Networks and Data Communication, Fall 04

Lecture 10. Introduction into QoS
Exercises

1. QoS Routing
Consider the following Network Topology:

All links have a capacity of 2Mb/s. Out of the six core routers R1,…,R6, only three act as Edge Routers to some access networks, i.e. traffic enters and leaves the network at E1,E2,E3.
Consider the following traffic matrix:

\[
T = \begin{bmatrix}
0 & 0.2 & 0.56 \\
0.6 & 0 & 0.8 \\
0.3 & 0.7 & 0
\end{bmatrix}
\]

The element \(T_{ij}\) thereby indicates the traffic rate in Mb/s on data flows between \(E_i\) and \(E_j\).

a) Traditional routing: Determine the link utilization if shortest path routing is used based on hop-count. If two or more equivalent (wrt. Hop-count) paths exist, the next-hop router with the lowest number is chosen. [use figure above]

b) QoS Routing I: As a modification, routing is performed based on measured packet-loss rates on the individual links. Those are measured to be: \(p_{12}=p_{21}=5\%\), \(p_{23}=p_{32}=7\%\), \(p_{34}=p_{43}=12\%\), \(p_{14}=p_{41}=0.1\%\), \(p_{45}=p_{54}=20\%\), \(p_{56}=p_{65}=8\%\), \(p_{61}=p_{16}=3\%\)

- The path costs should be calculated as probability of packet loss for the end-2-end transmission, assuming the packet loss on the links is independent of each other. Develop the formula for the path cost \(c(P_i)\) using path \(P_1=R1\rightarrow R2\rightarrow R3\) as an example. (Note: link-loss is not additive!)
- Once you have determined the general formula for Path P1, use a Matlab program to compute all Path metrics (make use of symmetry & talk to supervisor about it).
- What are the new link utilizations for the traffic matrix above, if routing is performed based on this new path metric?[use first figure below]

c) QoS Routing II: Determine the link utilization, if the widest-shortest-path algorithm from the lecture is applied (Slide 36). Assume that the flows are routed according to the following order: T12, T13, T21, T23, T31, T32 [Use the router number as stated in (1a) as final decision rule, if there are still several paths remaining. Use figure below.]

d) A new network is built with same topology but 5Mb/s links. Assuming traditional routing, when would the network run into congestion, if the traffic matrix T from above is assumed today, but a yearly growth rate of traffic of 50% (equally for all flows) is predicted?