Optimizing Multi product Inventory using Genetic Algorithm for efficient Supply Chain Management involving Lead Time

N.Jeyanthi
Associate Professor
Dept. of Mathematics
Sri G.V.G. Visalakshi college
Udumalpet 642 128
Tamil Nadu, India

P.Radhakrishnan
Assistant professor
SVP Institute of Textile Management,
Coimbatore-641004
Tamil Nadu, India

Summary
Inventory management is considered to be an important field in Supply chain management. Once the efficient and effective management of inventory is carried out throughout the supply chain, service provided to the customer ultimately gets enhanced. Hence, to ensure minimal cost for the supply chain, the determination of the inventory to be held at various levels in a supply chain is unavoidable. Minimizing the total supply chain cost refers to the reduction of holding and shortage cost in the entire supply chain. Efficient inventory management is a complex process which entails the management of the inventory in the whole supply chain and getting the final solution as optimal, i.e. in the process of supply chain management, the stock level at each member of the supply chain should account to minimum total supply chain cost. The dynamic nature of the excess stock level and shortage level over all the periods is a serious issue when implementation is considered. In addition, the complexity of the problem increases when more number of products, distribution centers and agents are involved. Moreover, the supply chain cost increases because of the influence of lead times for supplying the stocks . A better optimization methodology would consider all these factors in the prediction of the optimal stock levels to be maintained in order to minimize the total supply chain cost. In this paper, these issues of inventory management have been focused and a novel approach based on Genetic Algorithm has been proposed in which the most probable excess stock level and shortage level required for inventory optimization in the supply chain is distinctively determined so as to achieve minimum total supply chain cost.

Keywords:
Supply Chain Management, Inventory control, lead time, Inventory Optimization, Genetic Algorithm, supply chain cost.

1. Introduction

Global competition, shorter product life cycles, dynamic changes of demand patterns and product varieties and environmental standards cause remarkable changes in the market scenario thereby thrusting the manufacturing enterprises to deliver their best in order to strive [1]. Decrease in lead times and expenses, enrichment of customer service levels and advanced product quality are the characteristics that determine the competitiveness of a company in the contemporary market place [11]. The above mentioned factors have made the business enterprises to contemplate about their supply chains. An ensemble or organizations providing products and services to the market may be called as a supply chain. A supply chain can also be described as a collection of numerous entities that work in unison towards 1) obtaining raw materials, (2) converting these raw materials into precise end products, and (3) delivering the end products to retailers [19].

The activities included in a traditional supply chain are purchase of raw materials and manufacturing items at one or more factories, shipping the items to various warehouses for storage and in turn distribution of the same to the respective retailers or customers [20]. Hence, a beneficial coordination and integration of organizations with individual objectives to achieve a common goal can be referred to as a supply chain.

Processes that support the effective integration of suppliers, manufacturers, warehouses and stores to guarantee suitable production and distribution of right quantities to the right location in right time and decreasing the total supply chain eventually in addition to satisfying service level requirements are incorporated in Supply chain management. The manufacturer who is in charge of the acquirement of raw materials, conversion in to end products and distribution of the same to customers, is considered to the manager of the supply chain. A huge problem that a majority of the supply chains aiming to reduce the supply chains costs besides improving customer service levels face is that of the administration of the dynamic demand [10]. A variety of process that aid the planning, implementation, control, ,manufacturing and the delivery processes originating from the raw material reserve to the point of utilization of the end product [6], are considered to be an integral part of the supply chain managements. Shorter product lifecycles that lead to higher demand uncertainty and their effect on global markets accordingly increasing the supply chain complexity, results in severe problems in the management of the supply chain [11, 8]. The research proposed tends to address four problems from the operational perspective: Inventory management and control; production, planning and scheduling; information sharing, coordination, monitoring; and operation tools [9].

Manuscript received May 5, 2010
Manuscript revised May 20, 2010

The effective management of the supply chain has become unavoidable these days due to the firm increase in customer service levels [5]. The supply chain cost was immensely influenced by the overload or shortage of inventories. Thus inventory optimization has transpired into one of the most recent topics as far as supply chain management is considered [3], [15], [17].

Inventory is defined as the ensemble of items stored by an enterprise for future use and a set of procedures called inventory systems aid in examination and control of the inventory [4]. It is possible to stock the inventory through various stages along the production and distribution supply chain [3]. The inventory system supports the estimation of amount of each item to be stored, when the low items should be restocked, and the number of items that must be ordered or manufactured as soon as restocking becomes essential [4]. It is the responsibility of a supply manager to make a decision on the offers that need to be accepted in addition to updating the anticipated future inventory replacement costs.

Inventory optimization application organizes the latest techniques and technologies, thereby assisting the enhancement of inventory control and its management across an extended supply network. Some of the design objectives of inventory optimization are to optimize inventory strategies, thereby enhancing customer service, reducing lead times and costs and meeting market demand [3], [15], [17]. The design and management of the storage policies and procedures for raw materials, work-in-process inventories, and typically, final products [19] are illustrated by the inventory control. The costs and lead times can be reduced and the responsiveness to the changing customer demands can be significantly improved and subsequently inventory can be optimized by the effective handling of the supply chain [8].

