Advanced Network Design

(1) Node location problems

(Pióro - Medhi : 6.1)

- node location : relevant in long-term planning phase of network design
- node : routers, hubs, switches ....

Problem :

N : # areas (sources) to be connected

M : # locations candidate to locate "connection" nodes

η_j : cost of location j, if opened, $\forall j = 1, .. M$

ξ_{ij} : cost of connecting area i to location j, if opened, $i = 1 .. N$, $j = 1, .. M$

K_j : maximum number of areas that can be handled at j, $j = 1 ... M$

Constraints : each area needs to be connected to exactly one location node

Objective : minimize the overall cost

Variables

$$x_j = \begin{cases} 1 & \text{if a "connection" node is located at } j \\ 0 & \text{otherwise} \end{cases}$$

location decisions

$$j = 1, \dots M$$

$$u_{ij} = \begin{cases} 1 & \text{if area } i \text{ is connected to location } j \\ 0 & \text{otherwise} \end{cases}$$

allocation / connection decisions

$$i = 1, \dots N, \quad j = 1, \dots M$$

$$\text{MIP} \quad \text{Min} \sum_{i=1}^{N} \sum_{j=1}^{M} \xi_{ij} u_{ij} + \sum_{j=1}^{M} \eta_j x_j$$

$$\sum_{j=1}^{M} u_{ij} = 1 \qquad i = 1, \dots N$$

$$\sum_{i=1}^{N} u_{ij} \leq K_j x_j \qquad j = 1, \dots M$$

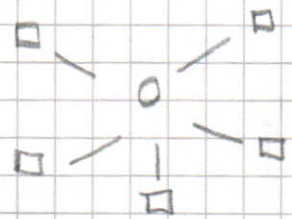
$$u_{ij} \in \{0, 1\} \qquad i = 1, \dots N, \quad j = 1, \dots M$$

$$x_j \in \{0, 1\} \qquad j = 1, \dots M$$

- This is a NP-Hard 0-1 Linear Programming problem, which can be addressed via the optimization techniques presented in the intermediate part of the course
- Additionally : ad-hoc heuristics

Add Heuristic

- <u>start</u> with any location and all areas connected to this



this may be an infeasible solution (capacity constraints)

- <u>then</u> consider the other locations one at a time, choose the one with the best "savings" and open it to strive feasibility and low cost.