A Novel and Efficient Approach for Materials Demand Aggregation using Genetic Algorithm

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Summary
Today, web-based material demand aggregation is one of the important as well as the active research areas in the supply chain management**.** In general, the Demand Aggregation technique synchronizes and combines the requirements with the involvement of a web-based agent to offer a clear picture of purchasing requests throughout the enterprise. The effectiveness of supply chain management also depends on the demand aggregation. The purpose of utilizing material demand aggregation is to offer all the buyers (manufacturers) in a cost effective manner. But the web-based agent faces difficulty in selecting the raw materials suppliers as enormous suppliers supply different kinds of raw materials. Moreover, each supplier offers dissimilar slab rates for different quantities of the raw materials which add additional challenge to the web-based agent. Now, the selection of the suppliers who can fulfill the aggregated demand of raw materials in a cost-effective manner, with optimal slab rate, as long as the quantities supplied is closer to the aggregated demand, by the web-based agent is critical. To work in such a situation, we propose an approach to the web-based agent in conjunction with the aggregation of requirements of the manufacturers, the customary facet in material demand aggregation, by utilizing the Genetic algorithm, one of the popular algorithms in evolutionary computations. Our approach intends to facilitate all the manufacturers in acquiring all the raw materials with optimal slab rates by recognizing the suppliers who can supply the raw materials to all the manufacturers in an optimal cost assisted by the web based agent.

Key words:
Demand aggregation, Supply chain management, Supply chain, Genetic algorithm (GA), demand analysis, web-based agent.

1. Introduction

All through the last decade, the rapidly changing market owing to the global competition, shorter product life cycles, dynamic changes of demand patterns and product varieties and environmental standards has created demands for manufacturing enterprises to expertly survive [1]. The classification of products and/or raw materials is a vital decision that the companies encounter on a regular basis. Surplus inventories that are costly or inadequate inventory that cannot meet its customer demands are the outcome of poor decisions [2]. The globalization of commerce, global distribution of manufacturing and warehousing facilities, rapid commoditization of products, demand for customized products, competitive pressures, rapid advances of information technology, etc. swiftly augment the challenges faced by the business organizations. The business organizations are forced to ponder on their supply chains owing to the above mentioned features [4].

The supply chain was defined as a system of facilities that carry out the functions of the procurement of material, transformation of material to intermediate and finished products, and the delivery of finished products to customers, by Lee and Billington [4]. A supply chain may be defined as an incorporated process involving a number of diverse business units (i.e., suppliers, manufacturers, distributors, and retailers) working collectively to: (1) obtain raw materials, (2) transform these raw materials into specified final products, and (3) distribute these final products to retailers [5]. Sourcing or procurement, manufacturing and distribution, and inventory disposal are the three sections of a supply chain viewed from a processes outlook. Supply availability and market fluctuation are the factors that influence this extremely vibrant setting. Consequently, the communications between the entities, the length of the supply chain, the lead times of manufacturing and shipping, the complexities of modeling the individual entities, the stochastic nature of the demands, etc create problems which are often exceedingly huge and multifarious [2]. The synchronization of the flows of materials and information amid suppliers, manufacturers and customers, and accomplishment of product postponement and mass customization in the supply chain is entailed in a well incorporated supply chain [7]. The diverse processes of the supply chain have been chiefly studied in isolation by the researchers and practitioners for many years [5].

In the 1990s, the need for group effort of manufacturers and service providers with their suppliers to advance their purchasing and supply management functions from a clerical role to a vital part of a new phenomenon known as supply chain management was sought after by numerous manufacturers and service providers [7]. Diverse

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organizations with diverse objectives are well synchronized and incorporated towards a universal goal in supply chain management [5]. The setting up for obtaining materials, gathering of finished products from these materials and delivery of products to customers is involved in this process [6]. An extensive variety of activities that support the planning, implementation and control manufacturing and the delivery processes right from the source of raw material to the place where the end product is utilized are integrated in the theory of supply chain management [3]. It is possible to reduce the product costs drastically whilst sustaining outstanding product quality and customer services by means of the enhanced supply chain management [10].