The inventory and supply chain managers are mainly concerned about the estimation of the exact amount of inventory at each point in the supply chain free of excesses and shortages although the total supply chain cost is minimized. Owing to the fact that shortage of inventory yields to lost sales, whereas excess of inventory may result in pointless storage costs, the precise estimation of optimal inventory is indispensable [20]. In other words, there is a cost involved in manufacturing any product in the factory as well as in holding any product in the distribution center and agent shop. More the products manufactured or held, more will be the holding cost. Meanwhile, there is possibility for the shortage of products. For the shortage of each product there will be a shortage cost. Holding excess stock levels as well as the occurrence of shortage for products lead to the increase in the supply chain cost.

This paper supplements the previous paper that focuses only on a single product [34]. In this paper, we are considering the situation of multiple products and multiple members of the supply chain. Thus the complexity of the problem has been increased. As the lead time plays vital role in the increase of supply chain cost, the complexity in predicting the optimal stock levels increases. We have developed a novel and efficient approach using Genetic Algorithm to solve this complexity. 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 proposed approach of genetic algorithm predicts the emerging excess/shortage stock levels of the future by considering the stock levels of the past years, which is an essential information for supply chain inventory optimization as well as total supply chain cost minimization.

The remainder of the paper is organized as follows; Section 2 gives a brief review of relevant researches on inventory optimization. Section 3 gives the fundamentals of Genetic algorithm. The proposed approach of the genetic algorithm is presented in Section 4 and conclusions are summed up in Section 5.

2. Related Works

A fresh genetic algorithm (GA) approach for the integrated inventory distribution problem (IIDP) has been projected by Abdel et al. [33]. They have developed a genetic representation and have utilized a randomized version of a formerly developed construction heuristic in order to produce the initial random population.

In [8] Pupong et al., have put forth an optimization tool that works on basis of a multi-matrix real-coded Generic Algorithm (MRGA) and aids in reduction of total costs associated within supply chain logistics. They have incorporated procedures that ensure feasible solutions such as the chromosome initialization procedure, crossover and mutation operations. They have evaluated the algorithm with the aid of three sizes of benchmarking dataset of logistic chain network that are conventionally faced by most global manufacturing companies.

A technique to utilize in supply-chain management that supports the decision-making process for purchases of direct goods has been projected by Scott et al. [20]. RFQs have been constructed on basis of the projections for future prices and demand and the quotes that optimize the level of inventory each day besides minimizing the cost have been accepted. The problem was represented as a Markov decision process (MDP) that allows for the calculation of the utility of actions to be based on the utilities of substantial future states. The optimal quote requests and accepts at each state in the MDP were determined with the aid of Dynamic programming.

A supply chain management agent comprising of predictive, optimizing, and adaptive components called the TacTex-06 has been put forth by David et al. [6]. TacTex-06 functions by making predictions regarding the future of the economy, such as the prices that will be proffered by component suppliers and the degree of customer demand, and then strategizing its future actions so as to ensure maximum profit.

Beamon et al. [19] have presented a study and evaluations of the performance measures employed in supply chain models and have also displayed a framework for the beneficial selection of performance measurement systems for manufacturing supply chains. Three kinds of performance measures have been recognized as mandatory constituents in any supply chain performance measurement system. New flexibility measures have been also created for the supply chains.

The accomplishment of Beam-ACO in supply-chain management has been proposed by Caldeira et al. [28]. Beam-ACO has been used to optimize the supplying and logistic agents of a supply chain. A standard ACO algorithm has aided in the optimization of the distributed system. The application of Beam-ACO has enhanced the local and global results of the supply chain

A beneficial industry case applying genetic algorithms (GA) has been proposed by Kesheng et al. [29]. The case has made use of GAs for the optimization of the total cost of a multiple sourcing supply chain system. The system has been exemplified by a multiple souring model with stochastic demand. A mathematical model has been implemented to portray the stochastic inventory with the many to many demand and transportation parameters as well as price uncertainty factors

A genetic algorithm which has been approved by Chih-Yao Lo [30] to deal with the production-inventory problem with backlog in the real situations, with time-varied demand and imperfect production due to the defects in production disruption with exponential distribution. Besides optimizing the number of production cycles to generate a (R,Q) inventory policy, an aggregative production plan can also be produced to minimize the total inventory cost on basis of the reproduction interval searching in a given time horizon.

In [31] Barlas et al., have developed a System Dynamics simulation model of a typical retail supply chain. The intent of their simulation exercise was to build up inventory policies that enhance the retailer's revenue and reduce costs at the same instant. Besides, the research was also intended towards studying the implications of different diversification strategies.

