Operational research:
Theory and Applications to Networking
The Logical Topology Design Problem

1) Formulate the Logical Topology Design (LTD) problem considering a scenario in which the number of nodes N and the number of transmitters and receivers per node Δ (the same for every node) are given. Formalize the problem considering detailed flow variables (e.g., f_{ij}^{sd}). Consider the cases where flow splitting is allowed/not allowed.

2) Discuss the meaning of all the variables and parameters introduced in the two formulations.

3) For each formulation:

a) Solve the problem for N = 12 and Δ = 4. Consider a uniform traffic matrix, in which the traffic sent from any source to any destination is a uniform random variable in the range [6,12], i.e., traffic sent from node s to node d can be expressed as t^{sd}= Uniform[6,12]. Set the maximum timeout for the solver to 5 minutes with the following command:

setparam("XPRS_MAXTIME",-300)

Consider different traffic matrices instances, obtained by choosing different seeds.

For one of the previous formulations:

b) Repeat the experiment by varying the number of nodes N=8,16,24 with Δ = 4. Consider different random seeds to generate traffic for each N. Plot average/minimum/maximum values for computation time and gap.

c) Repeat the experiment varying the number of transmitters/receivers Δ = 1,2,4 and keeping N=10. Consider different random seeds to generate traffic for each Δ. Plot and comment average/minimum/maximum values for computation time and gap.

4) In the case for N = 16 and Δ = 4, restrict the topology to be an assigned bidirectional square grid mesh topology and solve the flow problem in the cases where flow splitting is allowed. Consider a uniform traffic matrix, in which the traffic sent from any source to any destination is a uniformly distributed random variable in the range [1,10], i.e., traffic sent from node s to node d can be expressed as tsd= Uniform[1,10]. Plot and comment the values of maximum flow for different scenarios obtained with different seeds to generate the traffic matrix.

5) {to be done later] When flow splitting is allowed formulate the problem considering aggregated (e.g., f_{ij}^{s}) flow variables.

6) [Optional] Repeat 3-b) considering an unbalanced traffic matrix, i.e., some nodes exchange a large amount of traffic, while others exchange a small amount. The traffic matrix can be produced by setting t^{sd} equal to:

- t^{sd}=Uniform[15, 30] for ($1<s\leq N/2$, $1<d\leq N/2$) and ($N/2<s\leq N$, $N/2<d\leq N$)
- t^{sd}=Uniform[1,3] for ($1<s\leq N/2$, $N/2<d\leq N$) and ($N/2<s\leq N$, $1<d\leq N/2$)