VI International Workshop on Locational Analysis and Related Problems

New products supply chains: the effect of short lifecycles on the supply chain network design.

GELOCA
Grupo Español de Localización

REDLOCA 2015

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The elevator speech

- Node-demand is stochastic
- Facility location
    - Transportation_Cost
- Capacity decisions
    - – Newsboy-type problem
        - Cost of Undercapacity: C_u= (Unit_Revenue – $\boxed{\text{Unit\_Cost}}$) – Margin_Outsourcing
        - Cost Overcapacity: C_o=Capacity_Cost
        - Critical Ratio: $CR=C_u/(C_u+C_o)$
- Difficulty
    - – Unit_Cost(Capacity_Cost, Transportation_Cost)

Agenda

- Motivation
- The problem
- The cost of capacity
- The formulation
- The single facility case
- The multi-facility case
- Bounds on the objective function

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Overview

- H. Frank (1966): Optimum Location on a Graph with Probabilistic Demands
- ***Facility Location as an strategic level problem: capacity***
- Consider a problem where capacity has to be built up or reserved/bought from third-party
- Planning period is well ahead of product-introduction period
- Demand is unknown and described by scenarios and their probabilities
- Result: Facility Location w/ Capacity Decision (newsvendor type)

The Problem (a)

- Consider a vector of demand scenarios: $\partial=(D_1, D_2,\ldots, D_y)$ and a network $G(N,A)$. $|N|=n$. D_s *is the demand vector for all node-demand in scenario* s.
- Each scenario ∂_i, happens with probability $f(\partial_i)$
- Facilities are labeled 1, 2, …, are located according to a location set $S=\{S_1, S_2,\ldots, S_p\}$, where $p\leq n$. Vector C is the capacity vector corresponding to each facility.
- For every pair node-facility (i, j), there is a corresponding unit margin for serving node i from facility at j.
- a denotes an allocation matrix where element a_{ij}^{d} defines the quantity sent from facility at j to node at i when demand is d.

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The Problem (*b*)

- A feasible allocation *a* is such that $\sum_i a_{ij}^d \le C_j;\ \forall\ j \in \{1,\dots,p\}, d \in \partial\ and$
  $\sum_j a_{ij}^d \le d_i;\ \forall\ i \in N, d \in \partial$
- Cost parameters
  - m_0 is unit margin when outsourcing, m_{ij} is the margin from serving node *i* from facility at *j*.
- Quantity outsourced $L(C) = \max\{\sum_i D_i - \sum_j C_j,\ 0\}$
  - Cost of outsourcing is $\boldsymbol{m_0\,L(C)}$
- Capacity cost: $\varphi(C)$

