CHAPTER - 4

METHODOLOGY FOR RESOURCE UTILIZATION OPTIMIZATION
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4.1. INTRODUCTION

In the context of scheduling, Genetic Algorithm (GA) views sequence (of jobs) as chromosomes, which in turn are members of a population. Each individual (a schedule) is characterized by its fitness (e.g., by its makespan value). Thus, fitness of an individual is measured by associated value of objective function. GA procedure works iteratively with members of population and new iteration is referred to as a generation in GA terminology.

In GA environment, a generation of chromosomes consists of surviving chromosomes of previous generations and some new solution or progenies created from previous generation. While GA is iterating, population size is usually kept constant from one generation to next. Progenies are produced through reproduction, mating by crossover, and mutation of chromosomes of previous generation (parents).

4.2. PRINCIPLE BEHIND GA

Essentially GA is a set of procedures which, when repeated enable solutions to specific problems. In order to achieve objectives, GA generates successive population of alternate solutions until a solution is obtained that yields acceptable results. Within the generation of each successive population, improvements in the quality of individual solutions are gained. In this way, GA can quickly move to a successful outcome without need to examine possible solution to problem.
The procedure used is based on fundamental process, which control evolution of biological organisms, namely, natural selection, and reproduction (Kopfer and Mattfield, 1997). These two processes together improve an organism's ability to survive within its environment in following manner:

1. Natural selection determines which organisms has opportunity of reproduction and survival within a population.

2. Reproduction involves genes from two separate individuals combining to form offspring, which inherit survival characteristics of their parents.

These algorithms seek to initiate way in which beneficial genes reproduce themselves through successive populations and hence contribute gradual ability of an organism to survive (Masters, 1993).

In context of scheduling, a chromosome may represent information regarding job sequence on a machine. Different holding positions in this sequence are known as 'alleles'. Mutation in a parent chromosome may be equivalent to an adjacent pair wise interchange in corresponding sequence. Crossover combines some features of two parent chromosomes to create progenies inheriting some characteristics from each parent. As GA iterates, the fittest chromosomes in each generation reproduce and the least fit die. Birth, death, and evolutionary reproduction processes that determine the characteristics of the next generation of solutions can lead to a complicated stochastic process (Michalewicz, 1992).
4.3 GENERAL SCHEMA OF GA

The skeleton or framework of the proposed GA is illustrated in the flow chart in Figure-2. The details of different modules are explained along with necessary illustrations in this section.

Figure-4.1: Framework of Genetic Algorithm
The structure of genetic algorithm is given below.

**Procedure GA()**

Begin:

\[ t \rightarrow 0 \quad /\!*t: \text{iteration number} */ \]

*Initialize Pop (t);* /*Pop (t): population in iteration `t` */

*Evaluate Pop (t);*

While (NOT termination condition) do

Begin:

\[ t = t + 1; \]

*Select parents from Pop (t – 1);*

*Delete dead from Pop (t – 1);*

*From Pop (t);*

*Reproduce the parents;*

*Evaluate Pop (t);*

End:

End:

**4.3.1. Initialization module**

Each chromosome represented processing sequence of jobs. Jobs are processed as per their position in chromosome. Initial population is selected randomly. Population size is equal to number of jobs.

**4.3.2 Population evaluation module**

The evaluation parameter \( f(c) \) depends on objective function, which is minimum makespan.
4.3.3 Selection of new population

New population of same size is found by roulette wheel selection. Construction of roulette wheel includes calculation of probability of survival \( p(c) \) for each chromosome and cumulative probability \( cp(c) \) for each chromosome. Spinning roulette wheel includes generating a random number and selecting chromosome, which satisfies \( cp(c-1) \leq r2 \leq cp(c) \).

4.3.4 Crossover module and Crossover probability

Crossover operation generates a new string (i.e. child) from two parent strings. Jobs randomly selected are inherited from one parent to child, and other jobs are placed in order of their appearance other parent. From sensitivity analysis, probability crossover \( p_c \) is arrived as 0.90. Crossover operator used in this study is Partially Mapped (PMX). PMX operator proposed by Goldberg and Lingle, pioneers in Genetic Algorithms had been widely used in many problems.

The probability of crossover (p_cross) is vital parameter which needs attention at this juncture. The value for p_cross is assumed between 0.1 and 0.9. Normally, 0.3 is used so that at least 30% of chromosomes are selected for new population would undergo crossover operation. Procedure for this selection is as following:

Random numbers between 0 and 1 are generated for all chromosomes and those chromosomes that got random number less than p_cross value are selected for crossover. If odd numbers of chromosomes are selected, then the above procedure is repeated until one or more chromosomes got selected and number of selected chromosomes becomes an even number.
4.3.5 Mutation module and Mutation probability

Mutation is an operation to change order of $n^{th}$ job in selected gene. From sensitivity analysis, probability mutation $p_m$ is arrived as 0.10. Numerous mutation operators are tried by researchers. However, unary random mutation has been used widely. Hence, unary random operator is used in this study.

The purpose of mutation is introduction of new genetic material, to recreate good genes that are lost by change through poor selection of mates. This avoids entrapment in local minima and leads to search of global optima. To do this effectively, effect of mutation must be profound. At the same time, valuable gene pool must be protected from wanton destruction. Thus, probability of mutation should be tiny (Michaelwicz 1994). On the above grounds, probability of mutation ($p_{mut}$) is usually assumed between 0.05 and 0.15.

4.3.6 Check for termination

The number of times whole process iteration of evaluation, selection, reproduction, and mutation is to be repeated depends on nature of the problem. No generalization is possible with respect to behavior of model considered. Number of iterations is considered as termination criterion and fixed at $10^\ast n$.

4.4. SUMMARY

A Decision Support system using GA is developed to enhance delivery performance. It is aimed to be useful for management to know probable date of delivery for new orders and to generate a production plan.