Revenue Optimization in Tourism and Hotel Industry using Genetic Algorithm

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ABSTRACT

Revenue management is the collection of strategies and tactics firms use to scientifically manage demand for their products and services. The practice has grown from its origins in airlines to its status today as a mainstream business practice in a wide range of industry areas, including hospitality, energy, fashion retail, and manufacturing. Revenue management (also known as yield management) is used to find optimal inventory allocation and scheduling strategies as well as price setting for perishable assets so as to maximize revenue within the planning horizon. This dissertation is about revenue optimization which may be called as revenue management in action. It is sometimes also known Yield Management. Here we are using all the three terms revenue management, revenue optimization and yield management interchangeably.

In this dissertation the concepts of revenue optimization are explained with regard to tourism and hotel industry. Also deterministic linear programming models of airline and hotel are presented and solution is proposed through genetic algorithm.

INTRODUCTION

Revenue Optimization is a process that can significantly increase revenues of capacity constrained firms through better inventory management and pricing. By using YM concepts, these firms can protect premium inventory for sale at higher prices, stimulate market growth by offering discounts and minimize wastage of perishable inventory.

Hence, yield management integrates pricing and inventory management, in attempt to determine what capacity to offer at which price so as to maximize yield or revenue. It involves segmenting the demand for a product or service, offering the product or service at multiple prices, and differentiating the price at each price point. Airlines, Hotels, Television Broadcasters, Theatres, Car Rental Agencies, Hospitals, Telecommunications are only some of the industries where YM techniques have been successfully utilized. Revenue gains of 2-8% due to YM are frequently reported; most of this goes to the bottom line leading to profit increase of 50-100%.

The term is used in many service industries to describe techniques to allocate limited resources, such as airplane seats or hotel rooms, among a variety of customers, such as business or leisure travelers. Since these techniques are used by firms with extremely perishable goods, or by firms with services that cannot be stored at all, these concepts and tools are often called perishable asset revenue management or simply revenue management. The techniques of yield management are relatively new – the first research to deal directly with these issues appeared less than 20 years ago. These days, yield management, including overbooking and dynamic pricing, has been an enormously important innovation in the service industries.

Airline Revenue Optimization:

The field of airline revenue optimization studies maximization of revenues obtained by selling airline seats. The product (airline seat) in airlines is said to have a “perishable” nature because its value becomes zero if it is not sold by the end of the booking horizon, which begins when the flight is opened for sale and ends when the flight takes off. Before we can understand what airline revenue optimization is, we must understand the marketing strategies of an airline. The marketing department at any airline cannot be expected to meet the exact requirements of all customers, as each customer is to a degree unique in his/her requirements. It is therefore impossible for airlines to orient their product, pricing, distribution and promotional policies to meet every customer’s needs exactly.

Hotel Revenue optimization:

The triumph of revenue management in the airline industry has also stimulated utilization and development of this management system in other service industries and the transportation sector. In 1991, Marriott International,
Inc. launched the installation of its first revenue management system resulting in increased revenue by 100 million US dollars.

In the hotel industry, the perishable asset is the room once a room is left empty for a night, that night’s revenues can’t be recaptured. In airline industry, the departure of one flight is exactly the same. You could find a deadline for it. But in hotel industry, the customer can choose anytime to check-in or depart. Customers may confirm how many days they will stay, but the length is always changeable. So the consecutive arrivals and the length of stays will be unique characteristics compared to revenue optimization in other industries. These things may make hotel revenue optimization more sophisticated. In the hotel industry different prices are charged for a room depending on features such as: the time of booking, company affiliation, multiple day stays and the intermediary sales agent.

Structure of this Dissertation

All the research in the field of revenue optimization in tourism (especially, airlines) and hotel industry has been thoroughly studied. This makes you familiar with the models and theories developed by various researchers in the related field. It helps us to formulate the problem studied in this dissertation.

The revenue optimization problem is defined and models regarding the problem have been described. Firstly, generic revenue optimization model and its entire terminology have been explained. Then revenue optimization models of airline and hotel have been explained respectively. At last the mathematical formulation of airline and hotel revenue optimization models is presented. Both the problems are formulated as Deterministic Integer Programming problems.

The proposed solution of problems through genetic algorithm is implemented. The implementation of both the models, airline and hotel, are implemented. Firstly, an overview of the solution technique, i.e., is given. Then, various aspects of genetic algorithm are discussed. Also the steps required to find the solution of the problem are explained. We report computational results on the models we develop in previous chapters. The results of both the models are analyzed with the help of graphs. Also, a comparison is made by applying different operators of genetic algorithm to the optimization problem. The dissertation is concluded along with the limitations of the model. Also the possibilities of research that can be made further in the related field are described.

Proposed Solution through Genetic Algorithm

The formulation presented in the previous section is a linear integer model. The problem could be solved using any standard optimization software like simulation and modelling software as reviewed in most of the literature studies. But, as the system grows, the number of decision variables and the constraints increase proportionally. The presence of discrete integer variables makes the problem complex and computationally difficult to solve using traditional optimization software. Further, such software requires a large amount of input information (constraints), necessitating complex computer simulation and modelling.

Hence, an attempt is made to solve the problem using genetic algorithms (GAs), an evolutionary optimization technique. GAs are founded on a randomized search and optimization technique based on Darwin’s theory of the “survival of the fittest” and a stochastic information exchange procedure.