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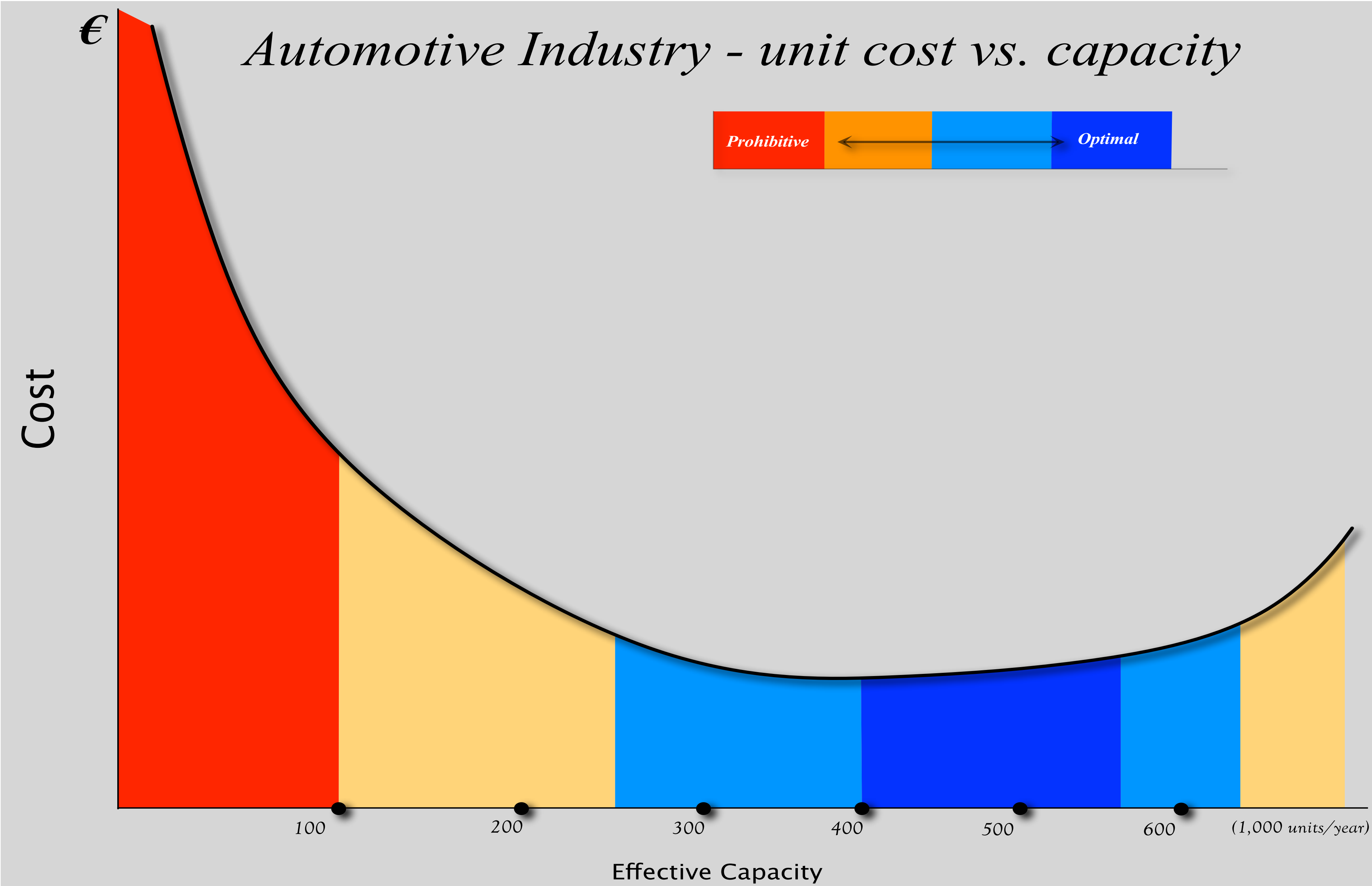

€
Automotive Industry - unit cost vs. capacity
Prohibitive
Optimal
Cost
100
200
300
400
500
600
(1,000 units/year)
Effective Capacity

The Problem (*c*)

