Redes de Alto Débito (23/24)

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 (see slides 62-64, Chap. 2). 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 given in http://www.av.it.pt/anp/on/refnet2.html.

The networks used in the project are "The Very-High Performance Backbone Network Service (vBNS)" and "Czech Education and Scientific Network (CESNET)". The networks to be used by each group are described in Table 1. Note that the physical topologies corresponding to these networks are given in the linked site above. Furthermore, these topologies are to be modified by adding an extra 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 Maps 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.
c) Determine the average number of hops per demand and the network diameter. Explain how these parameters are calculated.
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*.

The third phase uses the original physical topology (**without the extra link**) of the project and requires the knowledge of the traffic matrix. The traffic matrix is given in Table 2, and the traffic units are (Gb/s). The values provided for the elements of the traffic matrix must be corrected with the factor $(1+\bar{d}/d_{ij})$ where d_{ij} is the shortest distance between the nodes i and j, and $\bar{d}$ is the average distance calculated between all the nodes.

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 what the best sorting

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

strategy is, 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 as a metric and adopting the shortest-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. Define then the following steps: 1) $u(i,j) = l_{max}$, where $u(i,j)$ is the capacity of link (i,j); 2) $u(i,j) = 0.95 \times l_{max}$; 3) $u(i,j) = 0.9 \times l_{max}$; 4)) $u(i,j) = 0.85 \times l_{max}$, and so on up to the point where the blocking ratio is larger than 0.5 For each step, compute the blocking ratio, maximum path length, and average path length, and represent both the blocking ratio and the paths lengths on a graph. Explain the results obtained.

Table 1

Group	Network	Link Added	Distance Factor	X	Y
1	CESNET	Pilsen-Usti	2	Praga	Budweiss
2	CESNET	Pardubice-Jihlava	2.2	Praga	Olomouc
3	CESNET	Pardubice-Brno	2.4	Budweiss	Brno
4	CESNET	Pardubice-Budweiss	2.6	Hradec	Olomouc
5	CESNET	Hradec-Ostrava	2.8	Praga	Brno
6	CESNET	Liberec- Ostrava	3	Ostrava	Budweiss
7	CESNET	Brno-Hradec	3.2	Pardubice	Brno
8	vBNS	Seatle-Chicago	1	San Francisco	Chicago
9	vBNS	Los Angeles-Chicago	0.98	San Francico	Houston
10	vBNS	Chicago-Atlanta	0.96	Chicago	Atlanta
11	vBNS	Seatle-Boston	0.94	Denver	Chicago
12	vBNS	Altlanta-Cleveland	0.92	Houston	Chicago
13	vBNS	Seatle-Cleveland	0.9	Seatle	Chicago
14	vBNS	Chicago-Washington	0.88	Houston	Atlanta

Table 2: Traffic Matrix

Node d / Node *s*	1	2	3	4	5	6	7	8	9	10	11	12
1	0	X	Y	Z	X	Y	0	X	Y	0	X	Z
2	X	0	X	Y	X	0	Z	0	X	Y	0	Z
3	Y	X	0	X	Y	0	Z	X	Y	0	X	Z
4	Z	Y	X	0	Y	X	Z	X	0	X	Y	Z
5	X	X	Y	Y	0	X	Z	0	X	Y	0	Z
6	Y	0	0	X	X	0	Z	X	0	Y	0	Z
7	0	Z	Z	Z	Z	Z	0	Z	X	0	Z	Y
8	X	0	X	X	0	X	Z	0	Z	0	X	Y
9	Y	X	Y	0	X	0	X	Z	0	X	Z	Y
10	0	Y	0	X	Y	Y	0	0	X	0	X	Y
11	X	0	X	Y	0	0	Z	X	Z	X	0	Y
12	Z	Z	Z	Z	Z	Z	Y	Y	Y	Y	Y	0

Table 3: Project Parameters

Group	*X* (Gb/s)	*Y*(Gb/s)	*Z*(Gb/s)
1	35	50	55
2	35	49	56
3	36	48	57
4	36	47	58
5	37	46	59
6	37	45	60
7	38	50	55
8	38	49	56
9	39	48	57
10	39	47	58
11	40	46	59
12	40	45	60
13	41	50	55
14	41	49	56