A supply chain model functioning under periodic review base-stock inventory system to assist the manufacturing managers at HP to administer material in their supply chains has been introduced by Lee et al. [32]. The inventory levels across supply chain members were obtained with the aid of a search routine.

3. Genetic Algorithm

Genetic algorithm is a randomized search methodology having its roots in the natural selection process. Initially the neighborhood search operators (crossover and mutation) are applied to the preliminary set of solutions to acquire generation of new solutions. Solutions are chosen randomly from the existing set of solutions where the selection probability and the solution's objective function value are proportional to each other and eventually the aforesaid operators are applied on the chosen solutions. Genetic algorithms have aided in the successful implementation of solutions for a wide variety of combinatorial problems.

The robustness of the Genetic algorithms as search techniques have been theoretically and empirically proved [23]. The artificial individual is the basic element of a GA. An artificial individual consists of a chromosome and a fitness value, similar to a natural individual. The individual's likelihood for survival and mating is determined by the fitness function [21]. In accordance with the Darwin's principle, individuals superior to their competitors, are more likely to promote their genes to the next generations. In accordance with this concept, in Genetic Algorithms, we encode a set of parameters mapped into a potential solution, named chromosome, to the optimization problem [22]. The population of candidate solutions is obtained through the process of selection, recombination, and mutation performed in an iterative manner. [24].

Chromosomes refer to the random population of encoded candidate solutions with which the Genetic algorithms initiate with [23]. Then the set (called a population) of possible solutions (called chromosomes) are generated [27]. A function assigns a degree of fitness to each chromosome in every generation in order to use the best individual during the evolutionary process [26]. In accordance to the objective, the fitness function evaluates the individuals [24]. Each chromosome is evaluated using a fitness function and a fitness value is assigned. Then, three different operators- selection, crossover and mutation- are applied to update the population. A generation refers to an iteration of these three operators [25]. The promising areas of the search space are focused in the selection step. The selection process typically keeps solutions with high fitness values in the population and rejects individuals of low quality [24]. Hence, this provides a means for the chromosomes with better fitness to form the mating pool (MP) [27].

After the process of Selection, the crossover is performed. In the crossover operation, two new children are formed by exchanging the genetic information between two parent chromosomes (say C1 and C2 which are selected from the selection process) [27]. A crossover point is chosen at random by the crossover operator. At this point, two parent chromosomes break and then exchange the chromosome parts after that point. Consequently, the partial features of two chromosomes are combined to generate two off springs. The chromosome cloning takes place when a pair of chromosomes does not cross over, thus creating off springs that are exact copies of each parent [26].The ultimate step in each generation is the mutation of individuals through the alteration of parts of their genes [24]. Mutation alters a minute portion of a chromosome and thus institutes variability into the population of the subsequent generation [27]. Mutation, a rarity in nature, denotes the alteration in the gene and assists us in avoiding loss of genetic diversity [24]. Its chief intent is to ensure that the search algorithm is not bound on a local optimum [26].

4. Inventory Optimization Analysis Using GA

The inventory control for more number of products along with different levels of supply chain is a complex task. To make the inventory control effective, the most primary objective is to predict where, why and how much of the control is required. Such a prediction is to be made here through the methodology we have proposed. This leads to an easy estimation of the level of stocks of the particular products to be maintained in the upcoming periods. For instance, we are taking a three stage supply chain having seven members and it is depicted in the figure

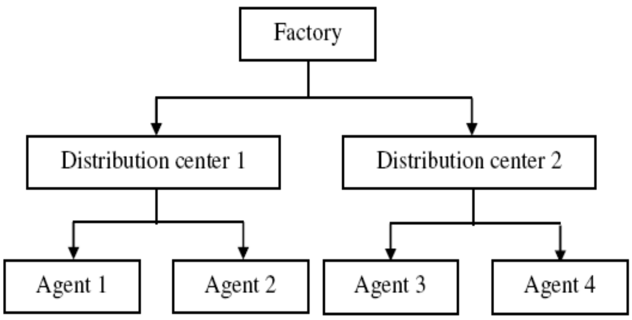

Figure 1: 3 stage-7 member supply chain

As illustrated in figure 1, a factory is the parent of the chain and it is having two distribution centers Distribution center 1 and distribution center 2. Each distribution center further comprises of several agents but as stated in our exemplary case, each distribution center is having two agents. So, in aggregate there are four agents, Agent1 and Agent2 for Distribution center 1 and Agent 3 and Agent 4 for Distribution center 2. The factory manufactures different products that would be supplied to the distribution centers. From the distribution center, the stocks will be moved to the corresponding agents. Our methodology is taking the responsibility here in determining the exact product that needs to be concentrated on and the amount of stock levels of the product to be maintained by the different members of the supply chain. Also, the methodology analyses whether the stock level of the particular product needs to be in abundance in order to avoid shortage of the product or needs to be held minimal in order to minimize the holding cost.