More proficient fulfillment of customer's demand is the eventual objective of supply chain management. For a manufacturing endeavor, it is precisely, to build the right product, for the precise customer, in the exact amount, at the accurate time [10]. The problems where the decisions of supply, production and demand are incorporated in a single framework are considered by Supply Chain Management (SCM). Supply, production and demand are the uncertain factors encountered by a classic supply chain. At present, demand planning is one of the supreme confronts posed to manufacturers owing to the globalization of demand–supply networks and the desire for a more integrated operation plan. Appropriate demand aggregation and statistical forecasting approaches are known for the efficient management of the demand variability [11]. The essential process, Material Demand Aggregation in the organization and optimization of supply chains extremely manipulate the affluence of a firm under uncertain business environment. Usually, this process keeps track of purchasing requests throughout the enterprise by categorizing and merging the requirements.

In order to provide the management with the information necessary to assess purchasing practices and trends, the historical purchasing data is analyzed by demand aggregation. By means of enhanced quality management information, the aggregation of demand offers advantages. For further proficient dealings with markets and enhanced value for money, aggregating, or coordinating demand information both inside and among public sector organizations is vital. Demand Aggregation results in high savings on the cost of direct and indirect goods and the services which utilize automated workflow and a flexible Request for Quote (RFC) management as the different departments or the companies of the enterprise are aided to optimize the buying strength. A single purchasing request is accomplished by the aggregation of the product demand across multiple plant locations, distribution channels or other units of the enterprise, which is ordered from limited set of suppliers whilst following the standardized purchasing procedures. The companies are assisted to expand their purchasing power and attain bigger savings on the costs of goods and services by the information and visibility of the purchasing requests all over the entire company provided to the businesses by the Demand Aggregation.

The real end consumer demand may cause a fluctuation in the order inter-arrival time, even though the incoming orders are comparatively stable. Consequently, during lead time, an exact estimation of mean and variance of the demand by the suppliers facing discrete demand is not possible. Aggregating demand data into larger time units might be useful to reduce this problem [25]. One can create a course of action which best meets the business goals by carrying out the processes that stabilize the aggregated demand and supply [26]. In order to optimize the supply chain performance, all supply chain stages must work in cooperation with an aggregate plan [27].

However, it is necessary to choose an optimal set of suppliers who can deliver the preferred set of item while obtaining a set of items from diverse suppliers who may sell merely a subset (bundle) of a preferred set of items. The vast numbers of suppliers, each supplier supplying diverse materials make this process of choosing optimal suppliers to face more complexity in material demand aggregation. Every supplier offers a dissimilar slab rates for certain quantities of every material as well. In the case of web-based material demand aggregation, the selection of the optimal suppliers for all the buyers is the duty of a web-based agent who encounters problems owing to all the abovementioned complexities in this selection of optimal suppliers. In this paper, we propose a novel approach based on Genetic algorithm (GA), by which these suppliers can supply cost-effective materials to all the buyers with an optimal slab rate by supporting the web-based agent in identifying the optimal suppliers. This paper intends to recognize the optimal suppliers who can meet the raw material requirements of all the manufacturers and supply the same with an optimal cost by performing an analysis of the raw material suppliers who are supplying the raw materials to all the buyers i.e. manufacturers.

The remainder of the paper is organized as follows; Section 1.1 gives the fundamentals of GA, one of the evolutionary algorithms we have used for our analysis. Section 2 gives a brief review of relevant researches on material demand aggregation. The proposed analysis is presented in Section 3 with two sub sections, namely Analysis for Aggregated Demand and Analysis for optimal suppliers based on GA. The implementation and the results obtained are visualized in Section 4 and Section 5 concludes the paper.

1.1. GA

GA, a computational model is simulating the process of genetic selection and natural elimination in biologic evolution. In 1960s, Holland conducted the pioneer work in this field. GA exhibits encouraging performance on finding solutions for the combinatorial optimization problems, in the form of a highly proficient search strategy for global optimization [27]. In the initial stages, the generation of new solutions is obtained by applying the neighborhood search operators (crossover and mutation) to the preliminary set of solutions. A random selection of solutions from the existing set of solutions is performed where higher the solution's objective function value higher is the probability of selection and ultimately the chosen solutions are subjected to the abovementioned operators. A broad range of combinatorial problems have been solved successfully with the aid of GAs in implementation.

