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Data envelopment analysis and interdiction median problem with fortification for enabling IoT technologies to relieve potential attacks

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Abstract

Fortifying the facilities to relieve the impact of disaster can be a significant operation for service industries. This study introduces an integrated assignment-allocation model that combines three issues: customer-facility assignments, allocation of fortification resources and data envelopment analysis (DEA). To justify the approach used to deal with a more reasonable solution for real world applications, we consider the outputs of the model as a function of the assignment variables. In new proposed model, the DEA efficiency measure is used to allocate fortification resources and select the best facilities for serving the customers after interdiction operations. For this purpose, we present a new bi-objective optimization model that optimally serves customers' demands in a remarkably efficient manner and allocates fortification resources to relieve potential disaster, including interdiction operations. Also, Internet of Things (IoT) optimizes the performance of the customers and enhances the safety of facilities. Indeed, a new parking management system based on IoT is proposed to assist parking drivers in managing and handling parking in the presence of protection and interdiction operations considerably. The proposed model is multi-objective and Non-deterministic Polynomial-time (NP)-hard; so, a weighted metric approach by using the CPLEX solver through MATLAB and Non-dominated Sorting Genetic Algorithm II (NSGA II) are utilized in problem solving. Several numerical instances are generated and solved by CPLEX and NSGA II. Experimental results show that NSGA II solves instances in considerably less time than CPLEX. Besides, it is seen that none of the solutions obtained by these two approaches are not dominated.

Keywords: Data envelopment analysis, Facility fortification, Disaster relief, Bi-objective model, NSGA II

1. Introduction

The critical infrastructure of a society comprises systems such as communications, supplies, transportation, health services facilities, and stockpiles. In a widely accepted definition of critical infrastructure, it is included systems of enormous proportions or complexities, for example service industries or systems, which deliver services to satisfy the needs or demands of customers and are of great importance to the economic prosperity. Also, critical infrastructure fortification is considered as a major problem to tackle system security. Disturbances in the service systems can emanate from natural disasters, technical failures, terrorist attacks, and human errors. These disasters may lead to the losses of critical elements or system failure. So, these are the top five challenges for managing infrastructures: 1) to determine the critical elements that are exposed to natural disasters and detect their effect on performance of system; 2) to determine the critical elements that if exterminated by an attacker, would provide the most operating loss in a service system; 3) to determine the critical elements that should be fortified against interdiction operations, in order to maintain the ability of the system; 4) to plan a new system so that its elements are as resistant as possible against intentional and natural losses; and 5) to allocate fortification resources for minimizing ruination and system deficiency due to intentional and natural disasters. Many researchers have extensively studied these five major problems under various assumptions in the recent years. These assumptions can be divided into two categories: modeling and solution methods. A brief review on fortification/interdiction literature is listed in Table 1.

In this paper, we develop an integrated bi-objective decision-making approach to optimize the interdiction median problem with fortification (IMF) in problem areas 5. Unlike the traditional interdiction/fortification problems, the proposed model, integrating the data envelopment analysis (DEA) and IMF (DEA/IMF), considers both allocation of fortification resources and customer-facility assignments, and aims to maximize the sum of efficiencies and minimizing distances between customers and facilities. Here, it is assumed that we have a service system, and it includes two sets of facilities and customers. Each of these customers are served by closest facility through distance. If a facility is lost or ruinated,

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