Applied Mathematical Modelling 000 (2016) 1–14

Contents lists available at ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

A multi-objective fuzzy queuing priority assignment model

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A R T I C L E I N F O

Article history:
Received 4 September 2013
Revised 12 June 2016
Accepted 16 June 2016
Available online xxx

Keywords:
Queuing theory
Fuzzy logic
Priority assignment
Buffer control
Fuzzy data envelopment analysis

A B S T R A C T

After disasters such as earthquakes or floods, the provision of necessary and vital services involves dealing with queues which have parameters and variables that depend on fuzzy decisions made by both service-providing personnel and service-needing people. In modeling these cases, fuzzy and stochastic queuing models are necessary. Although the interesting subject of fuzzy queues has been discussed by different researchers, none has considered fuzzy decisions made by service-providing personnel and service-needing people simultaneously. In this work, tools from both fuzzy logic and queuing theory have been used to address the fuzzy decisions made by service-providing personnel and service-needing people. The service-providing personnel make fuzzy decisions in order to manage the queues; the service-needing people also make fuzzy decisions for choosing among different queues. This study also highlights the application of fuzzy multi-criteria decision making for management of fuzzy queues. A discrete time fuzzy priority queue with partial buffer-sharing is modeled and analyzed where both priority assignment and buffer-control are subject to fuzzy decisions. Since the performance measures of such queues are expressed by fuzzy numbers rather than by crisp values, the multi-objective priority assignment problem is addressed by fuzzy Data Envelopment Analysis (FDEA). Based on the proposed fuzzy DEA, the properties of the fuzzy threshold-based space priority buffer management scheme are explored.

1. Introduction

In the aftermath of disasters such as earthquake, flood, fire, heavy storm that rescue crew and people try to provide different services to the affected people, different necessary queues need to be formed. The number of affected people can be very large. Thus the speed of providing different services is vital for proper management of such situations. Queues can be formed for different services from non-emergency medical services, food and clean water, basic needs like clothing and shelter, fuel, returning precious found goods to transportation, telecommunication, and seeking information.

In many real world applications of queuing systems which involves humans - either as newcomers or servers- the queues have parameters and variables that depend on decisions made by both service-providing personnel and service-needing people and the observed values of system parameters, service rate for example, are imprecise or ambiguous. This can be due to human perception bias, human judgment, incomplete, or non-obtainable data. Human judgments including preferences are

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http://dx.doi.org/10.1016/j.apm.2016.06.024
0307-904X/© 2016 Published by Elsevier Inc.

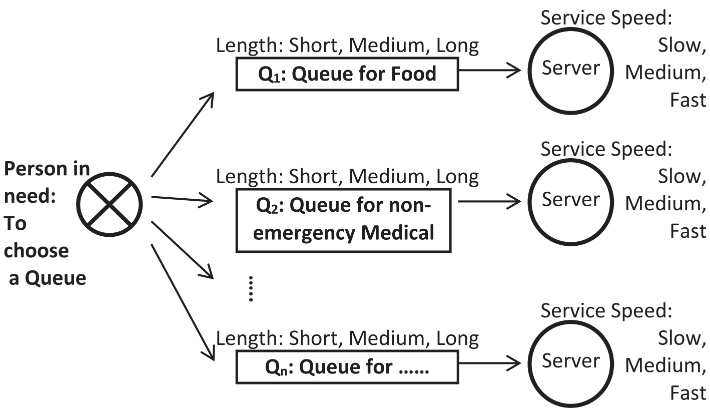

Fig. 1. The service-needing person wants to pick a queue.

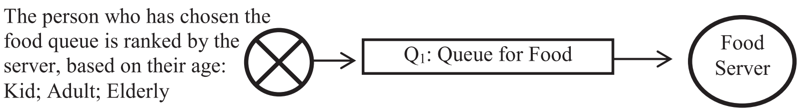

Fig. 2. Person who chose food queue is ranked by the server.

often vague and therefore their preference cannot be estimated with an exact number. Owing to vague concepts frequently represented in decision data, the crisp value is inadequate to model real-life situations. Since there are fuzzy decisions to be made as described above, the use of fuzzy set theory is appropriate in order to model such real-life problems more realistically. The following paragraphs illustrate two cases in which human decisions lead to fuzzy parameters for the corresponding queue system.

A service-needing person might choose which queue to attend based on the length of different available queues. There may be several different queues to choose, for instance the food queue or the non-emergency medical services queue. The perception of the service-needing person about the length of each queue (short, medium, or long) is fuzzy. Furthermore, his or her impression of the service-providing person‘s work speed (slow, medium or fast service rate) is also fuzzy. Hence, the service-needing person might decide to go to a specific queue based on the length of the queues and the speed of the servers (Fig. 1). In this case, the server may limit the buffer capacity of some of the queues to balance out the working load between all servers. This can be considered as buffer control scheme

The other fuzzy choice is made by service-providing persons (Servers) to prioritize people in their respective queue based on their vulnerability. Vulnerability can be attributed to age, health condition, level of injury, pregnancy, etc. Each server might classify people as vulnerable differently. For example, although age is a quantitative vulnerability criterion, but each server's notion of a kid, an adult or an elderly is fuzzy. Based on such fuzzy variables, the servers prioritize the service-needing people in their respective queues (Fig. 2). This choice is not possible for the cashier in a store. Cashiers have no right to prioritize people waiting in queue, but in a disaster case, servers may enforce their own choice, despite the fact that their choice is based on their fuzzy perception. Please note that in this study, the level of priority assigned to some service-needing people (namely priority coverage) as well as the buffer capacities are decision variables and should be optimized. Therefore, a feasible solution for priority assignment and buffer control is regarded as a possible alternative for the queue system setting.

To the best of the authors' knowledge, none of the previous works has addressed the fuzzy decision-making regarding prioritization and queue selection of service-needing people in disaster aftermath. This paper presents a new formulation for the problem of fuzzy priority assignment and buffer control. We use FDEA to find the best values for system parameters. In other words, the problem of priority assignment in fuzzy queues is formulated as a fuzzy decision making problem with different conflicting criteria. In this application of DEA, the observed values of input and output data are imprecise or fuzzy. This is due to fuzzy analysis of the queuing system so that performance measures of the queue system are calculated as fuzzy numbers. The decision making units are different possible alternatives of fuzzy priority assignment and buffer control. Some researchers justified the applicability and usefulness of DEA to find efficient solutions for optimization problems. Keshavarz and Toloo [1] verified the relationships between DEA and Multi-Objective Integer Linear Programming (MOILP) and showed that a supported efficient solution in MOILP is a BCC-efficient DMU in DEA. Azadeh et al. [2] used FDEA for optimization of operator allocation in a simulated multi product cellular manufacturing systems (CMS) with learning effects. In another study, Azadeh et al. [3] employed FDEA to find the efficient layouts of the single-row facility layout problem. For more on nondeterministic data in DEA see Hatami-Marbini et al. [4] and Hatami-Marbini et al. [5].

Please cite this article as: F. Jolai et al., A multi-objective fuzzy queuing priority assignment model, Applied Mathematical Modelling (2016), http://dx.doi.org/10.1016/j.apm.2016.06.024