APPLICATION OF GENETIC ALGORITHMS FOR OPTIMIZATION OF INVENTORY USING SUPPLY CHAIN MANAGEMENT

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Abstract— Summary Inventory management plays a vital role in supply chain management. The service provided to the customer eventually gets enhanced once the efficient and effective management of inventory is carried out all through the supply chain. Thus the determination of the inventory to be held at various levels in a supply chain becomes inevitable so as to ensure minimal cost for the supply chain. Minimizing the total supply chain cost is meant for minimizing holding and shortage cost in the entire supply chain. The minimization of the total supply chain cost can only be achieved when optimization of the base stock level is carried out at each member of the supply chain. A serious issue in the implementation of the same is that the excess stock level and shortage level is not static for every period. In this paper, we have developed a new and efficient approach that works on Genetic Algorithms and Web Technology in order to distinctively determine the most probable excess stock level and shortage level required for inventory optimization in the supply chain such that the total supply chain cost is minimized.

Index Terms— Algorithm, Crossover, Genetic Algorithm, Genetic Operations, Inventory Optimization, Inventory Control, Mutation, Selection, Supply Chain Management.

I. INTRODUCTION

COMPETITIVENESS in today's marketplace depends heavily on the ability of a company to handle the challenges of reducing lead-times and costs, increasing customer service levels, and improving product quality. Traditionally, sourcing (procurement), production, distribution and marketing have been working independently. Unfortunately, although they may seem to be working towards a common goal, these organizational units have different objectives. Marketing wants to have a high customer service level as well as high sales volume, but they conflict with the objective of production and distribution. Sourcing decisions normally depend solely on minimizing the cost of goods, and production and distribution decisions often consider only maximizing throughput while minimizing production (unit) costs without any consideration for high inventory levels or long lead-times. Supply chain management is the effective coordination and integration of different organizations with different objectives towards a common goal.

We have applied a novel and efficient approach using Genetic Algorithm to solve this complexity. Genetic Algorithms are inspired by the evolutionist theory explaining the origin of species. In nature, weak and unfit species within their environment are faced with extinction by natural selection. The strong ones have greater opportunity to pass their genes to future generations via reproduction. In the long run, species carrying the correct combination in their genes become dominant in their population. GA operates with a collection of chromosomes, called a population. The population is normally randomly initialized. As the search evolves, population includes fitter and fitter solutions.

GA avoids local optimal levels. It plays effective role in SCM since it is not based in fixed rules like other traditional and statistical approaches that are stiff. As inventory has dynamic nature too, varying demand for products is efficiently predicted using GA. We have also considered a variation in demand as per seasons and festivals since demand for certain products increases for some weeks. We are checking past years' records for those corresponding 3 weeks and if the increase in demand for a particular product in higher than the threshold value for respective product, option would we provided to supply chain member to place an order according to seasonal demand suggestion.

In order to minimize the total supply chain cost, the proposed approach clearly determines the most probable excess stock level and shortage level that are required for inventory optimization in the supply chain. In practice, the dynamic nature of the excess stock level and shortage level over all the periods is the typical problem occurring in inventory management. The determination of the stock level that occurs in a maximum rate is the vital operation to be performed. Thus, the maximum occurrences of stock level should be considered in order to optimize effectively. The employed fitness function of the genetic algorithm isformulated in such a way that it will consider the past periods to determine the necessary stock level. The proposed approach of genetic algorithm predicts the optimum stock levels of the future by considering the stock levels of thepast years such that the total supply chain cost will be maintained as minimum.

II. INVENTORY OPTIMIZATION ANALYSIS BASED ON GENETIC ALGORITHM

The primary goal of inventory optimization is to predict such an inventory level value which will avoid both the shortage and surplus conditions. In the proposed methodology, correct stock levels are to be maintained in weekly manner that will minimize the inventory cost. Supply chain is divided into following three stages and optimization is to be performed in all those stages.

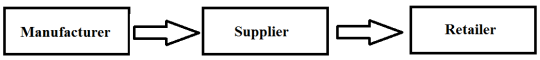

Figure (A)

In the above figure (A), the Manufacturer manufactures different products and decides how they would be supplied to the suppliers connected to him and also how the inventory will be forwarded to the retailers.

