Resource Availability Modeling and Optimization in a Car Park Management Problem

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ABSTRACT

This paper addresses the modeling and optimization of resource availability in car parks, serving different priority classes of customers. The authors examine various formulations of the problem concerning two general objectives: a) increasing the availability for high priority customers and b) maximizing the aggregate service level. In the current context, priority classes are specified according to different space reservation options provided by the parking management company (monthly parking, hourly parking, parking on demand, etc.). Based on actual historical traffic data and under certain methodological assumptions, they calculate the arrival and service rates for each class of customers. These are subsequently used as inputs in a Markov model that describes the evolution of the number of free parking spaces in time, given that some spaces are reserved for higher priority classes. Optimization techniques and OR heuristics are applied to deal with numerical aspects of the associated reservation planning issues.

KEYWORDS

Integer Optimization, Markov Model, Parking Management, Resource Availability, Resource Reservation

INTRODUCTION

In heavy traffic areas which are usually very crowded and with the difficulty of finding a parking space, car park companies take advantage of the situation in order to offer their services. It is critical for these companies to have high QoS (Quality of Service) for their customers who are usually classified into different priority classes. These classes are specified according to membership fee, organizational hierarchy, revenue management policy, etc. QoS for these companies consists in providing parking space availability for their high priority customers and simultaneously satisfy as many customers as possible. At low level demand it is easy to satisfy all the incoming requests but if the demand increases resource exhaustion occurs, thus no parking spaces are available for some customers. In such cases, the available parking space should be offered with respect to priorities assigned. To deal with parking spaces availability, the parking administration should reserve spaces for the higher priority classes of customers.

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In this paper, the case study refers to a Car Park Company, called CPS Athens S.A. that operates at Athens Greece. The company provides parking services to various different types of customers, aiming in serving as many customers as possible in order to maximize its profit. The otherness among customers depends on various factors such as membership, recurrence and parking time differentiation. On the other hand, the price of the service settled by the company depends on the parking time and the membership. The customers can use the parking for a minimum period to as long as they wish paying the corresponding ticket price. Nevertheless, customers who use the parking in a regular basis, can register to a certain membership class according to their needs and pay the corresponding fee. Based on customers’ needs, the company has separated them into five different classes. The first one, namely Monthly, consist of customers who have a standard payment fee in order to have an available parking space 24/7 per month. The customers of this class are either employed in companies or ministries around the area of the parking station, or even residents of this area. Thus, they need parking availability on a daily basis. This kind of everyday customers is assigned with the highest priority. The second class, namely Lawyers, have a standard payment fee for an available parking space from Monday to Friday at peak hours, usually are from 8:00 AM to 05:00 PM. Similarly, the third class, namely Students, consists of customers who need an available parking space from Monday to Friday but not at peak hours, usually after 05:00 PM. For the company the latter two classes are a special target group, and they enjoy a special discount policy since the parking station is located nearby the courts and the university, a fact that makes these classes a kind of permanent customers. Thus, parking availability for these classes is of prior importance. Apart from the above mentioned types of customers, there are also two more classes. The forth class, namely Frequent Hourly, consists of customers who visit the parking station more than once in a month but they do not register in none of the previous membership classes. Finally, there is an important amount of customers who visit the parking station totally in random and hence they are not classified into the above classes. These customers are characterized as Random Hourly customers and compose the fifth priority class.

With respect to the aforementioned disaggregation into priority classes (with descending order) the company has planned a service strategy in order to serve properly each class. Higher priority classes should be served under any circumstances. Nevertheless, according to historical data, the number of customers of lower priority classes is importantly higher. The company aims in serving as many customers as possible in order to increase its profit. But providing service to lower priority classes can lead to parking spaces exhaustion resulting hence in service unavailability for an incoming customer, who may belong to a higher priority class. To deal with this problem, we propose for the company to reserve parking spaces that can be used only by higher priority classes. Nevertheless, reserving parking spaces for high priority classes will eventually cause a denial of service for lower priority classes. To counteract this problem, a trade-off between higher priority classes’ demands on parking spaces availability and serving as many customers of lower priority classes as possible, has to be distinguished (Koutras & Platis 2009; Koutras & Platis 2008; Koutras & Platis 2006; Koutras, Platis & Gravvanis 2009; Koutras, Platis & Salagaras 2013). This trade-off can be achieved by using optimization techniques. The optimization consists in minimizing the probability of denial of service for a customer. Thus our aim is to minimize simultaneously the probability of service denial of all the classes through a multi-objective optimization problem. In our work, we use intelligent optimization heuristics for determining availability plans with a view on minimizing the service-denial rate for high-priority classes.

The idea of resource availability optimization has gained a lot of research effort through the past years as far as computer system and networks (Ha 1997; Haring, Marie, Puigjaner, & Trivedi, 2001; Koutras et al 2009; Xiao, Cao, & Sha, 2004) and web services (Koutras & Platis 2009; Koutras & Platis 2008; Koutras & Platis 2006) are concerned. Particularly when referring to client-server systems.
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