- The deterministic cost function

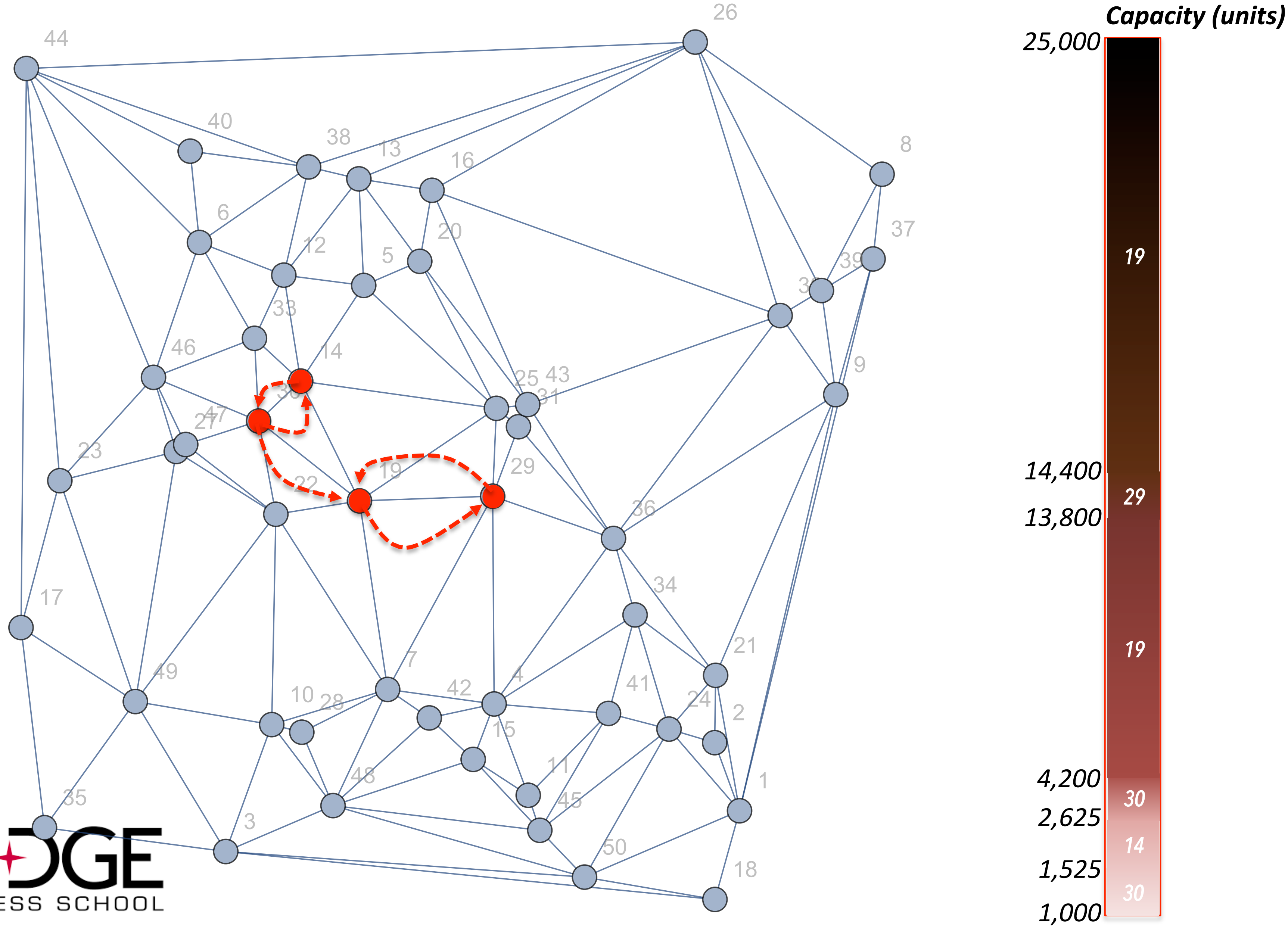
Cost of Overstock ***Cost of Understock***

$$Z(S,C,a \mid d) = \underbrace{\left(\sum_i \sum_j m_{ij}\ a_{ij}\right)}_{\textit{revenue}} - \underbrace{\psi(C)}_{\textit{capacity cost}} + \underbrace{m_0 L(C)}_{\textit{outsourcing margin}}$$