In accordance with the Darwin's principle, the likelihood of the individuals better than their competitors, promoting their genes to the next generations is higher. In proportion to this concept, we encode a set of parameters mapped into a potential solution, named chromosome, to the optimization problem, in GAs. [16]. Overall, the term "genetic algorithm" refers to any population-based model for evolution, employing numerous operators (e.g. selection, crossover and mutation) [26]. The artificial individual is the fundamental element of a GA. An artificial individual contains a chromosome and a fitness value, like a natural individual [15].

A random population of encoded candidate solutions, called chromosomes is used initially by GAs [18]. The set of probable solutions (called chromosomes), called a population is produced [19]. A function should assign a degree of fitness to every chromosome in each generation so as to employ the best individual during the evolutionary process [20]. A numerical amount, called fitness is allotted to every member of population in order to specify how optimum every solution is. In accordance with the objective, the fitness function evaluates the individuals [17]. Three diverse operators- selection, crossover and mutation- are applied to update the population subsequent to the evaluation of each chromosome using a fitness function and allotting a fitness value. The term "generation" denotes an iteration of these three operators [21]. In the selection step, the promising areas of the search space are focused by the search. Typically, individuals of low quality are rejected and solutions with high fitness values are kept in the population by the selection operator [17]. The selection operation aids the formation of the mating pool with the chromosomes with better fitness [19].

The Crossover operation is performed subsequent to the process of Selection. Crossover operator exchanges genetic material to proliferate the characteristics of the fittest individuals [26]. The Crossover operator chooses a crossover point at random, where the chromosome of the two parents break and the chromosome parts after that point are exchanged. Consequently, the partial features of two chromosomes are combined to produce two offspring. The chromosome cloning occurs and the offspring created are exact copies of each parent when a pair of chromosomes does not cross over [20]. One-point crossover (1X), two-point crossover (2X), three-point crossover (3X) and uniform crossover, etc are some examples of this operator [26]. The mutation of individuals by altering parts of their genes is the final step in each generation [17]. Mutation initiates unevenness into the population of the next generation by altering a small portion of a chromosome [19]. It is a reproduction operator that modifies the value of genes in a copy of a single parent's chromosome to create a new chromosome [26].

2. Related Works

Several problems that had not received much attention in the literature but to do with the aggregation of data, incompleteness of data, and the isolation of demand data for defined supply chains that are part of a greater supply web were caused by the practical measurement of the bullwhip effect. Those conceptual measurement problems and the experiences in dealing with some of those problems in an industrial project were discussed by Jan C. Fransoo et al. [9].

A schema for constructing an E-Market and a model to support the supplier selection decision were presented by Sanchoy K. Das et al. [8]. The E-Market schema employed to obtain two key measures that can be utilized by the manufacturer to acquire an evaluation of the supplier's performance and hence build adequate assurance to issue a supply order, incorporated a description of the Vendor Performance History database. In addition, they also presented An Intelligent Vendor Selection model that estimated the submitted E-Market proposals and approved a supply strategy. The model was devised as a mixed integer program and was solved within the E-Market negotiation template.

Recently, a novel iterative algorithm proposed in the literature provided the solution for the vendor selection problem. It was illustrated that the application of that iterative algorithm led to an iterative procurement auction that improved the efficiency of the procurement process, by Narahari et al. [22]. The authors demonstrated remarkable increase in computational efficiency of the algorithm by employing reinforcement learning to coordinate the iterations of the algorithm.

The allegation that partial pooling of customers was occasionally favored over complete pooling on the solitary basis of demand correlation was scrutinized by Kefeng Xu et. al [12]. The management of inventory within a supply chain was discussed initially, where risk-pooling was explicitly considered. Subsequently, they hypothetically discussed the assertion that partial pooling can dominate. Based on this, techniques to check correlation matrices for guaranteeing their validity were presented.

A robust, highly-adaptable and easily-configurable mechanism for efficiently dealing with all SCM facets, from material procurement and inventory management to goods production and shipment was built by Ioannis Kontogounis et al [14]. One of the most challenging SCM environments, the trading agent competition SCM game was utilized to crash-test the agent. In addition, Mertacor and its main architectural primitives were introduced, an overview of the TAC SCM environment was presented and the performance of Mertacor was discussed.

Argon Chen et al. [11] examined the effects of aggregating two interrelated demands by employing the bivariate VAR(1) time-series model as a study vehicle. The illustration of the aggregated time series of two VAR(1) times series being equal to the sum of two AR(1) time series was presented. In addition, the properties of the aggregated time series was investigated and guidelines for practitioners to establish proper aggregation and forecasting approaches were offered.

