8th AIMMS-MOPTA Optimization Modeling Competition
Submit your solution by June 15, 2016, 23:59 EDT

Multiobjective Network Disruption

Imagine the following scenario: A set J of agents compete to generate profit by transporting resources from production centers to demand centers, using a shared transportation network subject to capacity constraints. Another agent seeks to maximally reduce the profit of a subset J^- of agents in J, while preserving as much as possible the profit of a subset J^+ of agents in J. The disrupting agent has a finite budget to totally disable or reduce the capacity of links of the transportation network. Your team's task is to design a user-friendly system to optimize the decisions of the disrupting agent that takes into account the optimal behavior of all agents in J, and to make it possible for a decision maker to visualize solutions in an intuitive way, and explore the tradeoff between the two objectives of the disrupting agent and the sensitivity to the budget.

1 Problem Description

The agents in J are indexed by j. The set J^+ and J^- have an empty intersection. The set of agents in J that are neither in J^+ nor J^- is denoted J^0.
The transportation network is described by the graph (V, E) where V is a set of nodes indexed by n and $E \subset V \times V$ is a set of links indexed by ℓ. For each agent j, source nodes for resource procurement are given by the sets $S_j \subset V$ and sink nodes for resource sales are given by the sets $T_j \subset V$.
Demand is defined at each node and for each agent by d_{nj}, where $d_{nj} > 0$ if $n \in T_j$ and 0 otherwise. Demand can be served in full or in part. The price paid to agent j per unit of resource sold at node n is given by p_{nj}, such that $p_{nj} > 0$ if $n \in T_j$ and $p_{nj} = 0$ otherwise. The resource is obtained by agent j at the source nodes in S_j, at no cost, and without constraint on the quantity.
There are base transportation costs that each agent faces to transport the resource along each link ℓ, that are linear in the quantity transiting along the link. The cost per unit is $b_\ell > 0$. The link capacities are described by w_ℓ which is the upper bound on the total quantity transiting in any direction along the link ℓ. When the transportation capacity of link ℓ is insufficient to satisfy the transportation needs of all agents, a congestion fee for using link ℓ is levied, which is linear in the quantity transported by each agent. The congestion price is set to the minimal price that is needed to keep the use of the link at its capacity.
The goal of disrupting agent is twofold: (i) to reduce the total profit from the agents in J^-, while (ii) protecting the total profit from the agents in J^+. The modeling of the multiobjective tradeoff is left to your teams' appreciation.
The disrupting agent has a budget to disable individual links or simply to reduce their capacity. The budget is expressed as the fraction β of the total transportation capacity $W = \sum_\ell w_\ell$. Thus, for instance, if the network has $|E| = 10$ arcs each of capacity $w_\ell = 100$, the total capacity is 1000 and a budget $\beta = 25\%$ means that a capacity of 250 can be disabled, e.g. by eliminating 2 links and halving the capacity of a third one.

2 Goals

Part I: Your team is asked to consider the case with a single agent in J. In this case, the goal of the disrupting agent is to maximally reduce the profit of the single agent in J. Furthermore, in this case, there is no sharing of the transportation resource, so there is no need to incorporate congestion charges. Your team is asked to develop a method to optimize the disruption plan when the budget for network disruption corresponds to eliminating a fraction β of the total transportation capacity. Results for (a) $\beta = 15\%$, and (b) $\beta = 20\%$ should be reported.
Part II: Your team is asked to consider the case with 2 agents in J, where J^+ and J^- are singletons. Your team is asked to develop an approach to model the tradeoff between the two objectives of the disrupting agent, and to optimize the disruption plan. The results for budgets (a) $\beta = 15\%$, and (b) $\beta = 20\%$ should be reported as well as the impact of the network disruption on the profits of each agent. Submissions without this second part of the competition will still be given consideration for selection to the final.

3 Data

The topology of the transportation network is a modification of a 24-node 55-edge network "ta1–U-U-E-N-C-A-N-S" which is part of the SNDlib library, `http://sndlib.zib.de/`. The modified network has 33 nodes and 72 links. X-Y coordinates of the nodes $n = 1, \ldots, 33$ in V are provided in the file `V.txt` for visualization purposes. The undirected links $\ell = 1, \ldots, 72 \in E$ are described in the file `E.txt` by from-nodes and to-nodes; the direction is irrelevant. The per unit base transportation costs b_ℓ and link capacities w_ℓ are provided in the files `b.txt` and `w.txt`, following the order of the links in `E.txt`.
For the first part of the competition which has a single agent $j = 1$ using the transportation network, the list of source nodes is in the file `S.txt`, and the nodal demand $d_n := d_{n1}$ and nodal prices $p_n := p_{n1}$ are provided in the files `d.txt` and `p.txt`.
For the second part of the competition which has two agents in J, the convention is $j = 1 \in J^-$ and $j = 2 \in J^+$. The source nodes S_1 and S_2 are in the files `S1.txt` and `S2.txt`. The nodal demands d_{n1} and d_{n2} are given in the files `d1.txt` and `d2.txt`.

4 Deliverables

Your team needs to deliver a complete solution to the problems described above, including (i) An implementation of the model in AIMMS, including a user interface, providing the user graphical and textual output; (ii) A solution of the models for the given data sets; (iii) A report of 15 pages maximum about the mathematical background of the model, the solution techniques, results and recommendations.
You are free to browse and use the literature for inspiration. Please cite all sources and carefully distinguish your ideas from those obtained in the literature.
The deadline for submission is June 15, 2016 23:59 EDT. If you have questions about the problem or the competition in general, please contact Boris Defourny at defourny@lehigh.edu. The subject of the email should start with "MOPTA competition 2016". For questions regarding the AIMMS software, please contact support@aimms.com.