Redes de Alto Débito (24/25)

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 networks used in the project are: “National Science Foundation Network (NSFNET)” and “Italy Network (ITALY)”. The networks to be used by each group are described in Table 1. Note that the physical topologies corresponding to these networks are given on the linked site above. Furthermore, these topologies are to be modified in the third phase of the project by removing a link, as specified in Table 1. The initial step in the analysis involves obtaining the corresponding weighted graph, using the length of the links as an attribute. To calculate the link lengths, it is recommended to use Google Earth or Google Earth Pro in order to determine the distances between different cities and then multiply this value by the factor given in Table.1 It is suggested to assign numbers to the city names in the graph generation.

The first phase of the project involves the study of the network node degrees. This study requires the knowledge of the average node degree $<\delta>$, variance of the degrees $\sigma^2(\delta)$, and the distribution of the degrees. This distribution is assessed by generating a histogram of the degrees. To perform this study, one assumes that the network is described through an unweighted graph.

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 average no degree, and explain how they relate.
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 1.
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 original physical topology without the link referred and requires the knowledge of the traffic matrix. The traffic matrix is given in Table 2, and the traffic units are (Gb/s).

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

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

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

Group	Network	Link Removed	Distance Factor	X	Y
1	ITALY	Milan-Venice	1.1	Milan	Rome
2	ITALY	Milan-Florence	1.2	Milan	Naples
3	ITALY	Milan-Bologna	1.3	Milan	Cagliari
4	ITALY	Turin-Bologna	1.4	Milan	Bari
5	ITALY	Milan-Genoa	1.5	Bologna	Naples
6	ITALY	Florence-Bologna	1.6	Florence	Naples
7	ITALY	Pescara-Naples	1.7	Roma	Venice
8	ITALY	Naples-Bari	1.8	Roma	Caglari
9	ITALY	Florence-Naples	1.9	Naples	Venice
10	ITALY	Bologna-Naples	2.0	Naples	Roma
11	NSFNET	Pittsburgh-Princeton	0.99	Seatle	Ithaca
12	NSFNET	Pittsburgh-Ithaca	0.98	Seattle	Princeton
13	NSFNET	Ann Arbor-Princeton	0.97	Houston	Princeton
14	NSFNET	Ithaca-Colege Pk (Maryland)	0.96	Houston	Pittsburgh
15	NSFNET	Colege Pk-Princeton	0.95	Houston	Seattle
16	NSFNET	Ann Arbot-Ithaca	0.94	San Diego	Pittsburgh
17	NSFNET	Ithaca-Pittsburgh	0.93	San Diego	Ann Arbor
18	NSFNET	Princeton-Pittsburgh	0.92	Palo Alto	Princeton
19	NSFNET	Princeton-Colege Pk	0.91	Palo Alto	Houton
20	NSFNET	Ithaca-Colege Pk	0.9	Palo Alto	Pittsburgh
21	ITALY	Florence-Rome	2.1	Turin	Pescara

Table 2: Traffic Matrix

Node s \ Node d	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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
9	Y	X	Z	0	0	Z	Y	X	0	X	Y	Z	X	Y
10	0	Y	X	Z	Y	X	Z	Y	X	0	X	Y	Z	X
11	X	Z	0	X	0	Y	X	Z	Y	X	0	X	Y	Z
12	0	0	Z	0	0	0	0	X	Z	Y	X	0	X	Y
13	0	0	0	Z	0	X	Z	0	X	Z	Y	X	0	X
14	0	Z	0	0	Z	0	X	Z	Y	X	Z	Y	Y	0

Table 3: Project Parameters

Group	*X* (Gb/s)	*Y*(Gb/s)	*Z*(Gb/s)
1	25	40	60
2	25	41	59
3	25	42	57
4	26	43	56
5	26	44	55
6	26	45	56
7	27	46	57
8	27	47	58
9	27	48	59
10	28	49	60
11	28	50	59
12	28	49	58
13	29	48	57
14	29	47	56
15	29	46	55
16	30	45	56
17	30	44	57
18	30	43	58
19	31	42	59
20	31	41	60
21	31	40	59