A comparison between the performance of new machine learning based forecasting techniques and the more traditional methods was presented by Real Carbonneau et al. [13]. They applied a representative set of traditional and ML-based forecasting techniques to the demand data and compared the accuracy of the methods.

3. Proposed Analysis for Optimal Suppliers Based on GA

As mentioned previously, the web-based agent carry out the chief role of taking decision about better raw material suppliers in web-based demand aggregation. The web-based agent experiences complexity in selecting the raw-material suppliers owing to the enormous raw materials suppliers. Furthermore, different raw materials are supplied by every supplier. In addition, certain quantity of every raw material is offered at a different slab rate by every supplier. Hence the decision to be taken by the web based agent about the superior supplier who offers an optimal slab rate to all the manufacturers is very critical. Here, we propose a method to prop up the web-based agent in deciding about the optimal suppliers, called optimal raw material suppliers analysis based on GA. Figure 1 demonstrates the involvement of our analysis in web-based demand aggregation of raw materials.

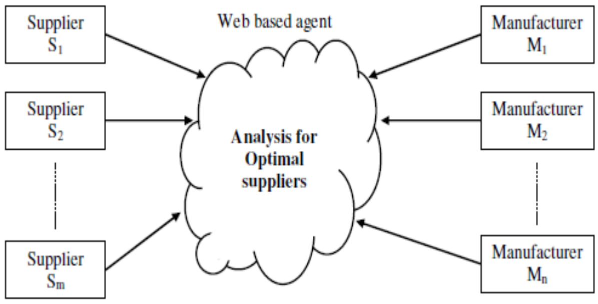

Fig. 1 Aiding the web-based agent by using our GA based analysis in Web-based demand aggregation of raw materials

Our analysis employs n number of manufacturers and a vector is used to signify them as given below

$$M = [M_1 \quad M_2 \quad M_3 \quad \cdots \quad M_n] \tag{1}$$

and m number of suppliers and the vector used to represent them is given by

$$S = [S_1 \quad S_2 \quad S_3 \quad \cdots \quad S_m] \tag{2}$$

In this case, every supplier can provide any number of raw materials which is given by

$$S_r(i) = [R_i] << [R_j], \quad ; i = 1, 2, \cdots\cdots, m \,;\, \mathrm{j} \in l \tag{3}$$

Such that

$$|R_i| \in l \tag{4}$$

In equation (3), i^{th} supplier supplies the raw materials $S_r(i)$ and the maximum number of raw materials available is denoted by l. Owing to the fact that any supplier can supply any raw materials, it is necessary to remember the condition that j need not be consecutive. In order to perform our analysis, it is essential that web-based agent maintains some databases. The complete information regarding the raw materials, suppliers who are supplying the raw materials, the slab rates offering each supplier for every level of quantity of the raw material are contained in the database. Hence a comprehensive knowledge of all the mentioned factors is possessed by the web-based agent. Figure 2 demonstrates the proposed optimal supplier analysis.

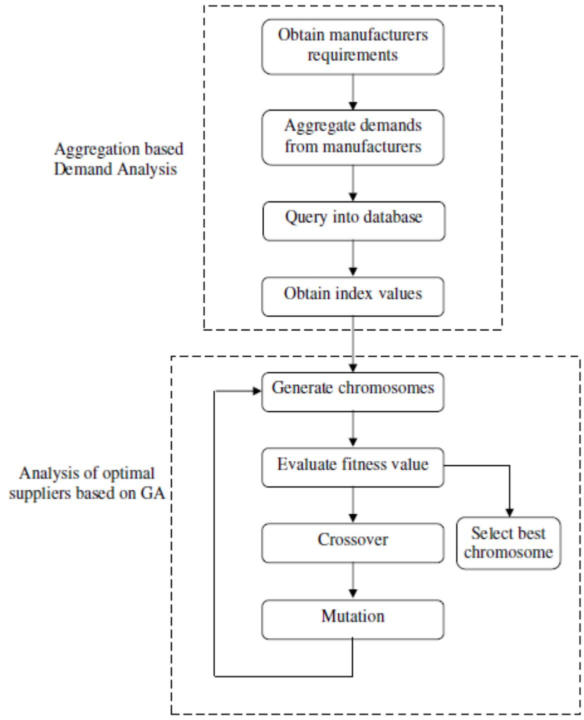

Fig. 2 The proposed optimal suppliers analysis constituted by Aggregation based Demand Analysis and Analysis of optimal suppliers based on GA.

