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Lab work #1. An introduction to Net2Plan

(1 session)

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1 Objectives

The goals of this lab work are:

1. Introduce the Net2Plan tool to assist the modeling and solution of network design problems.
2. Know the basic elements composing a (single-layer) network representation in Net2Plan: nodes, links, demands, routes, protection segments, forwarding rules, multicast demands, multicast trees and shared risk groups.
3. Create and normalize traffic matrices in Net2Plan.
4. Use some of the automatic design functionalities of Net2Plan *Offline network design* tool in the graphical user interface.

2 Duration

This lab work is designed for one session of two hours.

3 Evaluation

This lab work has been designed to guide the students in their learning of Net2Plan. The annotations the students make in this document are for their use when studying the course, and do not have to be delivered to the teacher for evaluation.

4 Documentation

The resources needed for this lab work are:

- Net2Plan tool and their documentation (see <http://www.net2plan.com/>).
- Instruction in this wording.

5 Previous work before coming to the lab

The students should install the newest version of Net2Plan in the website, and read Chapters 1, 2 and 3 (skipping section 3.4) of the Net2Plan user's manual (available pressing F1 in Net2Plan).

To install Net2Plan, download it from <http://www.net2plan.com/>, and decompress the .rar file in any folder. To launch it, double-click in the file `Net2Plan.jar`. The system needs a Java 7 version or higher to work.

6 Offline network design

Enter the menu `Tools` → `Offline network design` and follow the instructions below.

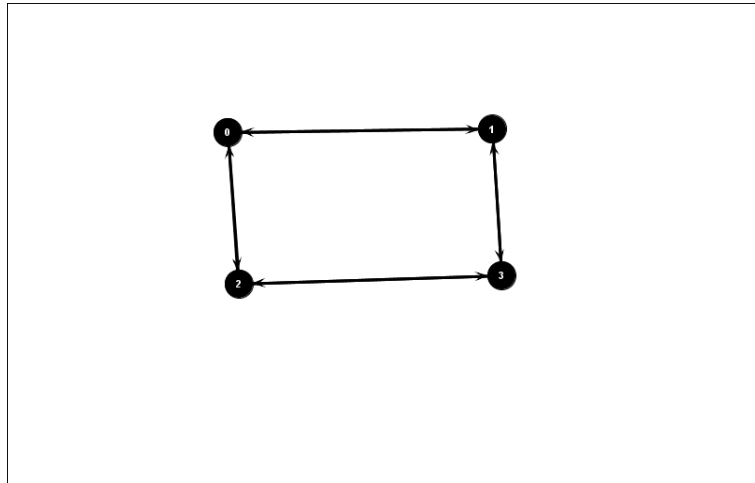


Figure 1: `network1.n2p`.

6.1 Adding the links and nodes manually

1. Create the design shown in Fig. 1 by placing the nodes and links manually (right-click in the desired position).
2. Try to move the nodes dragging them, and get familiar with the zooming buttons.
3. Use right-click in a node to create the links. See that by clicking **SHIFT** while clicking the mouse right button, you can create two links between the nodes, in opposite directions.
4. Save the topology with the name `network1.n2p`

6.2 Adding and routing traffic

In this section we continue the previous design, adding unicast and multicast traffic to it:

1. Go to the tab *View/edit network design*.
2. In the *Network* tab, set the name of the design as **My first design**.
3. In the *Layer* tab, set a name and a description (the one you prefer). Set the link capacity units and the demand carried traffic units to “Gbps”. Set the routing type for the network as *source-routing*. What tabs appear and disappear when the routing is not source-routing?

With source-routing, the tabs *Routes* and *Protection segment* appear, while the tab *Forwarding rules* disappear. The opposite happens in the hop-by-hop routing.

4. In the *Nodes* tab, set the name of the nodes as **n0**, **n1**, **n2**, **n3**. Using the options available right-clicking the mouse in the table, add two attributes to each node: **population** and **level**. Populations will be 1000, 1000, 5000 and 5000 respectively. All nodes should have level 1.
5. In the links tab, set the capacity of all the links to 100 units. You can make it one by one, or use the right-click option to set the capacity of all the links to the same value. Use the option that automatically sets the link length, to the euclidean distance between the link end nodes.

6. In the *Demands* tab, use the option that adds one traffic demand per each input-output node pair. How many demands are added? Set the traffic of all the demands to 10 units. Is this traffic carried or is it blocked? Can you see traffic in the links? Why?

All the demands offered traffic is blocked, since it is not carried. For the same reason, we cannot see traffic in the links. We have to add routes that carry the traffic.

7. In the *Routes* tab, use the option that allows you to add one route per demand, carrying its traffic through the shortest path measured in km. Go back now to the *Demands* tab. Check that all the traffic is carried now, and we have “green” in all the demands. Click in each demand and each route to see the sequence of links that follows its traffic.
8. Protection segments are a set of links with reserved capacity, that can be associated to a route as a backup resource to use if the route primary path fails. In the *Route* tab, use the option that removes all the routes. Then, use the option that permits adding one route per demand, with 1+1 protection of a link disjoint path, minimizing the total number of hops. Click in a route, and see in blue and in yellow the sequence of links of the primary path (route) and the backup path (protection segment) respectively.
9. Remove all the routes and protection segments. In the *Layers* tab, change the routing type to hop-by-hop. Use the option *Generate ECMP forwarding rules from link IGP weights*. This option creates the forwarding rules as if the nodes were IP routes running an OSPF protocol, and all the links had a weight of one (in this case). How can you check that all the traffic of all the demands is routed?

