

# COMP9334 Revision Problems for Week 11

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1. A network is represented as a directed graph  $G = (N, E)$  where  $N = \{1, 2, \dots, n\}$  is the set of nodes and  $E$  is the set of directed edges. The cost of using link  $e_{ij} \in E$  is  $c_{ij}$  and the remaining capacity on link  $e_{ij}$  is  $r_{ij}$ . The propagation delay of link  $e_{ij}$  is  $d_{ij}$ . A customer of the network wants the network to carry a flow of size  $b$  for it. The customer has the following requirements:
  - The flow's source and destination are respectively node  $n_1 \in N$  and node  $n_2 \in N$
  - The network must provide 2 different paths with for the flow. The flow normally uses only the first path but if it fails, it is switched to the second (or backup) path.
  - Both paths begin at the source and end at the destination.
  - All the links of both path must have at least a capacity  $b$ , i.e. links with a residual capacity less than  $b$  cannot be used.
  - The total propagation delay in each path must not be greater than  $d_{\max}$
  - The two paths must not have any common link.
  - The total cost of the two paths is minimised.
- (a) Formulate an integer programming problem which solves for both paths simultaneously.
- (b) Using the data given below, find the paths for the customer.
  - Number of nodes = 6. The nodes and edges in the network are defined overleaf in AMPL format.
  - The cost, propagation delay and residual bandwidth are given overleaf in AMPL format.
  - Source node = 1. Destination node = 4;
  - $b = 2$ .
  - $d_{\max} = 8$ .

You will find the following pre-ample useful if you are using AMPL.  
In the "mod" file:

```
set NODES; #set of nodes
set EDGES within {i1 in NODES,i2 in NODES: i1 <> i2}; #set of edges
param cost {(i,j) in EDGES};
param delay {(i,j) in EDGES};
param remaining_bandwidth {(i,j) in EDGES};
```

In the "dat" file:

```
set NODES := 1,2,3,4,5,6;
set EDGES := (1,2),(2,1),(2,3),(3,2),(3,4),(4,3),(4,5),(5,4),(5,6),(6,5),
(1,6),(6,1),(2,6),(6,2),(2,5),(5,2),(3,6),(6,3),(3,5),(5,3);
```

param:	cost	delay	remaining_bandwidth	:=
[1,2]	1	5	9	
[2,1]	3	1	6	
[2,3]	2	4	4	
[3,2]	3	3	3	
[3,4]	2	1	4	
[4,3]	3	3	7	
[4,5]	3	3	4	
[5,4]	2	4	4	
[5,6]	4	3	5	
[6,5]	1	1	6	
[1,6]	3	3	3	
[6,1]	4	4	4	
[2,6]	2	1	5	
[6,2]	3	2	6	
[2,5]	1	2	7	
[5,2]	2	2	9	
[3,6]	1	2	3	
[6,3]	3	1	4	
[3,5]	2	3	1	
[5,3]	2	3	3;	