As depicted in the figure 2, aggregation based demand analysis and GA based optimal supplier analysis are the two segments of the optimal supplier analysis performed. The aggregation based demand analysis and the pre-analysis for the supplier analysis which is based on GA are similar. An elucidation about both is provided below.

3.1. Aggregation based Demand Analysis

In this case, a presumption that all the n numbers of manufacturers are under the requirement of same raw materials is made. A following vector denotes the raw materials required by all the manufacturers

$$R = [R_1 \quad R_2 \quad R_3 \quad \cdots \quad R_p] \tag{5}$$

Every manufacturer needs p numbers of same raw materials although at different quantities which is depicted as

$$\begin{pmatrix} M_1 \\ M_2 \\ M_3 \\ \vdots \\ M_n \end{pmatrix} = \begin{pmatrix} Q_1^{(1)} & Q_1^{(2)} & Q_1^{(3)} & \cdots & Q_1^{(p)} \\ Q_2^{(1)} & Q_2^{(2)} & Q_2^{(3)} & \cdots & Q_2^{(p)} \\ Q_3^{(1)} & Q_3^{(2)} & Q_3^{(3)} & \cdots & Q_3^{(p)} \\ \vdots & & & & \\ Q_n^{(1)} & Q_n^{(2)} & Q_n^{(3)} & \cdots & Q_n^{(p)} \end{pmatrix} \tag{6}$$

Where $Q_n^{(p)}$ is a quantity required by the raw material R_p by n^{th} manufacturer.

Subsequently, the aggregation of the quantity of each raw material required by the manufacturers is computed to determine the total requirement of each raw material by all the n manufacturers, which is given by

$$T_r(j) = q + \sum_{i=1}^{n} Q_i^{(j)}; \qquad j = 1,2,\cdots,p \tag{7}$$

where $Q_i^{(j)}$ is the amount of j^{th} raw material required by i^{th} manufacturer.

In equation (7), q is only a little quantity to be summed with those usual requirements, which is owing to the uncertainty of the demand. The total requirement of raw materials by all the manufacturers can be accomplished after the above aggregation as

$$[T_r] = [T_r(1) \quad T_r(2) \quad \cdots \quad T_r(p)] \tag{8}$$

The web-based agent will build up its own new database on the basis of obtained total requirements. The quantity of the raw materials bordering to the entire prerequisite we have obtained, the different suppliers and their slab rates offered by the corresponding suppliers for that kind of quantity will be included with the intention that the database will contain the particular raw material having the quantity approximately equal to the total requirement, its suppliers and their slab rates. This approach ensures the availability of information for p numbers of raw materials in this database. In this database, for each raw material we are indexing separately, which is given as follows

$$I = \begin{bmatrix} I_{r1} \\ I_{r2} \\ I_{r3} \\ \vdots \\ I_{rp} \end{bmatrix} = \begin{bmatrix} 1 & 2 & \cdots & \mathrm{i}_{\mathrm{r}1} \\ 1 & 2 & \cdots & \mathrm{i}_{\mathrm{r}2} \\ 1 & 2 & \cdots & i_{r3} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & 2 & \cdots & i_{rp} \end{bmatrix} \tag{9}$$

The web-based agent will move to GA based supplier analysis when provided with this database along with these indices.

3.2. Analysis of optimal suppliers based on GA

Our analysis of determining the raw materials suppliers who are supplying raw materials to all the manufacturers with an optimal cost uses GA, one of the popular algorithms in Evolutionary computations. An explanation of the step by step procedure of this analysis part which was illustrated in the figure is given below.

Chromosome initialization: Initially, the value of an optimization factor O_f will be set to one. Subsequently, the chromosomes will be initialized in an arbitrary manner. Every chromosome has p number of genes (i.e. the chromosome length is p) and every gene is has the index value of a certain raw material. The chromosome hence obtained is as follows

$$X(j) = \left\{ x_1^{(j)} \; x_2^{(j)} \; x_3^{(j)} \cdots\cdots x_p^{(j)} \right\} \qquad (10)$$

The formulation given below is utilized to produce every gene of the chromosome

$$x_i^{(j)} = 1 + (\, r \,\% \left| I_{r_i} \right|) \; ; \; i = 1,2,\ldots., p \qquad (11)$$

where, r is an arbitrary integer, $x_i^{(j)}$ is the i^{th} gene of j^{th} chromosome.