The proposed methodology's mail goal is to determine the amount of stock levels of the products to be maintained by all members of the supply chain. We are using genetic algorithm to find optimal values. The flow of operating is illustrated in the figure (B) which depicts the steps applied for the optimization analysis.

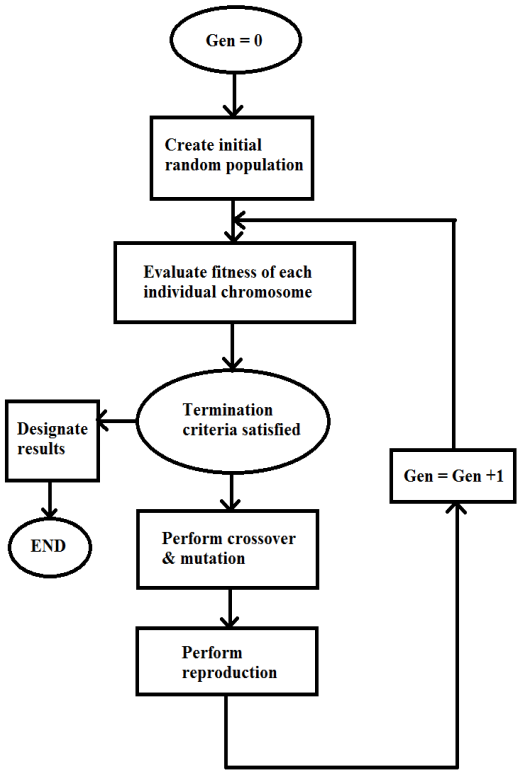

Figure (B)

Initially, the amount of stock levels in different supply chain members are represented by zero or non-zero values. Zero means that, inventory control is not needed while non-zero data requires the inventory control. Positive value refers to excess stock level and negative value refers to shortage.

A. Generation of Individuals

Each individual is generated with random value. Here, the chromosome will consists of the manufacturer and all suppliers and retailers connected to that product. A random individual generated for the genetic algorithm is shows in figure (C). After the generation of individuals, the number of occurrences of the individual in the past records is determined.

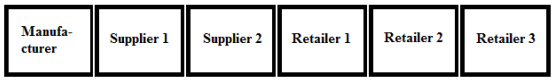

Figure (C)

Chromose structure of a product with 2 suppliers and 3 retailers

B. Evaluation of fitness function

A specific kind of objective function that calculates the optimality of a solution in a genetic algorithm in order to rank certain chromosome is known as Fitness Function. Optimal or near optimal chromosomes are permitted to breed and merge their datasets through one of the several techniques in order to produce a new and better generation.

The fitness function is given by:

$$f(i) = \log\left(1 - \frac{n_{occ}(i)}{n_{tot}}\right),\ i = 1,2,3,\cdots,n$$

Where:

nocc (i) = The number of occurrences of the chromosome i in the record set

ntot = The total number of records that have been collected from the past or total number of data present in the record set.

This fitness function ranks these randomly generated chromosomes. Then, they are subjected to genetic operations.

C. Genetic operators

Once fitness calculation is done, genetic operations are performed which are selection, crossover, mutation.

Selection: The selection operation is the initial genetic operation which selects of the fittest chromosome for further genetic operations. This is done by giving ranks based on the calculated fitness to each of the prevailing chromosome. On the basis of this ranking, best chromosomes are selected for further proceedings.

D. Crossover

A two point crossover operator is used in this study. The first two chromosomes in the mating pool are selected for crossover operation. Then two crossover points are chosen randomly. The crossover operation that is performed as shown in the following figure.

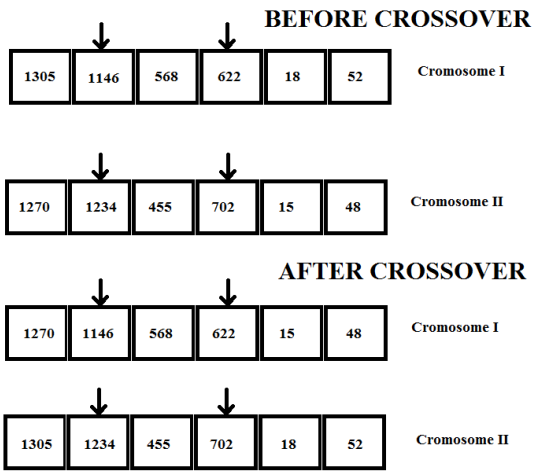

Figure (D)

The genes that are in between the two cross over points in the two chromosomes are swapped and hence the cross over operation is done. After the crossover operation two new chromosomes are obtained.

