

**COE 444 - Internetwork Design and Management
Fall 2004 (Term 041)**

**Homework 7
- Solution -**

Date: Monday, December 13, 2004

Problem1

Q1. The optimal solution to this terminal assignment problem is:

(a, C), (b, C), (c, A), (d, A), (e, B), (f, B)

The total cost is: **13**

Q2.

- a. $\gamma_{AB} = \gamma_{BA} = 130$ pps, $\gamma_{AC} = \gamma_{CA} = 90$ pps, $\gamma_{BC} = \gamma_{CB} = 150$ pps,
- b. $\lambda_{AB} = 370$ pps, $\lambda_{BC} = 370$ pps, and $\lambda_{CA} = 370$ pps.
- c. $\rho_{AB} = \rho_{BC} = \rho_{AC} = 37\% \rightarrow$ All links are primary bottlenecks
- d. The average number of links \bar{n} traversed by a packet to go from any source to any destination is: **1.5 links**
- e. The average delay per packet $T = 2.4$ ms
- f. The largest factor that will cause the network to saturate is: $\alpha_{\max} = 2.70$

Problem2

Q1. The optimal solution to this terminal assignment problem is:

(S1, B2), (S2, B3), (S3, B2), (S4, B1), (S5, B3), (S6, B1)

The total cost is: **15**

Q2.

- a. $\lambda_{S1,B2} = \lambda_{B2,S1} = 1300$ pps,
 $\lambda_{S2,B3} = \lambda_{B3,S2} = 1500$ pps,
 $\lambda_{S3,B2} = \lambda_{B2,S3} = 1700$ pps,
 $\lambda_{S4,B1} = \lambda_{B1,S4} = 2100$ pps,
 $\lambda_{S5,B3} = \lambda_{B3,S5} = 2400$ pps,
 $\lambda_{S6,B1} = \lambda_{B1,S6} = 2400$ pps,
 $\gamma_{B1,B2} = \gamma_{B2,B1} = 1200$ pps,
 $\gamma_{B1,B3} = \gamma_{B3,B1} = 2300$ pps,

$$\begin{aligned}\gamma_{B2,B3} &= \gamma_{B3,B2} = 800 \text{ pps,} \\ \lambda_{B1,B2} &= \lambda_{B2,B1} = 2000 \text{ pps,} \\ \lambda_{B1,B3} &= \lambda_{B3,B1} = 3100 \text{ pps.}\end{aligned}$$

- b. $\rho_{S1,B2} = \rho_{B2,S1} = 13 \%$,
 $\rho_{S2,B3} = \rho_{B3,S2} = 15 \%$,
 $\rho_{S3,B2} = \rho_{B2,S3} = 17 \%$,
 $\rho_{S4,B1} = \rho_{B1,S4} = 21 \%$,
 $\rho_{S5,B3} = \rho_{B3,S5} = 24 \%$,
 $\rho_{S6,B1} = \rho_{B1,S6} = 24 \%$,
 $\rho_{B1,B2} = \rho_{B2,B1} = 2 \%$,
 $\rho_{B1,B3} = \rho_{B3,B1} = 3.1 \%$.
- c. **(S5, B3)** and **(S6, B1)** constitutes the primary bottleneck links.
- d. The average number of links \bar{n} traversed by a packet to go from any source to any destination is: **2.89 links**
- e. The average delay per packet $T = 260 \mu\text{s}$
- f. The largest factor that will cause the network to saturate is: $\alpha_{\max} = 4.17$

Q3.

- a. Find P_l and P_s , the links and switches reliabilities (use precision at 10^{-5})

$$P_l = 0.99945$$

$$P_s = 0.99909$$

- b. Find the overall network reliability, that is, the probability that the network is connected.

$$P_c(T) = 0.98749$$

- c. Find $E(B_1)$, the expected number of nodes communicating with the root node B_1 .

$$E(B_1) = 8.97431$$

- d. Find $EPR(B_1)$, the expected number of node pairs communicating through the root node B_1 .

$$EPR(B_1) = 29.86$$