Hence z number of chromosomes will be generated at random. The index value of a particular raw material that points to certain quantity of the raw material and its slab rate is represented by each gene in such chromosomes.

Fitness evaluation: Subsequent to the generation of each chromosome, the fitness function evaluates all these chromosomes. The fitness function of the proposed analysis is given by

$$f\,(u\,) = \frac{O_f}{\frac{1}{p}\sum_{i=1}^{p} s_i^{(u)}} \; ; \; u = 1,2,\ldots\ldots, z \qquad (12)$$

where $s_i^{(u)}$ is the slab rate indexing by i^{th} gene of u^{th} chromosome.

In conclusion, the fitness values for the z numbers of chromosomes can be accomplished. Now the genetic operations will be performed on the chromosomes.

Crossover: As stated above, crossover operation is performed on the chromosome, one of the genetic operations. By crossover, each and every pair of parent chromosomes yields either a child or two children as shown in figure 3.

In chromosomes, for p length, there are $(t-1)$ points and the crossover point C_p we have chosen is given as

$$C_p = t/2 \qquad (13)$$

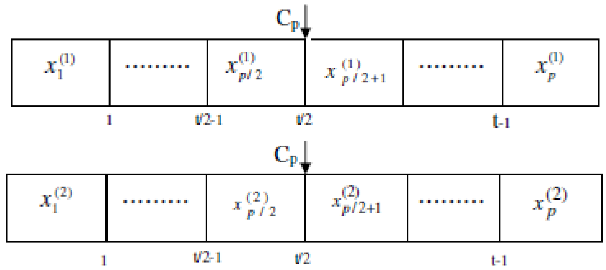

Fig. 3 (a): chromosomes before crossover (parent chromosomes)

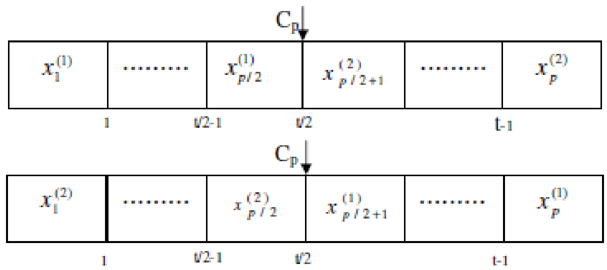

Fig. 3 (b): chromosomes after crossover (children chromosomes)

In this case, single point crossover is employed with crossover point $t/2$ as shown in figure 3. The children are produced as the genes of the parent chromosomes which are at the right of crossover point C_p get exchanged.

Mutation: The mutation operation, another genetic operation is performed on the children chromosomes after crossover operation.

Among several kinds of mutation, we perform a mutation operation in which the genes of a certain chromosome get changed within itself with the intention of obtaining a completely new chromosome which is represented as

$$X^{new}(k) = \left\{ x_{new_1}^{(k)} \; x_{new_2}^{(k)} \cdots x_{new_p}^{(k)} \right\} \; ;$$
$$k = z+1, z+2, \ldots\ldots, 2z \qquad (14)$$

Owing to the fact that the index value of each chromosome should not exceed the original index which was mentioned in the database, the limits of the completely new chromosome obtained after mutation is checked which can be performed as

$$1 \le x_{new_i}^{(k)} \le \left| I_{r_i} \right| \; ; \; i = 1,2,\ldots., p \qquad (15)$$

For a second time, the fitness function mentioned in equation (12) is used to evaluate the fitness of these newly obtained chromosomes. Now, we have accomplished

$2z$ numbers of chromosomes and its corresponding fitness values now

Selection of chromosomes: Next, in order to identify the superior z numbers of chromosomes, the selection operation is performed in which the chromosomes which are having minimum fitness values are selected. Thus z numbers of superior chromosomes are obtained from the $2z$ numbers of chromosomes. Awaiting the fulfillment of the termination condition, this process of crossover, mutation, fitness evaluation and selection is performed on the newly obtained chromosomes, repetitively. Achieving the maximum number of iterations is the termination condition in this case. The procedure of execution will be terminated after the maximum iteration is reached by the process.