The factory is manufacturing different types of product. The database holds the information about the stock levels of the product in each of the supply chain member, lead time of products in each supply chain member . For l members from factory to end-level-Agents, there are $l-1$ lead times for a particular product and these times are collected from the past records.. Each and every dataset recorded in the database is indexed by a Transportation Identification (TID). For p periods, the TID will be $\{T_1, T_2, T_3, \cdots, T_p\}$. This TID will be used as an index in mining the lead time information. Then each individual is queried into the database for obtaining the details regarding the TID and frequency of the individual. This obtained TID is queried into the database having the lead time of a particular product to a particular supply chain member. After all these queries, we have obtained the lead time of stocks as follows

$$T_s = [t_{q,1} \quad t_{q,2} \quad \cdots \quad t_{q,l-1}]$$

The methodology flow is illustrated in the figure 2 would analyze the past records very effectively and thus facilitate efficient inventory management with the contribution of Genetic Algorithm.

The analysis flow is initiated by the selection of valid records. The validation of records are done over the records of past periods. The stock levels at the different supply chain members are held for different products, namely P1, P2, P3, P4, P5, P6, P7, etc. throughout the period under consideration are considered as data set as shown in the table 1. In the valid record set selection, records having nil values are neglected and the records having positive or negative values are selected for the analysis. This can be done by means of clustering algorithms, extraction algorithms or by any of the data mining functions. Hence the extraction function results in data sets have either positive or negative values.

The record set having positive values represents excess stock levels of a particular product and the negative values represent shortage level of the particular product. This will be carried out for each product and for every members of the chain. Then the data set is subjected to Genetic Algorithm and the various steps performed in the genetic algorithm dedicated for our objective work are discussed below.

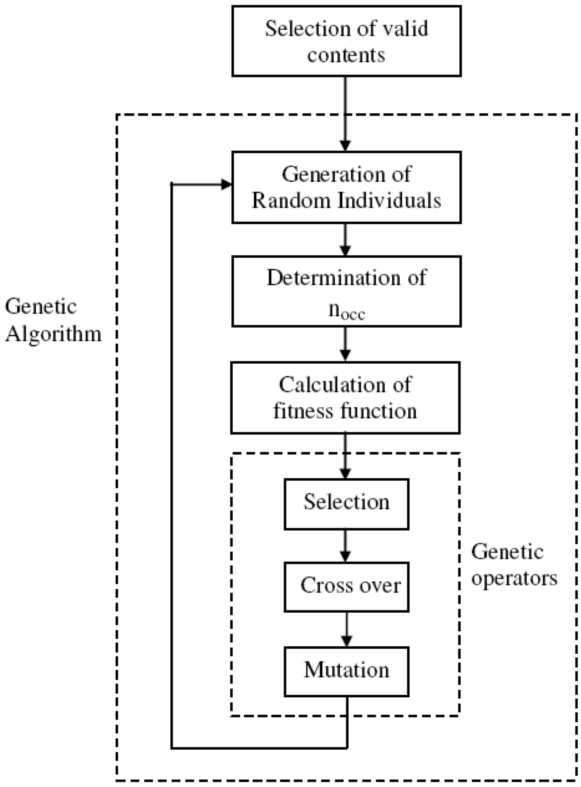

Figure 2: Genetic Algorithm flow for the proposed inventory management analysis

Table 1: The dataset for the analysis taken from the past periods

Produc	*Factor (F1)*	*Distributio Center 1 (F2)*	*Distributio Center 2(F*	*Agen (F4*	*Agen (F5*	*Agen (F6*	*Agen (F7*
P1	2000	500	-300	30	120	-130	200
P3	-4000	200	400	200	-300	-450	-160
P6	3000	-700	-600	-450	80	230	400
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

4.1 Generation of Individuals

Each individual which is constituted by genes is generated with random values. Here, the chromosome of seven genes where the random values occupies at each gene is generated along with the product representation. A random individual generated for the genetic operation is illustrated in the figure 3.

Each gene of the chromosome displayed in the figure 4 is the stock level of the product in that particular member. As for our three individuals, Individual1 deals with product 1, Individual 2 deals with product 4 and Individual 3 deals with product 5. So, the first individual P1 represents 2000 excess stocks in factory, 200 excess stocks in distribution center 1, shortage for 400 stocks in Distribution center 2 and so on. In such a manner the other individuals represent the product P4 and the Product P5.

P4	6000	-100	-500	700	-300	600	-700

P1	2000	200	-400	600	-800	-300	600

P5	5000	300	-600	400	900	-800	-600

Figure 3: random individual generated for the genetic operation

After the generation of the individuals, the number of occurrences of the individual in the past records is determined. This is performed by the function $count()$ and the total number of occurrences of that individual for the particular product is determined. This is equivalent to the number of occurrences of such situation of stock levels for the particular product in all the members throughout the ten years.

