Optimization with Uncertainties for the Location and Allocation of Medical Supplies in an Emergency Situation

Huseyin Onur Mete, Zelda Zabinsky
University of Washington

Project Scope: Decisions to support preparedness and response activities for disaster management are challenging due to the uncertainties of events and complications on the availability of real time data. Optimization models for the location and allocation problems of medical supplies to be used in emergencies are developed for the Seattle region, which is vulnerable to earthquakes. The location of the warehouses and their inventory levels for medical supplies are critical decisions to be able to respond to an earthquake. The locations must be chosen so they have a low risk of earthquake damage themselves yet provide fast distribution to hazardous areas. Moreover, the transportation roads are at risk of sustaining damage, which has to be considered in the allocation of materials to hospitals. The stochastic programming model is able to balance these risks with timely delivery of medical supplies. These optimization models provide optimal decisions to the players of RimSim, a simulation environment being developed for training of personnel in a command center in a disaster situation. The project is a part of the Pacific Rim Visualization and Analytics Center (PARVAC) with core funding from the Department of Homeland Security.

Recent Progress: We have been focusing on two major earthquake scenarios for the Seattle area, called Seattle and Cascadia Fault earthquakes. Hospitals in the region share nine warehouses for medical supply storage. In a disaster situation, it is predicted that 22 hospitals will have higher demand than their daily operations. Due to the increase in the demand, they will need immediate transfer of additional medical supplies. The uncertainties of the problem (e.g. demand of hospitals) led us to a scenario-based Stochastic Programming (SP) model.

The problem has a two-stage nature. In the preparedness stage, the warehouses to be active are selected and their inventory levels will be determined by the SP Model. After the disaster occurs, the transportation of each type of material from warehouses to the hospitals, including the loading and routing of vehicles is determined by the Mixed Integer Programming (MIP) model. Considering the possible disaster scenarios for the Seattle area, we provide an optimal solution for the preparation phase. After the onset of the disaster, the players on RimSim can consult with the optimization tool for an updated optimal solution according to the current conditions. The MIP model takes up-to-date parameters regarding the effect of the disaster and player's preferences to recommend an optimal allocation with routing of vehicles. In addition, we constructed a spreadsheet tool that takes the parameters, formulates the models, calls optimization software to solve, and presents the solutions.

Future Plans: The first item in our list is achieving seamless connection of RimSim and the optimization models. For this purpose, we have been working on coding of the system in an object-oriented language using the libraries of the OPL-CPLEX software, which is the state-of-the-art MP development and optimization tool. Furthermore, we are planning to get feedback from medical experts about our models and expand the research by incorporating more uncertainties of the medical and emergency management fields.