Redes de Alto Débito (25/26)

Project Description

The project will be focused on the study of the backbone part of transport networks. A transport network is a physical infrastructure used to interconnect in a transparent manner the nodes of different service networks. These networks can be classified as optical networks, since their links are implemented using optical fibres. The physical topologies of some of real-word optical transport networks are provided in http://www.av.it.pt/anp/on/refnet2.html. The final outcome of the project is a written report.

The network used in the project is the "Germany Network (GERMANY)". The city numbering is provided in Table I. The networks for each group are obtained by removing specific nodes from the Germany network, as indicated in Table II and replacing it with simple links. Note that the physical topologies corresponding to this network is given on the linked site above. The initial step in the analysis is to create the corresponding weighted graph, using the length of the links as an attribute and the city numbers given in Table 1. To calculate the link lengths, it is recommended to use Google Earth Pro in order to determine the distances between different cities and then multiply this value by the factor given in Table.2.

The first phase of the project involves the study of the network node degrees. This study requires the knowledge of the minimum, maximum and average node degree $< \delta >$, the degree variance $\sigma^2(\delta)$, and the degree distribution. This distribution is assessed by generating a histogram of the degrees. To perform this study, one assumes that the network is modelled as an unweighted graph. The procedure for calculating these parameters must be detailed in the final report.

The second phase requires both the weighted graph and unweighted graph, and involves the following steps:

a) Compute all the shortest paths between all the nodes and the corresponding distances in the weighted and in the unweighted graphs [1].
b) Using the values of the distances previously computed obtain one histogram for the number of hops, and another one for the node distances, and comment the results obtained.
c) Determine the average number of hops per demand and the network diameter. Explain how these parameters are calculated. Compare the values of the average number of hops obtained with those calculated using estimation equations.
d) Determine the node connectivity, the edge connectivity, the minimum node degree, and explain how they relate. Although not mandatory, the comparison with the algebraic connectivity would be interesting.
e) Determine the minimum x-y node cut set and the minimum x-y edge cut set, where x and y are given in Table 2.
f) Find a service path and all the backup paths between x and y, and indicate what criteria were used to find the different paths.

The third phase uses the physical topology with the specified nodes removed and requires the knowledge of the traffic matrix, which is given in Table 3. In this matrix, the traffic is given in Gb/s and the nodes are those defined Table 1.

In this situation determine:

1) The traffic matrix and the demand matrix.
2) Solve the uncapacitated routing problem using as metrics the number of hops and the total path length (distance). For these two metrics consider the following sorting strategies: shortest-first, longest-first, and largest-first. Compute the loads (Gb/s units) in all the links for the different metrics/sorting strategies and represent them through a bar chart. Explain which sorting strategy

[1] It is suggested to use the program routing_v2_proj to do these calculations

is the best, considering that this is the one that leads to the most balanced solution for the two metrics.

3) Solve the capacitated routing problem by using the number of hops and the total path length (distance) as metrics and adopting the longest-first as the sorting strategy. In the first step, assume that the capacities of all the links are identical and set these capacities to be equal to the maximum value of the load (l_{max}) obtained in 2) for the specified metric and sorting strategy. Then, define $u(i,j) = \alpha \times l_{max}$, where $u(i,j)$ is the capacity of link (i,j). In the following steps, gradually decrease the value of α, starting from $\alpha = 1$, until the blocking ratio exceeds 0.5. For each step, compute the blocking ratio, the maximum path length, and the average path length. Represent both the blocking ratio and the paths lengths as a function of the link´s capacity in a chart. Explain the results obtained.

Table 1: City Numbers

City	Number	City	Number
Norden	1	Suttgart	10
Bremen	2	Karlsruhe	11
Hamburg	3	Mannheim	12
Hannover	4	Frankfurt	13
Berlin	5	Koln	14
Leipzig	6	Dusseldorf	15
Nurnberg	7	Essen	16
Munich	8	Dortmund	17
Ulm	9		

Table 2

Group	Nodes Removed	Distance Factor	X	Y
1	Mannheim	1.1	Berlin	Koln
2	Ulm	1.2	Berlin	Frankfurt
3	Essen	1.3	Berlin	Munich
4	Mannheim	1.4	Berlin	Norden
5	Essen	1.5	Berlin	Suttgart
6	Ulm	1.6	Berlim	Dusseldorf
7	Essen	1.7	Hamburg	Frankfurt
8	Mannheim	1.8	Hamburg	Suttgart
9	Ulm	1.9	Hamburg	Munich
10	Mannheim	2.0	Hamburg	Dusseldorf
11	Essen	0.99	Hamburg	Koln
12	Ulm	0.98	Hamburg	Nurnberg
13	Essen	0.97	Hannover	Suttgart
14	Mannheim	0.96	Hannover	Munich

Table 3: Traffic Matrix

Node s \ Node d	1	2	3	4	5	6	7	8	10	11	13	14	15	17
1	0	X	Y	Z	X	Y	0	X	Y	0	X	0	0	0
2	X	0	X	Y	0	X	0	Z	X	Y	Z	0	0	Z
3	Y	X	0	X	Y	0	X	0	Z	X	0	Z	0	0
4	Z	Y	X	0	X	Y	Z	0	0	Z	X	0	Z	0
5	X	0	Y	X	0	X	Y	Z	0	Y	0	0	0	Z
6	Y	X	0	Y	X	0	X	Y	Z	X	Y	0	X	0
7	0	0	X	Z	Y	X	0	X	Y	Z	X	0	Z	X
8	X	Z	0	0	Z	Y	X	0	X	Y	Z	X	0	Z
10	Y	X	Z	0	0	Z	Y	X	0	X	Y	Z	X	Y
11	0	Y	X	Z	Y	X	Z	Y	X	0	X	Y	Z	X
13	X	Z	0	X	0	Y	X	Z	Y	X	0	X	Y	Z
14	0	0	Z	0	0	0	0	X	Z	Y	X	0	X	Y
15	0	0	0	Z	0	X	Z	0	X	Z	Y	X	0	X
17	0	Z	0	0	Z	0	X	Z	Y	X	Z	Y	X	0

Table 4: Project Parameters

Group	*X* (Gb/s)	*Y*(Gb/s)	*Z*(Gb/s)
1	25	40	60
2	25	41	59
3	26	42	58
4	26	43	57
5	27	44	56
6	27	45	55
7	28	46	54
8	28	47	53
9	29	48	52
10	29	49	51
11	30	50	50
12	30	51	49
13	31	52	57
14	31	53	56