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Optimization of Material Supply Chain System Using Genetic Algorithm – A Proposed System

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ABSTRACT : The system is about managing the effective utilization of raw materials needed in a particular manufacturing company so that it will produce minimum wastage and will maximize the profit. Every manufacturing company is connected to various suppliers and all the supplier companies are small scale companies so that they are not capable of appointing an expert person for managing the schedules of manufacturing company. These companies are required to manage their manufacturing process according to the schedules given to them. In any case if the schedule has been changed they will have to manage their production accordingly, this needs additional production and time, so this can waste their time, material as well as finance, this is not affordable for all these small scale as well as manufacturing companies to whom they are providing material.

To avoid all these problems, optimization of material supply chain system using genetic algorithm deals with changing schedules of the companies, reuse or proper utilization of materials effectively. The system is generalized that is it can be used wherever; there is a need of managing cost as well as changing schedules of any kind of manufacturing company. This is an intelligent system which will manage to take decision according to dynamic schedules of manufacturing company by itself using algorithms of AI (Artificial intelligence).

Keywords: Optimization, Supply chain, Manufacture, Genetic algorithm, Crossover, Mutation, AI

I. INTRODUCTION

With global economic factors and competition, manufacturers encounter strategic challenges of right pricing and rising costs. Products are becoming more and more complex with frequent feature enhancements; while target price points are falling progressively. Moreover, global demand is continuously shifting to rapidly growing emerging markets, where competition is largely based on price. Against this backdrop, companies must continue to create and bring new and highly differentiated products to the market cost effectively, and within compressed time frames.

To address these challenges; companies try to reduce their product prices and optimize costs. To reduce prices, companies adopt several techniques such as innovative pricing methods (e.g. smaller unit of sale) and optimizing their delivery network. For cost reduction, they build an organizational foundation that promotes a culture of cost containment and productivity improvement. However, both initiatives require careful balancing to avoid any compromise with positioning in the marketplace, and the ability to capitalize on future growth opportunities.

To achieve their strategic goals, companies need to assess their product realization value chain from a total cost optimization perspective [5]. Best in class companies adopt several initiatives that focus on opportunities in product engineering, manufacturing engineering and industrial engineering to optimize their product costs.

A. Need for Cost Optimization

Manufacturing organizations face a strategic dilemma between increasing revenue and decreasing cost to enhance profitability. In this context, cost optimization is often thought to be a purely cost reduction exercise. However, if carefully balanced, cost optimization can help in increasing both profits as well as revenue.

Cost optimization aims at reducing the costs 'built in' the product; this will ultimately help in increasing the profit margin of the product by lowering the price points, and expand the footprint of the product in virgin markets as also in existing markets[5].

To achieve complete cost optimization, organizations first need mechanisms of accurate cost assessment. Once costs are assessed, they need to understand the means to achieve cost optimization.

II. RELATED WORK

In a genetic algorithm, a population of strings (called chromosomes or the genotype of the genome), which encode candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem, evolves toward better solutions. Traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly mutated) to form a new population [4]. The new population is then used in the next iteration of the algorithm.

Commonly, the Algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.

Genetic algorithms find application in bioinformatics, phylogenetics, computational science, engineering, economics, chemistry, manufacturing, mathematics, physics and other fields.

A typical genetic algorithm requires:

1. genetic representation of the solution domain,
2. A fitness function to evaluate the solution domain.

A standard representation of the solution is as an array of bits. Arrays of other types and structures can be used in essentially the same way. The main property that makes these genetic representations convenient is that their parts are easily aligned due to their fixed size, which facilitates simple crossover operations. Variable length representations may also be used, but crossover implementation is more complex in this case. Tree-like representations are explored in genetic programming and graph-form representations are explored in evolutionary programming.

The fitness function is defined over the genetic representation and measures the *quality* of the represented solution. The fitness function is always problem dependent. For instance, in the knapsack problem one wants to maximize the total value of objects that can be put in a knapsack of some fixed capacity. A representation of a solution might be an array of bits, where each bit represents a different object, and the value of the bit (0 or 1) represents whether or not the object is in the knapsack. Not every such representation is valid, as the size of objects may exceed the capacity of the knapsack. The *fitness* of the solution is the sum of values of all objects in the knapsack if the representation is valid or 0 otherwise. In some problems, it is hard or even impossible to define the fitness expression; in these cases, interactive genetic algorithms are used.

Once we have the genetic representation and the fitness function defined, GA proceeds to initialize a population of solutions randomly, and then improve it through repetitive application of mutation, crossover, and inversion and selection operators.

III. PROPOSED SYSTEM

A. Objective

Businesses are examining every area of their supply chain to reduce costs. Reducing waste has become a key component of any cost reduction program that is implemented. There are a number of processes that can be used in order to reduce waste in a company’s supply chain.

