

# Chapter XLI

## Applications of JGA to Operations Management and Vehicle Routing

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### ABSTRACT

*Two of the most complex activities in production and operations management (POM) are inventory planning and operations scheduling. This chapter presents two problems related to these activities, namely, the capacitated lot-sizing and scheduling problem and the capacitated vehicle routing problem. For each of these problems, the authors discuss several solution methods, present a competitive genetic algorithm, and describe its implementation in the Java Genetic Algorithm (JGA) framework. The purpose of this chapter is to illustrate how to use JGA to model and solve complex business problems arising in POM. The authors show that JGA-based solutions are quite competitive and easier to implement than widely used methods found in the literature.*

### INTRODUCTION

JGA, the acronym for Java Genetic Algorithm, is a flexible and extensible computational object-oriented framework for rapid development of evolutionary algorithms for solving complex optimization problems. JGA shortens the implementation phase because the user of JGA does

not have to implement the underlying logic of a genetic algorithm, but just has to focus on the unique aspects of its specific problem. The previous chapter presents the technical aspects of JGA in detail; the purpose of this chapter is to illustrate the use of JGA with problems arising in the areas of operations management and vehicle routing.

Production and operations management (POM) decisions deal with the efficient use of the resources in the production of goods and services. Two important aspects in POM are inventory planning and operations scheduling. The former defines inventory policies and determines order quantities. The latter determines the detailed sequence of the production orders or jobs through the machines. These problems, also known in the literature as lot-sizing and scheduling problems, must support several (often conflicting) objectives, such as minimizing the total inventory and setup costs, while maximizing service level.

Our first application of POM was presented in the previous chapter. We illustrated JGA and other genetic algorithm tools in the classical dynamic lot-sizing problem, in which the decision maker is interested in defining order quantities over a discrete-time planning horizon, while meeting a set of dynamic demand requirements at a minimum total cost.

Traditional solution approaches of POM deal with lot-sizing and sequencing problems separately and do not consider the interrelationship between them. A common solution procedure is to solve these problems sequentially—that is, first find a solution for the lot-sizing problem (as in the previous chapter), and then solve the sequencing problem taking as input the lot-sizing solution without considering capacity constraints. This approach generates infeasible solutions which often exceed production capacity and must be adjusted in order to satisfy the capacity constraints. This adjustment often generates high-cost solutions. In this chapter we show how by integrating both problems by means of a genetic algorithm; it is possible to obtain a significant operational cost reduction.

The second application presented in this chapter deals with the distribution of products and services, namely, with the vehicle routing

problem (VRP). The VRP is to find the best way of assigning a group of customers to a fleet of vehicles and determining the sequence of customer visits. The managerial objective is to provide a high service level to the customers, while simultaneously minimizing operational and investment costs.

The next two sections of this chapter discuss the capacitated lot-sizing and scheduling problem and the capacitated vehicle routing problem. For each of these problems, we discuss its solution methods, and present a genetic algorithm approach and its implementation in JGA along with a computational experiment.

## **THE CAPACITATED LOT-SIZING AND SCHEDULING PROBLEM**

This problem deals with the integration of lot-sizing and scheduling decisions over a parallel machine environment. This problem, known as capacitated lot-sizing and scheduling (CLSS), formally can be stated as follows. There are  $N$  different products to be manufactured in a system with  $M$  parallel and identical machines over a finite horizon of time. The time horizon comprises  $T$  evenly spaced periods. Product  $i$  has a deterministic demand of  $D_{it}$  units for period  $t$ . There is an inventory holding cost  $h_i$  for each unit of product  $i$  held in inventory per time period. Each product is processed by one machine and requires  $p_i$  units of time per unit of product  $i$ . Associated with the production process, there is a cost  $C_p$  per unit of processing time. When a machine changes from processing product  $i$  to product  $j$ , it requires  $s_{ij}$  units of time for setup. Associated with this setup, there is a cost  $C_s$  per unit of time. Production is constrained to a maximum capacity of  $C$  units of time per period per machine. In conclusion, the CLSS problem is to find the number of units  $X_{it}$  of product  $i$  to be produced at period  $t$ , and

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