- The problem

$$\max_{S,C,a}\ V(S,C,a) = E_d[Z(S,C,a \mid d)]$$

One facility case: sensitivity analysis on capacity



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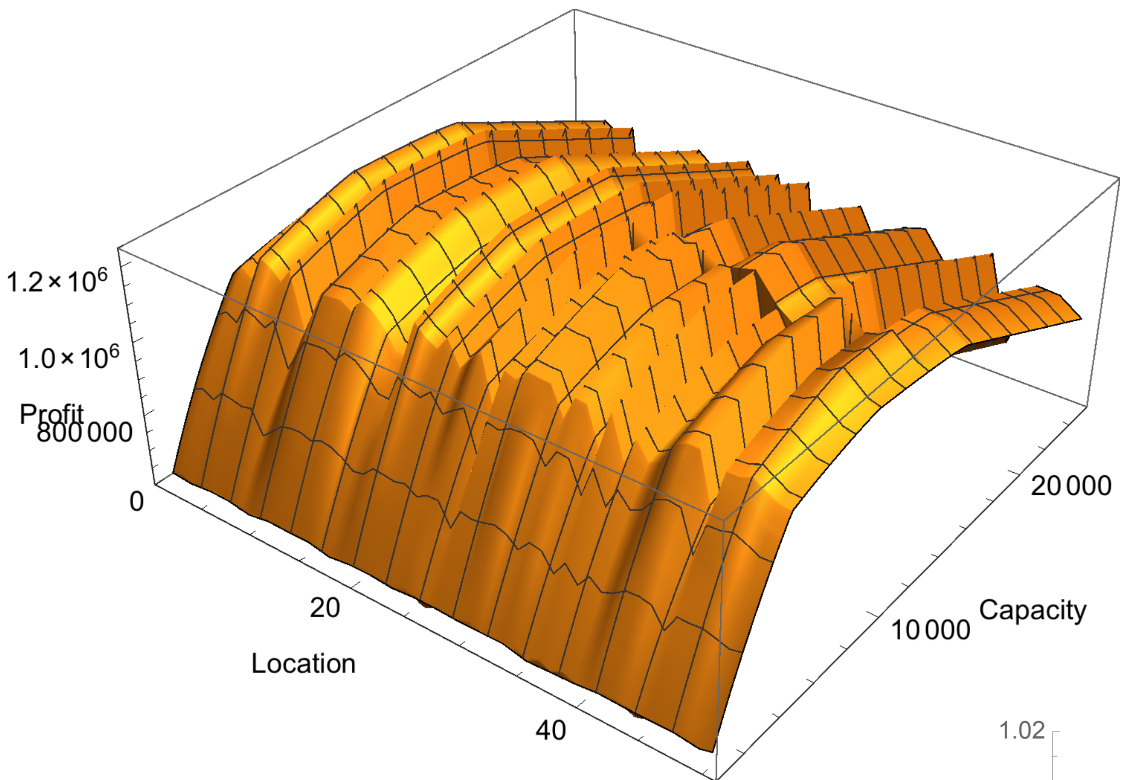
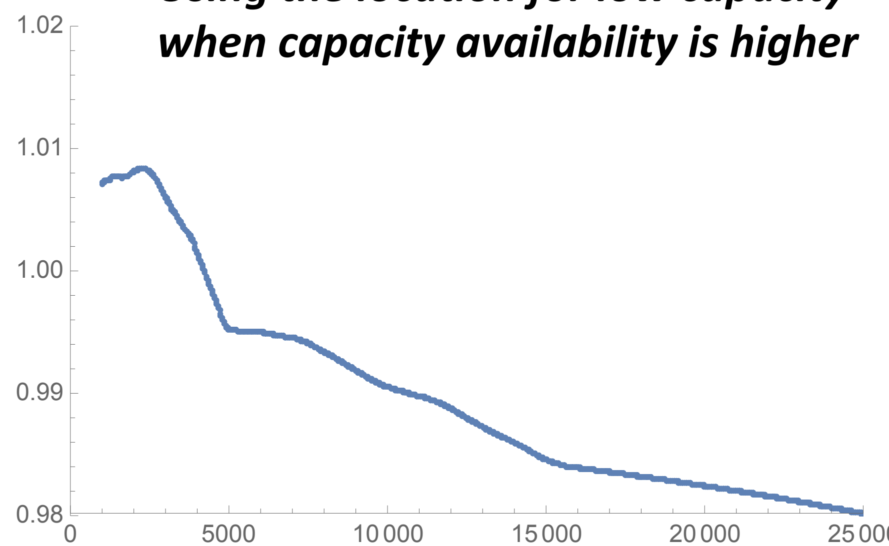