In several forms. In the *Demands* tab, seeing that all demands are in “green”. Also, in the *Layers* tab, you can see the statistic of the overall network unicast traffic blocking, which should be zero.

Remove all the forwarding rules. Change the routing type again to source routing, and create again the routes we had repeating the previous steps.

10. In the *Multicast demands* tab, use the option that permits creating one broadcast demand with a root in each network node. How many multicast demands are added? Set the traffic of all the demands to 0.5 units. Is this traffic carried or is it blocked? Why?

All the multicast demands offered traffic is blocked, since it is not carried by multicast trees. We have to add multicast trees that carry the traffic.

11. In the *Multicast trees* tab, use the option that carries the traffic using the multicast trees that minimize the end-to-end average number of traversed links. Click on each tree to see the links traversed. Click on the multicast demands, to see that all their traffic is carried.
12. The shared-risk groups are sets of links and nodes that are vulnerable to a particular common risk, so that if this risk happens, all of them fail simultaneously. They are useful in the network designs constrained to survive under certain failures. In the *Shared-risk groups* tab, use the option that creates as many SRGs as bidirectional links (the two links between the same nodes belong to the same risk), and establishes that each link fails in average once every 8760 hours (one year), and needs in average 12 hours to be repaired.

13. Save the design with the name `network2.n2p`

Take some time to observe in all the tabs the different statistics that are automatically provided by Net2Plan. See that, in all the tables:

- Placing the mouse on the column name shows a tip with a short description of it. This also happens in many other parts of the user interface.
- Clicking in the column name, reorders the table according to the values in that column. In the *Links* table, order the links from lower to higher carried traffic. Which is the column which states if a link has the highest utilization respect to the rest of the network links?

The column “Bottleneck”.

Some aggregated statistics appear in the *Layer* tab. For instance, the total number of links, nodes, total offered traffic, total blocked traffic etc. Placing the mouse on a statistic shows a tip with its description. Which is the average number of hops in the network? and the network congestion?

See the associated statistic in the *Layers* tab.

Quiz: Set the capacity of all the links, to that value that makes the network congestion equal to one (that is, the maximum link utilization becomes exactly one).

Go to the *Links* tab, see the carried traffic of the link that carries more traffic. Set the capacity of all the links to that value.

Quiz: Load the topology named as Abilene and repeat the previous steps, excepting that the unicast demands already in the file should be kept (keeping also the amount of offered traffic there).

Quiz: Use the option that automatically sets the capacity of the links, so that the utilization in all the links becomes 50% (that is, the link carried traffic occupies just the 50% of the link capacity).

Go to the *Links* tab, and use the option that sets each link capacity so that all links match a given link utilization.

7 Generation and normalization of traffic matrices

In the *Tools* menu, go to the *Traffic matrix design* interface.

1. Create the traffic matrix M_1 shown below, and save it with the name `M1.n2p`.

$$M_1 = \begin{pmatrix} 0 & 10 & 1 & 4 \\ 3 & 0 & 7 & 5 \\ 1 & 1 & 0 & 9 \\ 3 & 4 & 1 & 0 \end{pmatrix}$$

2. Using the *Total normalization* functionality, normalize the traffic matrix so that the sum of all its coordinates becomes 10 units. How does total normalization work?

Multiplies all the coordinates of the matrix by the same number, chosen so that the total sum of the matrix coordinates becomes a given amount.

Save the new matrix with the name `M1_n10.n2p`.

3. Create 5 random traffic matrices for a network of 4 nodes, using the uniform model (0,10). Normalize all the matrices so that the sum of the traffic in each is 10 units. Save them using the *Save all* functionality, so that the root name of all the matrices is `M_n10`. Which are the names provided by the tool to each of the matrices?

The names are `Mn10_tm0.n2p`, ..., `Mn10_tm4.n2p`

4. Create 5 random matrices using the population-distance model, for the network in file `network2.n2p`, with the following parameters:
- A random factor of 0.5.
 - The offset for population and distance is set to zero.
 - The distance between nodes and the product of the population affects according to a power $Dist_{power}$ and Pop_{power} equal to 0.5.
 - Activate the normalization per population and distance.
 - After creating the matrices, normalize them so that the total traffic in each equals 10 units.
 - Save the matrices with the names: `Mpn10_tm0.n2p`, ..., `Mpn10_tm4.n2p`.

Quiz: Load all the saved matrices generated with the uniform model. Which is the button that permits creating a symmetric version of a matrix (so that the traffic from node n_1 to node n_2 equals to the traffic from n_2 to n_1). How does it work?

Each coordinate (i, j) becomes the average between (i, j) and (j, i) . In other words: $M = (M + M^T)/2$, where M^T is the transpose matrix of M .

Quiz: Create a matrix for a network of four nodes, using the uniform model, and then normalize so that the total traffic sums 100 units. For us, this will be the traffic matrix at year 1. Assume that the traffic between two nodes, grows a 15% per year (this is compatible with the Compound Annual Growth Rate (CAGR) estimated by many traffic forecasts). Search for the option that permits you creating automatically the 9 new matrices with the traffic in the next 9 years.

In the panel *Create a set of traffic matrices from a seminal one*, choose the option *New matrices with compound annual growth rate*.

8 Work at home after the lab work

The student is encouraged to complete all the *Quizzes* that he/she could not finish during the lab session.