# Chapter 4
# Comparison of the Maximum Satisfaction Method with the Minimum Cost Method

## 4.1 Comparison by examples

Consider a network topology G = $\langle N, L \rangle$ as given in **Figure 2.2**. Given the cost consisting of delay and the purchasing cost of bandwidth for each link: $k_1 = \$5$, $k_2 = \$6$, $k_3 = \$10$, $k_4 = \$5$, $k_5 = \$4$, $k_6 = \$11$, $k_7 = \$6$, $k_8 = \$8$, $k_9 = \$6$, $k_{10} = \$7$, $k_{11} = \$12$, $k_{12} = \$6$, $k_{13} = \$5$, and $k_{14} = \$6$.

There are also given the maximal capacity of each link: $U_1 = 2{,}300$ kbps (i.e. kilobits/sec), $U_2 = 3{,}500$ kbps, $U_3 = 1{,}000$ kbps, $U_4 = 2{,}500$ kbps, $U_5 = 2{,}100$ kbps, $U_6 = 2200$ kbps, $U_7 = 2000$ kbps, $U_8 = 3000$ kbps, $U_9 = 2100$ kbps, $U_{10} = 2700$ kbps, $U_{11} = 1500$ kbps, $U_{12} = 1800$ kbps, $U_{13} = 3000$ kbps, and $U_{14} = 3500$ kbps. There are given three classes under the total available budget $B$ = \$90000, \$100000, \$110000, \$120000, \$130000, \$140000. The number of connection is $\lambda_i$, $i = 1, 2, 3$.

**Table 4.1 The bandwidth requirement and Average number of connections**

| Class | Bandwidth requirement | Average number of connections |
|---|---|---|
| 1 | 167 kbps | 10 |
| 2 | 83 kbps | 10 |
| 3 | 28 kbps | 10 |

**MCM** offers the system manager to estimate the quality of service in terms of bandwidth on networks and minimize the cost with which we can satisfy *Q*% of total bandwidth requirement. **MSM** offers the system manager to maximize the satisfaction with a total budget. Mathematically, MSM is a special case of **MCM.** That is, **MCM** becomes **MSM** as we lay out **MCM** to satisfy maximum bandwidth requirement.

We compare **MSM** with **MCM,** where we set up **MCM** to satisfy 95% of total bandwidth requirement, and the comparisons are given in the following table:

**Table 4.2 Compare MSM with MCM**

| | **MSM** | **MCM** | **MSM vs. MCM** |
|---|---|---|---|
| Budget | $80000 | $80000 | |
| Cost | $80000 | $79767.4 | -0.29% |
| Bandwidth | 4000 kbps | 3988 kbps | -0.30% |
| Satisfaction | 0.6092 | 0.6073 | -0.31% |
| Budget | $90000 | $90000 | |
| Cost | $90000 | $79767.4 | -11.37% |
| Bandwidth | 4500 kbps | 3988 kbps | -11.38% |
| Satisfaction | 0.7053 | 0.6073 | -13.89% |
| Budget | $100000 | $100000 | |
| Cost | $100000 | $79767.4 | -20.23% |
| Bandwidth | 5000 kbps | 3988 kbps | -20.24% |
| Satisfaction | 0.8152 | 0.6073 | -25.50% |

| | | | |
|---|---|---|---|
| Budget | $110000 | $110000 | |
| Cost | $110000 | $79767.4 | -27.48% |
| Bandwidth | 5472.7 kbps | 3988 kbps | -27.13% |
| Satisfaction | 0.9040 | 0.6073 | -32.82% |
| Budget | $120000 | $120000 | |
| Cost | $120000 | $79767.4 | -33.53% |
| Bandwidth | 5927.3 kbps | 3988 kbps | -32.72% |
| Satisfaction | 0.9807 | 0.6073 | -38.07% |
| Budget | $130000 | $130000 | |
| Cost | $130000 | $79767.4 | -38.64% |
| Bandwidth | 6375 kbps | 3988 kbps | -37.44% |
| Satisfaction | 1.0494 | 0.6073 | -42.13% |
| Budget | $140000 | $140000 | |
| Cost | $140000 | $79767.4 | -43.02% |
| Bandwidth | 6791.7 kbps | 3988 kbps | -41.28% |
| Satisfaction | 1.1082 | 0.6073 | -45.20% |

From **Table 4.2**, we learn that in simulation satisfaction degrades almost as the same percentage as the cost is reduced although the bandwidth requirements are kept the same for 95% guarantee. It is a tradeoff between cost and satisfaction. However, one may construct other satisfaction functions according to users' traffic patterns or network behaviors which reflect greater dependence on bandwidth than utilization. By a specified definition of satisfaction, MCM may be preferable to MSM.

