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 (equal at every node) are given. Formalize the problem considering detailed flow varables (e.g., f_{ij}^{sd}) for the cases where flow splitting is either allowed or 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 = 10 and Δ = 3. Consider a uniform traffic matrix, in which the traffic sent from any source to any destination is a uniform random variable in the range [1,10], i.e., traffic sent from node s to node d can be expressed as t^{sd}= Uniform[1,10]. Set the maximum timeout for the solver to 10 minutes with the following command:

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setparam("XPRS_MAXTIME",-600)
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Plot and comment the values of maximum flow for different scenarios obtained with different seeds to generate the traffic matrix.

b) Repeat the experiment varying the number of nodes N=4,6,8,12,16,20 and keeping Δ = 3. Consider different random seeds to generate traffic for each N. Plot and comment average/minimum/maximum values for computation time and gap.

c) Repeat the experiment varying the number of transmitters/receivers Δ = 1,2,3,4,5 and keeping N=8. 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 Manhattan street mesh topology and solve the flow problem in the cases where flow splitting is either allowed or not allowed. Consider a uniform traffic matrix, in which the traffic sent from any source to any destination is a uniform 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 varables.

6) [Optional] Repeat 3-b) and 4) 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[10,20] 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[1,2] for ($1<s\leq N/2$, $N/2<d\leq N$) and ($N/2<s\leq N$, $1<d\leq N/2$)