Using the location for low capacity when capacity availability is higher



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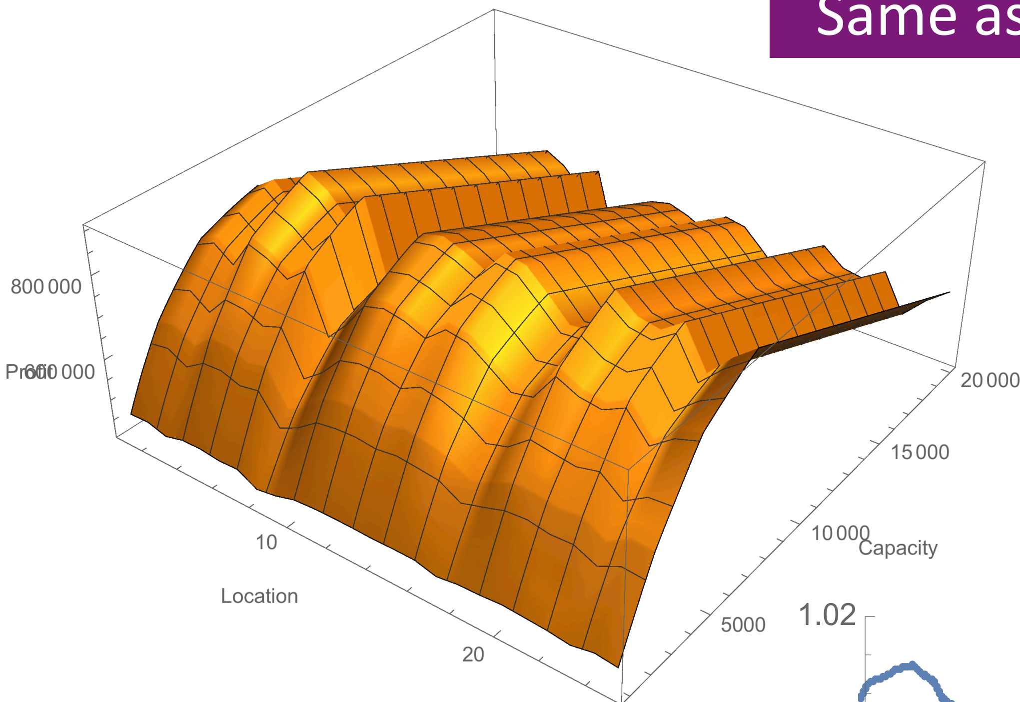
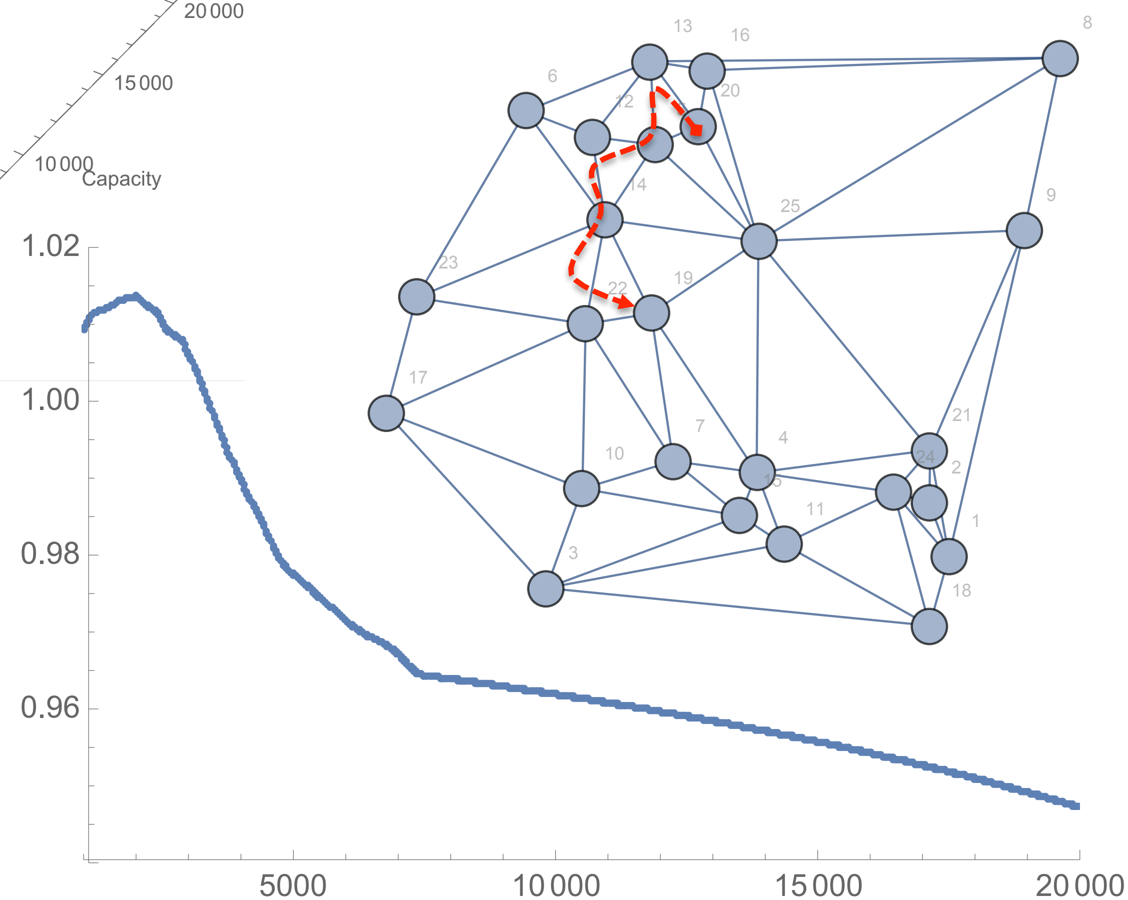
Same as previous with a smaller network





