DISK), queue length (QA,DISK), and response time (or delay) (RB,CPU) at the cpu and disk for both type of jobs. Also calculate the system response time (RA, Total)for class A and class B jobs. (Hint, you are providing a total of 18 answers.)



Figure for problem 2

Throughput for job class A at CPU:

Throughput for job class B at CPU: 



Similarly for Disk:



Response time A = 

Response time B =

1. Consider the following network. Assume that all links are bidirectional with identical link lengths as indicated in both directions. For example, the A-to-C link has length 9 and the C-to-A link also has length 9.



Is the network 2-connected? Briefly indicate why or why not.

1. Consider the following network. Assume that all links are bidirectional with identical link lengths as indicated in both directions. For example, the A-to-E link has length 5 and the E-to-A link also has length 5.

2

1

3

1

3

5

3

4

2

3

We wish to find a minimal spanning tree for this network (graph) using Kruskal’s Algorithm. At each step in the algorithm, **specify** the identified components. **Determine** the weight of the spanning tree. Finally, **draw** the resulting spanning tree.

Step 0 Components –

Step 1 Components –

Step 2 Components –

Step 3 Components –

Step 4 Components –

Step 5 Components –

Step 6 Components –

Weight =

1. Find the shortest path tree from every node to node D for the graph below using the Dijkstra algorithms. Show the computed weights to each node at every step. Finally, draw the resulting spanning tree.



|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| i | start | D0 | D1 | D2 | D3 | D4 | D5 | D6 |
| A | ∞ |  |  |  |  |  |  |  |
| B | ∞ |  |  |  |  |  |  |  |
| D | ∞ |  |  |  |  |  |  |  |
| F | ∞ |  |  |  |  |  |  |  |
| H | ∞ |  |  |  |  |  |  |  |
| J | ∞ |  |  |  |  |  |  |  |
| Q | ∞ |  |  |  |  |  |  |  |
| P = |  | {D}  Initial |  |  |  |  |  |  |

1. Consider a 4-node network with 7 directional links as shown. There are 10 packet streams with Poisson arrivals. Packet lengths are exponentially distributed.

BD

AB

CB

BA

CA

DC

DB

(a) Fill in the following table under the assumption that all links have equal capacity 10.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| M/M/1 Network |  |  |  |  |  |  |  |  |  |  | Total |
| Total Capacity | 70 |  |  |  |  |  |  |  |  |  |  |
| Stream | Xs | S | D | AB | BD | DC | CA | CB | BA | DB |  |
| 1 | 1 | A | C |  |  |  |  |  |  |  |  |
| 2 | 2 | A | D |  |  |  |  |  |  |  |  |
| 3 | 1 | B | A |  |  |  |  |  |  |  |  |
| 4 | 3 | B | D |  |  |  |  |  |  |  |  |
| 5 | 3 | C | A |  |  |  |  |  |  |  |  |
| 6 | 1 | C | D |  |  |  |  |  |  |  |  |
| 7 | 1 | C | B |  |  |  |  |  |  |  |  |
| 8 | 2 | D | A |  |  |  |  |  |  |  |  |
| 9 | 2 | D | B |  |  |  |  |  |  |  |  |
| 10 | 3 | D | C |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |  |  |
| Ci |  |  |  |  |  |  |  |  |  |  |  |
| N |  |  |  |  |  |  |  |  |  |  |  |
| T |  |  |  |  |  |  |  |  |  |  |  |
| Utilization |  |  |  |  |  |  |  |  |  |  |  |

(b) Now re-allocate the capacity of 70, optimizing the average delay and fill the table in again.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| M/M/1 Network |  |  |  |  |  |  |  |  |  |  | Total |
| Total Capacity | 70 |  |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 |
| Stream | Xs | S | D | AB | BD | DC | CA | CB | BA | DB |  |
| 1 | 1 | A | C |  |  |  |  |  |  |  |  |
| 2 | 2 | A | D |  |  |  |  |  |  |  |  |
| 3 | 1 | B | A |  |  |  |  |  |  |  |  |
| 4 | 3 | B | D |  |  |  |  |  |  |  |  |
| 5 | 3 | C | A |  |  |  |  |  |  |  |  |
| 6 | 1 | C | D |  |  |  |  |  |  |  |  |
| 7 | 1 | C | B |  |  |  |  |  |  |  |  |
| 8 | 2 | D | A |  |  |  |  |  |  |  |  |
| 9 | 2 | D | B |  |  |  |  |  |  |  |  |
| 10 | 3 | D | C |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |  |  |
| Ci |  |  |  |  |  |  |  |  |  |  |  |
| N |  |  |  |  |  |  |  |  |  |  |  |
| T |  |  |  |  |  |  |  |  |  |  |  |
| Utilization |  |  |  |  |  |  |  |  |  |  |  |