4.2 Evaluation of Fitness function

A specific kind of objective function that enumerates the optimality of a solution in a genetic algorithm in order to rank certain chromosome against all the other chromosomes is known as a Fitness function. Optimal chromosomes, or at least chromosomes which are more optimal, are permitted to breed and merge their datasets through one of the several techniques available in order to produce a new generation that will be further better.

Fitness functions ensure that the evolution is toward optimization by calculating the fitness value for each individual in the population. The fitness value evaluates the performance of each individual in the population.

$$f(i)=w_{1}.\quad \log\left(1-\frac{n_{occ}(i)}{n_{tot}}\right) \quad +\log(w_2 .t_{stock})$$

$$i = 1,2,3,\cdots,n$$

$n_{occ}(i)$ is the number of occurrences of the chromosome i in the record set n_{tot} is the total number of records that have been collected from the past or total number of data present in the record set.

n is the total number of chromosomes for which the fitness function is calculated.

w_1 and w_2 are the weightings of the factors, stock levels, lead time of stocks in optimization, respectively and they are determined as

$$w_1 = \frac{R_1}{R_1 + R_2}$$

$$w_2 = \frac{R_2}{R_1 + R_2}$$

R_1 and R_2 are the priority levels of influence of stock levels and lead time of stocks in optimization of respectively. Increasing the priority level of a factor increases the influence of the corresponding factor in the evaluation function. Hence this R_1 and R_2 decide the amount of influence of the factors The lead time of the stocks t_{stock} is determined as follows

$$t_{stock} = \sum_{i=1}^{l-1} \sum_{q} t_{q,i}$$

The fitness function is carried out for each chromosome and the chromosomes are sorted on the basis of the result of the fitness function.

In the fitness function, the ratio ($n_{occ}(i) / n_{tot}$)) plays the role of finding the probability of occurrence of a particular chromosome; and [1-($n_{occ}(i) / n_{tot}$)] will ensure minimum value corresponding to the maximum probability; (w2. .t stock) is structured to give the total lead time involved in the particular stock record .

So, the fitness function is structured to retain the minimum value corresponding to the various chromosomes being evaluated iteration after iteration and this in turn ensures that the fitness function evolution is towards optimization.

4.3 Genetic operations

Once fitness calculation is done of fitness calculation, Genetic operations are performed. Selection, Crossover and mutation comprise Genetic operations.

4.3.1. Selection:

The selection operation is the initial genetic operation which is responsible for the selection of the fittest chromosome for further genetic operations. This is done by offering 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.

4.3.2. Crossover:

Among the numerous crossover operators in practice, for our complex operation, we have chosen two point crossover. From the matting pool, two chromosomes are subjected for the two point crossover. The crossover operation performed in our analysis is pictured in the figure 4.

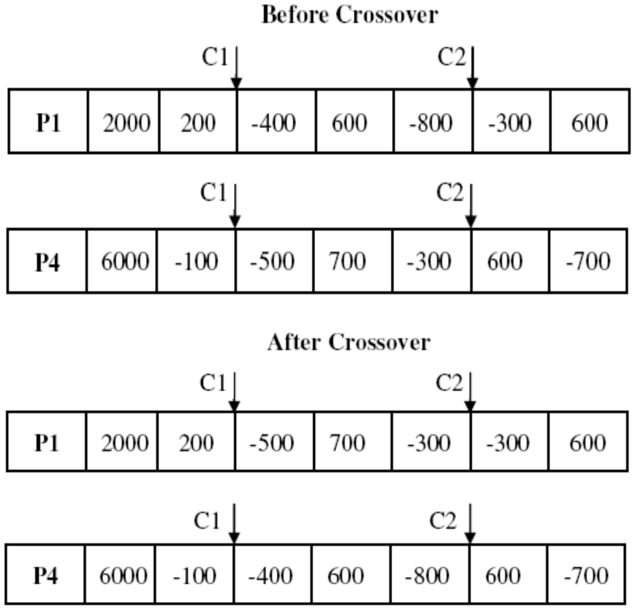

Figure 4: Chromosomes are subjected for Two point crossover operation

As soon as the crossover operation is completed, the genes of the two chromosomes present within the two crossover points get interchanged. The genes before the crossover point C1 and the genes beyond the crossover point C2 remain unaltered even after the crossover operation.

