King Fahd University of Petroleum and Minerals
College of Computer Sciences and Engineering
**Department of Computer Engineering**

**COE 444 – Internetwork Design and Management (T102)**

**Homework # 03 (*due date & time: Sunday 22/05/2011 during class period*)**

***** Show all your work. No credit will be given if work is not shown! *****

**Problem # 1 (30 points):** A company has 6 divisions, each serviced by a 10 Mbps Ethernet workgroup switch, labelled $S_1$ to $S_6$. The company has acquired three backbone switches $B_1$, $B_2$, and $B_3$, each with four interfaces. Two of these interfaces are 10 Mbps Ethernet interfaces, and the two others are 100 Mbps Fast Ethernet interfaces (i.e. **cannot** be used for 10 Mbps Ethernet connectivity).

Assume that the cost of connecting each of the workgroup switches to each of the backbone switches is as specified in the following cost matrix:

| | $B_1$ | $B_2$ | $B_3$ |
|---|---|---|---|
| $S_1$ | 2 | 5 | 9 |
| $S_2$ | 8 | 3 | 4 |
| $S_3$ | 3 | 1 | 5 |
| $S_4$ | 2 | 6 | 9 |
| $S_5$ | 2 | 7 | 3 |
| $S_6$ | 1 | 5 | 9 |

Find a minimum cost feasible assignment of the workgroup switches to the Backbone switches, and give the cost of such an optimum assignment.

**Problem # 2 (70 points):** Referring to Problem # 1, assume that the three backbone switches $B_1$, $B_2$, and $B_3$ are interconnected with full duplex links according to a tree topology with $B_1$ as the root of the tree, and $B_2$ and $B_3$ as the children of $B_1$. The links are running at Fast Ethernet speed.

Suppose that the 6 workgroup switches, labeled $S_1$ to $S_6$, are assigned as follows: $S_4$ and $S_6$ to $B_1$, $S_1$ and $S_3$ to $B_2$, and $S_2$ and $S_5$ to $B_3$. The workgroup switches are connected to the backbone switches with full duplex links of 10 Mbps speed. The average packet size has been estimated to be equal to 1000 bits. It has also been observed that the traffic (in pps) generated by the various workgroups is Poisson with rates as indicated in the following table:

| | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | $S_6$ |
|---|---|---|---|---|---|---|
| $S_1$ | - | 200 | 100 | 500 | 300 | 200 |
| $S_2$ | 200 | - | 100 | 200 | 500 | 300 |
| $S_3$ | 100 | 100 | - | 200 | 700 | 100 |
| $S_4$ | 500 | 200 | 200 | - | 500 | 500 |
| $S_5$ | 300 | 500 | 700 | 500 | - | 1000 |
| $S_6$ | 200 | 300 | 100 | 500 | 1000 | - |

**a.** **(15 points)** Find the internal traffic rates on all the links, that is $\lambda_{Si,Bj}$, and $\lambda_{Bj,Si}$, i = 1, …, 6, j = 1, 2, 3, where $S_i$ is connected to $B_j$, and $\lambda_{Bi,Bj}$, i, j = 1, 2, 3, i ≠ j and the link between $B_i$ and $B_j$ exists.

**b.** **(10 points)** Find the utilizations of all the links, that is $\rho_{Si,Bj}$, and $\rho_{Bj,Si}$, i = 1, …, 6, j = 1, 2, 3, where $S_i$ is connected to $B_j$, and $\rho_{Bi,Bj}$, i, j = 1, 2, 3, i ≠ j and the link between $B_i$ and $B_j$ exists.

**c.** **(5 points)** Which link constitutes the primary bottleneck link?

**d.** **(15 points)** What is the average number of links **ñ** traversed by a packet to go from any source to any destination?

**e.** **(15 points)** Find ***T***, the average delay suffered by a packet to go from any workgroup switch to any other workgroup switch.

**f.** **(10 points)** What is the largest load that can be sustained by the network before any of its links saturate?