9th AIMMS-MOPTA Optimization Modeling Competition

Production and Delivery of Radio-Pharmaceuticals to Medical Imaging Centers

In this competition, we are interested in a simplified model of production and delivery of radio-pharmaceuticals (RP) [4]. The primary challenge of production and distribution of RP is their very short radioactive half-life (e.g. some RP have a half-life around 2 hours, which means that after 10 hours their radioactivity is just 3% of the original radioactivity). In this competition, we will make a few simplifications just to simplify your tasks. We refer to [2, 1, 3] for teams interested in recent development of delivery of RP.

Problem Description

We consider one production center (Node 0) and set $J = \{0, 1, 2, \ldots, n\}$ represent imaging centers where radiopharmaceuticals are consumed. Each center $j \in J$ has a schedule of examination times t_j. When the patient comes the center, s/he will receive an injection of RP with total radioactivity $a \in [a_m, a_M]$ millicurie (mCi).

Production. Let us assume a simplified production line. The production line can produce in time p_i up to b_i dosages with radioactivity a_i. Immediately, after the production, the radioactivity of a dose starts to degrade. We assume that the decay happens in each 30 minutes and the activity at time $a_{t+30} = ca_t$. We assume that we have up to P production lines, and the cost of usage a production line is c_P per hour. Also if the production line is used, there is a fixed cost c_{PF} per line.

Distirbution. We assume that we have up to V vehicles capable of distribution or RP. The fixed transportation cost is M_F if a vehicle is used and the cost for each mile the vehicle drives is m_v and the time for each hour the vehicle is used is m_t. You can deliver multiple times to imaging center $j \in J$. We assume that the "unloading time" at center j is S_j. Also, the dosage used for the patient has to be at center at least 30 minutes before injecting the patient (i.e. if S is 30 minutes and we come to center at 10am, we will be unloading the RP until 10:30am but the dosage can be used only for patients from 11am).

We also denote by $L_{i,j}$ the length between node i and j a the travel-time between nodes i and j is $T_{i,j}$.

If a imaging canter doesn't have a RP dose for a patient, the examination has to be rescheduled, which impose a cost of M for each occurrence (e.g. the costs of life, loosing the reputation of the imaging center, ...).

Bonus problem: How would your modelling approach change if the duration between node i and j is stochastic, i.e. it takes values $1.5 \cdot T_{i,j}$ with probability $1/3$; $T_{i,j}$ with probability $1/3$; and $0.9 \cdot T_{i,j}$ with probability $1/3$?

Goals

We want to minimize the production and distribution cost of RP. The value of M will significantly affect the solution. Study the effect of M on production and distribution of RP.

Data

All data (except parameter M) are stored in files to be downloaded.

Deliverables

Your team needs to deliver a complete solution to the problems described above, including

- An implementation of the model in AIMMS, including a user interface, providing the user graphical and textual output;
- A solution of the models for the given data sets;
- A report, max. 15 pages 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, 2017 23:59 EDT. If you have questions about the problem or the competition in general, please contact Martin Takac "takac(at)lehigh.edu". The subject of the email should start with "MOPTA competition 2017". For questions regarding the AIMMS software, please contact "support(at)aimms.com".

References

[1] Ioannis Akrotirianakis and Amit Chakraborty. An optimization-based approach for delivering radio-pharmaceuticals to medical imaging centers.

[2] José Miguel De Magalhães and Jorge Pinho De Sousa. Dynamic VRP in pharmaceutical distribution—a case study. *Central European Journal of Operations Research*, 14(2):177–192, 2006.

[3] Maged Dessouky, Fernando Ordonez, Hongzhong Jia, and Zhihong Shen. Rapid distribution of medical supplies. In *Patient Flow: Reducing Delay in Healthcare Delivery*, pages 309–338. Springer, 2006.

[4] Mark S Jacobson, Raymond A Steichen, and Patrick J Peller. Pet radiochemistry and radiopharmacy. In *PET-CT and PET-MRI in Oncology*, pages 19–30. Springer, 2012.