## 4.2 Another Network

In this section, we are examining a different network topology to check the property that is observed in Section 4.1. The conclusion from our simulation tests are the same: MCM is preferable to MSM if bandwidth reflects the users' satisfaction in specific definition.

Let a network topology G $=\langle N,L\rangle$ [13] as **F igure 2.3**. Let SEA and MIA be the source and destination respectively. Each connection is delivered from source to destination. Given the cost taking account of delay and the purchasing cost of bandwidth for each link: $k_1=\$5$, $k_2=\$6$, $k_3=\$10$, $k_4=\$5$, $k_5=\$4$, $k_6=\$11$, $k_7=\$6$, $k_8=\$8$, $k_9=\$6$, $k_{10}=\$7$, $k_{11}=\$12$, $k_{12}=\$6$, $k_{13}=\$5$, and $k_{14}=\$6$.

There are also given the maximal capacity of each link: $U_1=2{,}300$ kbps (i.e. kilobits/sec), $U_2=3{,}500$ kbps, $U_3=1{,}000$ kbps, $U_4=2{,}500$ kbps, $U_5=2{,}100$ kbps, $U_6=2200$ kbps, $U_7=2000$ kbps, $U_8=3000$ kbps, $U_9=2100$ kbps, $U_{10}=2700$ kbps, $U_{11}=1500$ kbps, $U_{12}=1800$ kbps, $U_{13}=3000$ kbps, and $U_{14}=3500$ kbps.

Under the total available budget $B$ = \$100000. There are given three classes (as Table 1 shows). The number of connection is $\lambda_i$ $i=1,\ 2,\ 3$.

**Table 4.3 The bandwidth requirement and Average number of connections**

| Class | Bandwidth requirement | Average number of connections |
|---|---|---|
| 1 | 167 kbps | 5 |
| 2 | 83 kbps | 5 |
| 3 | 28 kbps | 10 |

We compare **MSM** with **MCM** by the results decide by the two methods respectively.  And the comparisons are following:

**Table 4.4 Compare MSM with MCM**

| | MSM | MCM | MSM vs. MCM |
|---|---|---|---|
| Budget | $45000 | $45000 | |
| Cost | $45000 | $42030 | -6.60% |
| Bandwidth | 2600 kbps | 2484 kbps | -4.46% |
| Satisfaction | 0.5357 | 0.4926 | -8.05% |
| Budget | $50000 | $50000 | |
| Cost | $50000 | $42030 | -15.94% |
| Bandwidth | 2785.2 kbps | 2484 kbps | -10.81% |
| Satisfaction | 0.6043 | 0.4926 | -18.48% |
| Budget | $55000 | $55000 | |
| Cost | $55000 | $42030 | -23.58% |
| Bandwidth | 2970.4 kbps | 2484 kbps | -16.37% |
| Satisfaction | 0.6685 | 0.4926 | -26.31% |
| Budget | $60000 | $60000 | |
| Cost | $60000 | $42030 | -29.95% |
| Bandwidth | 3138.5 kbps | 2484 kbps | -20.85% |
| Satisfaction | 0.7235 | 0.4926 | -31.91% |
| Budget | $65000 | $65000 | |
| Cost | $65000 | $42030 | -35.34% |
| Bandwidth | 3266.7 kbps | 2484 kbps | -23.96% |
| Satisfaction | 0.7635 | 0.4926 | -35.48% |
| Budget | $70000 | $70000 | |

| | | | |
|---|---|---|---|
| Cost | $70000 | $42030 | -39.96% |
| Bandwidth | 3394.9 kbps | 2484 kbps | -26.83% |
| Satisfaction | 0.8020 | 0.4926 | -38.58% |
| Budget | $75000 | $75000 | |
| Cost | $74100 | $42030 | -43.28% |
| Bandwidth | 3500 kbps | 2484 kbps | -29.03% |
| Satisfaction | 0.8328 | 0.4926 | -40.85% |

From **Table 4.4**, we have the same conclusion as from **Table 4.2**.