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Exam Revision Notes

This is exam revision notes to be condensed to a cheat sheet for the exam.;

Networks

The nodes in the network correspond to routers, and the edges of the network correspond to transmission links. Links will be notated with an integer that is representing some unit of capacity *Mb/s, Gb/s, Tb/s*. This defines the total amount of traffic that can be put on a link.

Minimum Cost Routing Formulation

In a minimum cost example, we also have a **cost**, these costs can be associated with an individual link or an entire path within the demand volume, for simplicity we will apply a cost to the entire path for this example.

A cost is notated with the following notation ϕ_{path}.

We want to find values for our decision variables x_{12}, x_{132} which **minimise** the total cost for serving the demand volume. We can now express the minimum-cost linear program for the single-commodity problem:

$$\begin{aligned} \text{min}_{[x]} \quad & \phi_{12}x_{12} + \phi_{132}x_{132} \\ \text{s.t} \quad & x_{12} + x_{132} = h \\ & x_{12}, x_{132} \geq 0 \\ & x_{12} \leq c_{12} \\ & x_{132} \leq c_{132} \end{aligned}$$

The above formulation is an example of an *optimization problem*, in which we aim to minimise the value of the objective function for all feasible solutions.

Load Balancing Formulation

We now establish another function by exchanging the objective function. We again consider the network from Figure 1, but our new aim is to balance the load properly. The goal is to make sure that path/link utilization is the same on both available paths. Or at least as close as possible.

Path utilization can be expressed in the following fashion:

$$\frac{x_{12}}{c_{12}}, \frac{x_{132}}{c_{132}}$$

$$\begin{aligned}
\text{minimise}_{[x]} \quad & max(\frac{x_{12}}{c_{12}}, \frac{x_{132}}{c_{132}}) \\
\text{s.t} \quad & x_{12} + x_{132} = h \\
& x_{12}, x_{132} \geq 0 \\
& x_{12} \leq c_{12} \\
& x_{132} \leq c_{132}
\end{aligned}$$

The reason this problem formulation makes sense is because by minimising the highest value of $x \in X$, the optimal solution will have the least distance between the possible paths x_{ij}.

Averaging Delay Formulation

If we want to minimize the average delay, then we need some idea how we can calculate the average delay on a path. For starters, each link along a path incurs its own delay and the delay of a path is the sum of the delays across all links within this path.

There are several factors that cause delay on a link, including the propagation delay, bitrate of the link, router processing times, and the delay introduced by queueing packets in the router output buffers for the link in question. Here we are only concerned with queueing delay.

The delay on a link can be expressed in the following fashion:

$$d_{12} = \frac{x_{12}}{c_{12} - x_{12}}$$

The problem formulation is then as follows:

$$
\begin{aligned}
\text{minimise}_{[x]} \quad & max(\frac{x_{12}}{c_{12}}, \frac{x_{132}}{c_{132}}) \\
\text{s.t} \quad & x_{12} + x_{132} = h \\
& x_{12}, x_{132} \geq 0 \\
& x_{12} \leq c_{12} \\
& x_{132} \leq c_{132}
\end{aligned}
$$

Capacity Design Problems