4.3.3. Mutation:

The crossover operation is succeeded by the final stage of genetic operation known as Mutation. In the mutation, a new chromosome is obtained. This chromosome is totally new from the parent chromosome. The concept behind this is the child chromosome thus obtained will be fitter than the parent chromosome. The performance of mutation operation is illustrated in the figure 6

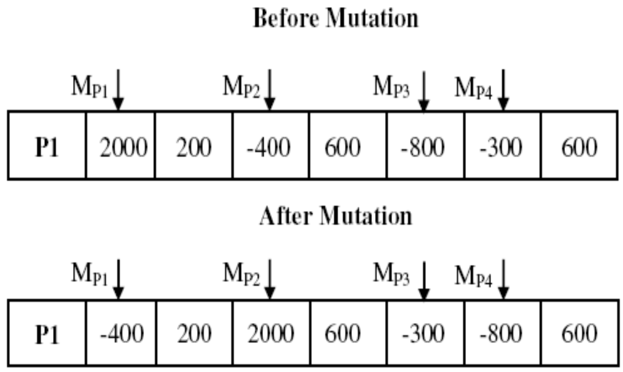

Figure 5: Chromosome subjected for mutation operation

As in figure 5 we have chosen four mutation points Mp1, Mp2, Mp3 and Mp4. The mutation is done on the particular gene present at the Mutation point points. This pointing of gene is done randomly. Hence, the four mutation points may point any of the seven genes.

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 chromosomes for the next iteration. Eventually, we obtain an individual which is the optimal one among all the possible individuals. Thus obtained chromosome has the optimal information about stock levels of the corresponding members of a particular product. 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 in the upcoming periods, the supply chain cost can be minimized.

5. IMPLEMENTATION RESULTS

We have implemented the analysis based on GA for optimal inventory control in the platform of MATLAB (version 7.4). As stated, we have the detailed information about the excess and the shortage stock levels in each supply chain member, the lead times of product stock levels to replenish each supply chain member . The sample data having this information is given in the Table 2.

Table 2: Sample data from database of different stock levels

TI	*PI*	*F1*	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*
1	3	632	424	247	-298	-115	365	961
2	5	-415	488	-912	979	-492	-922	205
3	2	369	-686	-468	-807	183	-386	-228
4	2	459	289	-522	-316	130	-854	468
5	3	-663	944	856	451	-763	657	484
6	4	-768	-937	-768	242	369	-890	289

The Table 2 is having the product ID, the Transportation ID, the stock levels which are in excess or in shortage at each supply chain member. Negative values represent shortage of stock levels and positive values represent the excess of stock levels. The transportation ID mentioned in table is working as an index in extracting the lead times for stocks .

Table 3 depicts the sample data which is having the transportation ID and the lead times for stocks. For seven member supply chain, six lead times can be obtained.

Table 3: Sample data from Database which is having lead times for stocks

TI	*PI*	*T1*	*T2*	*T3*	*T4*	*T5*	*T6*
1	3	23	22	9	19	18	17
2	5	26	33	16	14	24	15
3	2	28	38	10	17	10	18
4	2	20	22	9	21	21	13
5	3	38	40	25	21	16	11
6	4	33	41	17	13	21	19

Here T1 is the lead time involved for movements of the respective product from F1 to F2 ;
T2 is the lead time involved for movements of the respective product from F2 to F3 ;
T3 is the lead time involved for movements of the respective product from F3 to F4 ;
T4 is the lead time involved for movements of the respective product from F4 to F5 ;
T5 is the lead time involved for movements of the respective product from F5 to F6 ;
T6 is the lead time involved for movements of the respective product from F6 to F7 ;
For GA based analysis, we have to generate random individuals having eight numbers of particles representing product ID and seven supply chain members. Table 4 describes two random individuals.

Table 4: Initial random individuals

PI	*F1*	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*
3	855	61	215	863	24	75	-757
5	854	-154	145	-241	-215	415	845

and they will be subjected to genetic operations like Fitness evaluation, Selection, Crossover and Mutation. An iteration involving all these processes was carried out so as to obtain the initial best chromosome.

The simulation run on a huge database of 5000 past records showing Fitness function improvement at different levels of iteration is as follows:

Simulation Result showing Fitness function improvement with w1 = 0.6250; w2= 0.375

For iteration 20: fitness = 5.7845

For iteration 50; fitness = 5.6450;
Improvement: 2%

For iteration 70; fitness = 5.3749;
Improvement: 5%

For iteration 100; fitness = 4.8220;
Improvement: 10%

As for deciding the total number of iterations required, the criteria followed is that as long as minimization of the fitness function is still possible, then the iteration continues till such a time that no improvement in the fitness function value is noticeable. After a certain number of iterations, if the fitness function value is not improving from the previous iterations, then this is an indication that the fitness function value is stabilizing and the algorithm has converged towards optimal solution. For greater accuracy, the number of iterations should be sufficiently increased and run on the most frequently updated large database of past records.

The final individual obtained after satisfying the above mentioned convergence criteria is:

$$[3 \quad -602 \quad -280 \quad -821 \quad 398 \quad 382 \quad -764 \quad -125]$$

The database format of this final individual is given in Table 6.

Table 6: database format of Final Individual

PI	***F1***	***F2***	***F3***	***F4***	***F5***	***F6***	***F7***
3	-602	-280	-821	398	382	-764	-125

The final individual thus obtained represents a product ID and excess or shortage stock levels that has the potential to cause maximum increase of supply chain cost at each of the seven members providing essential information for supply chain inventory optimization.