RESULTS

Genetic algorithms are used as a solution technique for the linear integer programming models proposed in the dissertation. This chapter shows the results for both revenue optimization models. Also, a comparison of results is made using different genetic operators.

Single Leg Airline Revenue Optimization Results

The model is tested for a number of cases as described below:

Case I: Simple-case

In this case, a single flight leg expected to operate between a given origin and destination is considered. The capacity of the flight is established to be 100. The following GA parameters were established for the problem based on test runs using trial and error procedure.
Population = 75

Maximum number of generations = 50

Cross-over probability = 0.99

Mutation probability = 0.03

<table>
<thead>
<tr>
<th>Fare Class</th>
<th>Fare</th>
<th>Demand Lower Limit</th>
<th>Demand Upper Limit</th>
<th>Booking Limit</th>
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Booking Limits for Two Decision Periods

The fare classes, lower limit, and upper limit of the demand for each fare class are shown in Table 1. The estimated number of passengers for each fare class obtained as the model’s output is shown in the fourth column of Table 1. The lower limit, upper limit, and the estimated number of passengers for each fare class are shown in Figure 2. The model allocates the maximum number of seats to higher-fare classes and minimizes the number of passengers belonging to lower-fare classes. The total estimated revenue is $24,750.

Lower, upper limit, and the estimated booking limits

The convergence of the GAs is shown in Figure 3. An increase in the maximum and average objective function value with increase in generation number can be observed. The average value is not equal over the considered 50 generations even though the optimal value has been reached. But maximum and minimum values remain constant after a few generations. The best (optimal point) was first observed during generation 4. The maximum number of generations and hence the convergence criteria are established as 50 generations, considering the fact that the best solution was attained much earlier. This was tested on various such cases.

Case II: Demand variation over time

In reality, demand forecasts vary with time. As stated previously, this variation is due to market segmentation (time- and price-sensitive passengers). Hence, in this case, the
Convergence of GAs for the Simple-case. performance is tested considering different demands over two decision periods. The fare classes, lower limit, and upper limit for each fare class during first decision period and second decision period are shown in Table. Note that the lower limit and upper limit for the $500 fare class during first decision period are zeros. The total capacity is 100. First decision period is tested first. The model allocates as many seats as possible, which is the upper limit for each fare class. Note that summing the upper limits for all fare classes during first decision period does not exceed capacity.

Second decision period is then simulated considering the updated capacity. As seen previously, the model allocates the maximum number of seats to higher-fare classes. The estimated booking limits for each decision period are shown in Table 2. The total revenue considering both decision period is $27,650. Questions such as whether the system should forego a reservation during first decision period expecting a request from higher-fare class during second decision period were not considered.

<table>
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<tr>
<th>Fare Class</th>
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<th>Decision Period 1</th>
<th>Decision Period 2</th>
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<tr>
<td></td>
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<td>Demand Lower Limit</td>
<td>Demand Upper Limit</td>
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<tr>
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Booking Limits for Two Decision Periods
CONCLUSIONS AND FURTHER RESEARCH

The emphasis of this dissertation has been on the product inventory control problem in tourism (airline) and hotel industry. It is important to note that there are two basic components to the problem of maximizing revenue through product inventory control, the first being the actual determination of seat allocations in an optimization algorithm and the second being the application of these seat allocations in the form of booking limits in such a way that the potential of increased revenues is obtained. With this in mind, partitioned and nested control methodologies are presented in detail for both single leg and multiple leg flights. The driving force behind developing and designing new approaches to managing and controlling inventories is to capture additional revenue beyond that being realized from current product inventory control approaches. In order to effectively measure the revenue potential of the different inventory control approaches introduced in this dissertation, an integrated revenue optimization/booking process through was developed as a part of this research. The solution is computer-based, mathematical program which realistically models the booking process.

Maximizing operating profits includes searching and adopting strategies to maximize yield from customers. Simple linear programming models of revenue optimization for airline and hotel are presented and their solution through genetic algorithm is proposed and analyzed in this dissertation. Exploring the properties of GAs to allow procedure-based function declarations and coding of variables reduces the complexity of the problem. The GA-based model was tested with various hypothetical cases. The results observed are consistent with expectations. The results are also compared using different selection and crossover combinations. It is found that each behaves in a different manner depending on the problem. However, there are several limitations in the problem formulation that warrant further investigation and analysis.

1. In both the models, the demand is considered independent between classes. However, a passenger who was refused a seat in the lowest-fare class (say, $100) may opt for the next lowest-fare class (say, $200). This aspect was ignored in this article.
2. In case of network model, all itineraries (OD combinations) are given equal weight. However, the system manager may forgo a reservation for short itineraries (single legs), expecting a request for multiple legs in future. Hence, more weight should be given to passengers traveling over multiple legs.
3. The model presented for airline network is implemented only for linear network. To find the number of ODs and hence the implementation could be changed to make it for hub and spoke network.
4. Overbooking may also be applied to hotel and network model. If the actual arrivals exceed the hotel’s capacity, the hotel should implement strategies to deal with this problem, such as compensating or transferring customers.
5. The analysis was based on a rather simplified representation of the inventory control problem, with such factors as cancellations, no shows, and customer upgrades not included. These can be taken into consideration for future research.
6. Real Coding was used for hotel optimization. Not much of the genetic operators are introduced for real value encoding. Further research should be done in this area also.

REFERENCES

[10]. Curry, R. 1990 "Optimal Seat Allocation with Fare Classes Nested by Origins and Destinations” Transportation Science vol 24, pp.194-204;