Many companies are examining the design of their products to identify where the use of raw materials can be reduced or expensive materials be replaced. Indeed many businesses are reviewing each component to identify whether it can be manufactured or purchased more cheaply. When designing product packaging options, companies are examining cheaper and less wasteful materials.

Also in transportation domain like railway transportation, Air transportation there is lack of time management and resource management are generally observed. So the proper utilization of available resources is not done by that particular transportation system. Hence there profit margin decreases. There are two main objective of our system:

1) Maximize the profit.

2) Minimize the wastage.

B. Architecture

1) Initialization

Initially many individual solutions are randomly generated to form an initial population. The population size depends on the nature of the problem, but typically contains several hundreds or thousands of possible solutions. Traditionally, the population is generated randomly, covering the entire range of possible solutions (the search space). Occasionally, the solutions may be "seeded" in areas where optimal solutions are likely to be found.

2) Selection

During each successive generation, a proportion of the existing population is selected to breed a new generation. Individual solutions are selected through a fitness-based process, where fitter solutions (as measured by a fitness function) are typically more likely to be selected. Certain selection methods rate the fitness of each solution and preferentially select the best solutions. Other methods rate only a random sample of the population, as this process may be very time-consuming.

3) Reproduction

The next step is to generate a second generation population of solutions from those selected through genetic operators: crossover (also called recombination), and/or mutation.

For each new solution to be produced, a pair of "parent" solutions is selected for breeding from the pool selected previously. By producing a "child" solution using the above methods of crossover and mutation, a new solution is created which typically shares many of the characteristics of its "parents". New parents are selected for each new child, and the process continues until a new population of solutions of appropriate size is generated. Although reproduction methods that are based on the use of two parents are more "biology inspired", some research [1] [2] suggests more than two "parents" are better to be used to reproduce a good quality chromosome.

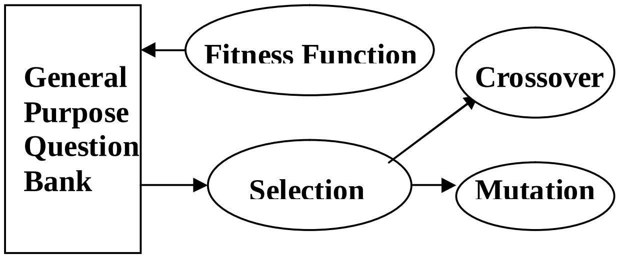

Fig: System Architecture

These processes ultimately result in the next generation population of chromosomes that is different from the initial generation. Generally the average fitness will have increased by this procedure for the population, since only the best organisms from the first generation are selected for breeding, along with a small proportion of less fit solutions, for reasons already mentioned above. Although Crossover and Mutation are known as the main genetic operators, it is possible to use other operators such as regrouping, colonization-extinction, or migration in genetic algorithms [.

4) Termination

This generational process is repeated until a termination condition has been reached. Common terminating conditions are:

- A solution is found that satisfies minimum criteria Fixed number of generations reached
- Allocated budget (computation time/money) reached

The highest ranking solution's fitness is reaching or has reached a plateau such that successive iterations no longer produce better results

- Manual inspection
- Combinations of the above

The Optimization of Material Supply Chain System works with the customers requirements like total number of material produced by that company, material Cost, profit margin etc. The system architecture consists of basic blocks like General Purpose question bank which is consist the various question according to the Problem and it is considered as a population and on that population Fitness function is applied. It gives the set of solution and from that list best optimal solution is selected using mutation and crossover function. In this way the proposed system will work.

5) Mathematical Model

Equations of the Objective Functions and Constraints

The equations of the objective function is given in equation (2) and the constraints according to the objective function are given in equations (3) to (5)

1. Total Material cost

$$TMC = PC+OC+SC \quad \ldots\ldots (1)$$

2. Objective Function is Minimize the total cost:

$$\text{Minimize} \sum \text{Total Material Cost} \quad \ldots\ldots (2)$$

$$3.\ PC = \sum_{i=1}^{N} Qi \times Pi \quad \ldots\ldots (3)$$

$$4.\ OC = N \times Co \quad \ldots\ldots (4)$$

$$5.\ SC = \sum_{t=1}^{D} SQt \times Cs \quad \ldots\ldots (5)$$

Where,
TMC = Total Material Cost
PC = Purchasing Cost
OC = Ordering Cost
SC = Storage Cost
N = No. of material order made
Qi = Quality of material for order i
Pi = unit price of material for order i
Co = average administrative cost for making single order
Cs = storage cost
SQt = Stock Quantity at time i

IV. CONCLUSION

The manufacturing companies and their supplier companies need to manage their schedule, manufacturing process and resources. Any change in schedule will require managing them again. This may lead to the wastage in time, material and finance. So the company aims to maximize profit with minimum wastage. We have proposed an effective system that works on this problem. The implementation of this proposed system will be done using Genetic algorithm. With this we can ensure minimum wastage and maximize the profit to facilitate the company.

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