By taking necessary steps to eliminate the identified emerging excesses/ shortages at different members of the supply chain, the supply chain cost can be minimized to that extent. Thus by following the predicted stock levels, we can avoid the increase of supply chain cost.

5. Conclusion

Inventory management is an important component of supply chain management. The members of the supply chain are responsible for minimizing the costs of a supply chain by managing inventory levels in a number of production and distribution operations associated with different chain stages. As the lead time plays vital role in the increase of supply chain cost, the complexity in predicting the optimal stock levels increases. We have proposed an innovative and efficient methodology that uses Genetic algorithm presented that is aimed at reducing the total supply chain cost as it undoubtedly established the most probable surplus stock level and shortage level along with the consideration of lead time involved in supplying the stocks for multi product situation, that are required for inventory optimization in the supply chain such that the total supply chain cost is minimal. The proposed approach was implemented and its performance was evaluated using MATLAB 7.4. The performance of Genetic Algorithm was well as predicted. By following the proposed genetic algorithm based approach for inventory management, we determined the products due to which the members of the supply chain incurred extra holding or shortage cost in the whole supply chain. The proposed approach of inventory management has achieved the objectives which are the minimization of total supply chain cost as well as lead time and the determination of the products due to which the respective supply chain members endured either additional holding cost or shortage cost with lead time consideration which is a vital information for supply chain inventory optimization.

References

[1] Sarmiento, A. Rabelo, L. Lakkoju, R. Moraga, R., “Stability analysis of the supply chain by using neural networks and genetic algorithms”, Proceedings of the winter Simulation Conference, pp: 1968-1976, 2007.

[2] Joines, J.A. Gupta, D. Gokce, M.A. King, R.E. Kay, M.G., “Supply Chain Multi-Objective Simulation Optimization”, Proceedings of the winter Simulation Conference, vol.2, pp: 1306- 1314, publication date. 8-11, Dec. 2002.

[3] “Optimization Engine for Inventory Control”, white paper from Golden Embryo Technologies pvt. ltd., Maharastra, India, 2004.

[4] Levi, R., Martin Pal, R. O. Roundy, D. B. Shmoys. “Approximation algorithms for stochastic inventory control models", Mathematics of Operations Research 32, pp: 284-302, 2007.

[5] Mileff, Peter, Nehez, Karoly, “A new inventory control method for supply chain management”, 12th International Conference on Machine Design and Production, 2006.

[6] D. Pardoe and P. Stone, "An autonomous agent for supply chain management". In G. Adomavicius and A. Gupta, editors, Handbooks in Information Systems Series: Business Computing. Elsevier, 2007.

[7] Roberto Rossi, S. Armagan Tarim and Brahim Hnich and Steven Prestwich, “Cost-based Filtering for Stochastic Inventory Systems with Shortage Cost”, Lecture Notes in Computer Science, 2007.

[8] Pongcharoen, P., Khadwilard, A. and Klakankhai, A., "Multi-matrix real-coded Genetic Algorithm for minimizing total costs in logistics chain network", Proceedings of World Academy of Science, Engineering and Technology, vol. 26, pp .458-463, December 14th-16th, 2007.

[9] Ganeshan, R., Jack, E., Magazine, M.J., Stephens, P., “A taxonomic review of supply chain management research", Quantitative Models for Supply Chain Management. Kluwer Academic Publishers, Massachusetts, pp. 841–879, 1999.

[10] Rajesh Gangadharan, “Supply Chain Strategies to Manage Volatile Demand”, 2007.

[11] Joines J.A., & Thoney, K, Kay M.G, “Supply chain multi-objective simulation optimization”, Proceedings of the 4th International Industrial Simulation Conference. , Palermo, pp. 125-132, 2008.

[12] Kanit Prasertwattana, Yoshiaki Shimizu; and Navee Chiadamrong. "Evolutional Optimization on Material Ordering and Inventory Control of Supply Chain through