E. Mutation

The newly obtained chromosomes from the crossover operation are then subjected to mutation. By performing the mutation, a new chromosome will be generated. This is done by randomly selecting one point and mutating that value slightly. The illustration of mutation operation is shown
following figure.

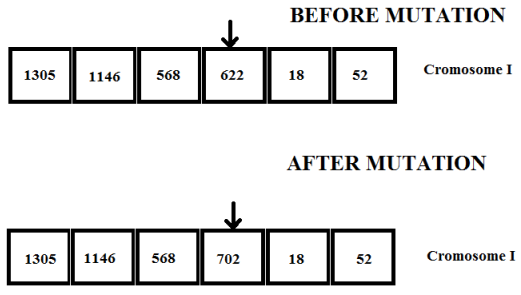

Figure (E)

The mutation operation provides new chromosomes that do not resemble the initially generated chromosomes. After obtaining the new chromosome, another random chromosome will be generated. The process explained so far will be repeated along with the new chromosome obtained from the previous process. In other words, at the end of each of the iteration, a best chromosome will be obtained. This will be included with the newly generated random chromosome for the next iteration. Eventually, an individual which is the optimal one among all the possible individuals is obtained. This best chromosome obtained has the optimal information about stock levels of a particular product at each member of the supply chain. From the information it can be concluded that the particular product and its corresponding stock levels play a significant role in the increase of supply chain cost. By controlling the stock level of that particular product at the respective member of the supply chain in the upcoming periods, the supply chain cost can be minimized.

F. Elitism

Sometimes next generation of genetic algorithm might have chromosomes that are not fitter than the ones in previous generation. In such cases to preserve the best individual concept called elitism is used. Here, we are preserving fittest 10 individuals from every generation and directly adding them in the chromosomes for the next iteration.

Thus obtained chromosome has the optimal information about stock levels of the corresponding members of a particular product.

III. RESULTS

The optimization of inventory control in supply chain management based on genetic algorithm is analyzed. The stock levels for the three different members of the supply chain, manufacturer, supplier and retailer are taken using excel sheet during sign-up process and this data set is used for evaluating the performance of the genetic algorithm.

id	pid	manufacturer	supp1	ret1	ret4
51	p11	1201	1369	645	583
52	p11	1345	1266	622	636
53	p11	1276	1188	544	718
54	p11	1258	1223	544	723
55	p11	1271	1161	564	724
56	p11	1279	1259	544	732
57	p11	1288	1253	546	727
58	p11	1294	1165	533	714
59	p11	1265	1219	554	739

Random population of 50 chromosomes is created. These initial chromosomes are subjected for the genetic operators, Crossover and Mutation. The resultant chromosome thus obtained after the application of crossover and mutation As for our iteration value of ‘100’, the resultant chromosome

moved towards the best chromosome after the each iterative execution. Hence at the end of the execution of 100th iteration, best chromosome '1256 1219 554 739' is obtained. Hence by comparing the obtained result from the genetic algorithm with the past records it is proved that the analysis obtains a stock level that is a better prediction for the inventory optimization in supply chain management.

CONCLUSION

Inventory management is a significant component of supply chain management We have discuss a method based on genetic algorithm Based Multi Product and Multi Agent to optimize inventory in supply chain management we also focus on to specifically determine the most probable excess stock level and shortage level required for inventory optimization in the supply chain such that the total supply chain cost is minimized. PHP and MySQL was utilized to implement the proposed approach and to evaluate the performance. The genetic algorithm performed well as anticipated. Thus the proposed work proffers a better prediction of stock levels amid diverse stock levels at various members of the supply chain. Henceforth the stock level obtained is the optimal value that is necessary in order to determine the stock level.

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