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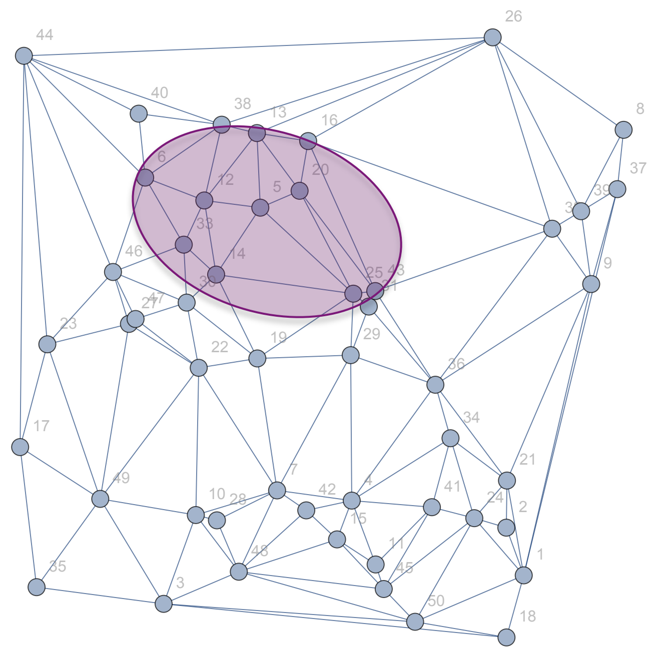
1-Facility Location Solution is Robust

- When independently generating node weights randomly from distributions with same mean value when building scenarios…
  - If the network is large enough then transportation cost dominates and induce solutions among the “usual suspects”; i.e. in the vicinity of each other.



Observations suggest…

- Solutions are robust for changes in critical ratios
- For a fixed set of facility location profit is concave in capacity vector
- Objective is(?) submodular on location set F and $C^*(F)$
- ***Proposed Greedy Heuristic***
  a) For a fix location set F
  b) $|F|=f$, find node $k_f = \arg_k$ maximizes $Z(C,a|\ F \cup k\ )$
  c) Stop when profit is not improved; otherwise go to (a) above.

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Still hard to compute optimality?

Bounds to the objective function value

- Consider dynamic setting where total capacity is chosen a priori…
- … but distribution of the capacity is done after scenario is realized
- The bound is easy to find for a fixed set S.
- **Recall: Objective function seems to inherity Submodularity property from other location problems (to be proven).**

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THANKS!

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