Incentive Scheme", Journal of Advanced Mechanical Design, Systems, and Manufacturing, Vol. 1, No. 4, pp. 562-573, 2007.
[13] R. Rossi, S. A. Tarim, B. Hnich and S. Prestwich, "Replenishment Planning for Stochastic Inventory Systems with Shortage Cost", In proceedings of The Fourth International Conference on Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems , pp.229-243, May 23-26, 2007.
[14] Sensing and Shaping Demand in a Consumer-driven Marketplace, Electronics Supply Chain Association Report, 2006.
[15] Jinmei Liu, Hui Gao, Jun Wang, “Air material inventory optimization model based on genetic algorithm," Proceedings of the 3rd World Congress on Intelligent Control and Automation, vol.3, pp: 1903 - 1904, 2000.
[16] Greg Scheuffele, Anupam Kulshreshtha, "Inventory Optimization A Necessity Turning to Urgency," SETLabs Briefings, vol. 5, no. 3, 2007.
[17] C.M. Adams, "Inventory optimization techniques, system vs. item level inventory analysis," 2004 Annual Symposium RAMS - Reliability and Maintainability, pp: 55 - 60, 26-29, Jan, 2004.
[18] Lummus R.R., Vokurka R.J., “Defining Supply Chain Management”, Industrial Management & Data Systems, 1999.
[19] Beamon BM, "Supply chain design and analysis: models and methods", International Journal of Production Economics, Vol: 55, No. 3, page: 281–294, 1998.
[20] S. Buffett, N. Scott, "An Algorithm for Procurement in Supply Chain Management", AAMAS-04 Workshop on Trading Agent Design and Analysis, New York, 2004.
[21] Aphirak Khadwilard and Pupong Pongcharoen ,“Application of Genetic Algorithm for Trajectory Planning of Two Degrees of Freedom Robot Arm With Two Dimensions”, in proc. of Thammasat Int. Journal on Science and Technology, vol. 12, no. 2, April-June 2007.
[22] M. A. Sharbafi, M. Shakiba Herfeh, Caro Lucas, A. Mohammadi Nejad, “An Innovative Fuzzy Decision Making Based Genetic Algorithm” , in proc. of World Academy of Science, Engineering and Technology, vol. 13, May 2006, ISSN:1307-6884.
[23] S. Behzadi, Ali A.Alesheikh, E.Poorazizi , “Developing a Genetic Algorithm to solve Shortest Path Problem on a Raster Data Model” in proc. of Journal on Applied Sciences, vol. 8, no. 18, pp: 3289-3293, 2008.
[24] Thomas Butter, Franz Rothlauf, Jörn Grahl, Hildenbrand Jens Arndt, Thomas Butter, Franz Rothlauf, Jörn Grahl, Tobias Hildenbrand, Jens Arndt , "Developing Genetic Algorithms and Mixed Integer Linear Programs for Finding Optimal Strategies for a Student’s Sports Activity”, in proc. of Research Paper on Universitat Mannheim2006.
[25] M. Soryani, N. Rafat , “Application of Genetic Algorithms to Feature Subset Selection in a Farsi OCR”, in proc. of World Academy of Science, Engineering and Technology, vol. 13, May 2006, ISSN:1307-6884.
[26] Saifuddin Md. Tareeq, Rubayat parveen, Liton Jude Rozario and Md. Al-Amin Bhuiyan , “Robust Face detection using Genetic Algorithm”, in proceedings of Journal on Information technology, vol.6, no. 1, pp: 142-147, 2007.
[27] Qureshi, S.A. Mirza, S.M. Arif, M., “Fitness Function Evaluation for Image Reconstruction using Binary Genetic Algorithm for Parallel Ray Transmission Tomography”
[28] Joao Caldeira, Ricardo Azevedo, Carlos A. Silva, Joao M. C. Sousa, "Supply-Chain Management Using ACO and Beam-ACO Algorithms", FUZZ-IEEE proceedings, pp: 1-6, 2007.
[29] K. Wang, Y. Wang, "Applying Genetic Algorithms to Optimize the Cost of Multiple Sourcing Supply Chain Systems – An Industry Case Study”, vol. 92, pp: 355-372, 2008.
[30] Chih-Yao Lo, “Advance of Dynamic Production-Inventory Strategy for Multiple Policies Using Genetic Algorithm”, Information Technology Journal, vol: 7, pp: 647-653, 2 008.
[31] Y. Barlas, A. Aksogan, "Product Diversification and Quick Response Order Strategies in Supply Chain Management" [web page], Bogazici University 1997 [cited 27 August 1999]. Available from http://ieiris.cc.boun.edu.tr/faculty/barlas,1999.
[32] Lee HL, Billington C, "The evolution of supply-chain-management models and practice at Hewlett-Packard", Interface, vol. 25, no. 5, 1995.
[33] Abdelmaguid T.F, Dessouky M.M,"A genetic algorithm approach to the integrated inventory-distribution problem", in proceedings of International Journal on Production Research 44, pp: 4445-4464, 2006.
[34] P.Radhakrishnan, M.R.Gopalan and N.Jeyanthi, " Design of Genetic Algorithm Based Supply Chain Inventory Optimization with Lead Time ,"IJCSNS International Journal of Computer Science and Network security, vol. 10, No. 4, pp.238-246, Apr. 2010

Prof.N.Jeyanthi has more than 2 decades of teaching experience in the area of Maths / Systems and her areas of interest include mathematical modeling and optimization. Currently she is also pursuing PhD in the area of supply chain Inventory Optimization as external, independent candidate of Bharathiar University, India

Prof. P.Radhakrishnan has more than 2 decades of teaching experience and held teaching positions in the area of Systems / IT and Management Science in reputed Institutions in India and abroad. His areas of interest include Software Engineering, Intelligent Systems, Supply chain Modeling & Optimization. He has published widely in International Journals and International Conference proceedings and submitted his PhD thesis in the area of Supply Chain Optimization at Jawaharlal Nehru Technological University, India.