The chromosome thus obtained will index suppliers for each raw material and slab rates for certain quantity. These suppliers, thus obtained from the analysis can supply the raw materials in a cost-effective manner to all the manufacturers with optimal slab rates.

4. Implementation Results

We have utilized the platform of MATLAB (MATLAB version 7.4) to execute our proposed methodology of optimal supplier analysis based on GA. As stated previously, the database containing the detailed information required for the analysis must be maintained by the web-based agent. The tabulation given below illustrates the database we maintained, consisting of some sample data we have used for our analysis.

The raw materials Identification (Raw material I.D.) and slab rates for certain quantities are the constituents of the tabulation illustrated in Table 1. The details of all the raw materials and their suppliers are given in Table 2. A detailed tabulation with the information about all the raw materials, their suppliers, different quantities and the slab rates they offer is presented by Table 3. The manufacturer's prerequisite table containing the quantity of the raw materials needed by each manufacturer is presented in Table 4. An illustration of these tables is given below.

Table 1: Sample data having details about raw material I.D., certain quantities and their slab rates offering by the supplier 1

Raw material Id	Quantity	Slab
R1	9292	1
R1	7531	9
R2	4262	3
R3	8520	3
R3	6679	3
R3	5315	3

Table 2: Sample data having details about the raw material I.D. and supplier I.D. who are supplying that raw material.

Raw material Id	Supplier Id
R1	1
R2	1
R3	1
R1	2
R2	2
R3	2
R1	3
R2	3
R3	3
R1	4
R2	4
R3	4

Table 3: Sample data having the details about the raw materials I.D., their suppliers, Quantity offering by the suppliers and its corresponding slab rates.

Raw material Id	Supplier Id	Quantity	Slab
R1	1	5148	5
R2	1	7659	4
R3	1	5277	5
R3	1	4160	4
R1	2	9292	1
R2	2	4262	3
R3	2	8520	3
R3	2	8520	3
R3	2	6679	3
R3	2	5315	3
R1	3	5996	8
R2	3	8498	7
R3	3	7026	4
R1	4	8371	4
R2	4	1631	4
R3	4	7858	5

Table 4: Sample data having the details about the manufacturers and their requirements of each raw material

Manufacturer	R1	R2	R3
1	34	40	34
2	37	12	35
3	19	31	14
4	20	31	30
5	39	31	46

The aggregated demand of each raw material is achieved by aggregating the data presented in the Table 4. A data file was prepared which contained the raw material I.D., their suppliers, quantity of the raw material closest to the aggregated demand and their slab rates by querying this aggregated demand of raw materials into the database. With the intention of facilitating further analysis, each data was indexed by index values.

As shown in the Figure 4 (a), an arbitrary chromosome containing index values as genes was generated initially, after that genetic operations such as crossover, mutation subsequently fitness evaluation will be performed on the generated chromosome. Figure 4 (b) illustrates the chromosomes after crossover and mutation

3	4	1

4	3	1

Fig. 4 (a): Initial chromosomes that are generated random

3	3	1

4	4	1

Fig. 4 (b): Chromosomes obtained after crossover and mutation

We can attain the best chromosome as the outcome of an iterative process of fitness evaluation of each of the chromosomes and selection of superior chromosomes. Hence, the optimal supplier for each raw material along with the quantity and its slab rates will be pointed by the index. Figure 5 illustrates the ultimate chromosome we had obtained and Table 5 illustrates the tabulated details given by that chromosome.

3	3	1

Fig. 5: final best chromosome obtained from the analysis

Table 5: optimal suppliers, quantity their slab rates offered by the analysis

Raw material Id	**Aggregated demand**	**Supplier Id**	**Qty**	**Slab**
R1	5620	3	5996	8
R2	5890	3	5996	8
R3	5026	1	5148	5

The index of raw material I.D R1 which signifies the supplier I.D ‘3’ as the optimal supplier for raw material ‘1’ who is providing an optimal slab of 8% when compared with others is denoted by the first gene of the Figure 5 and the second gene is index of raw material ‘2’ and raw material ‘3’ , likewise. Thus the suppliers who are offering optimal slab rates for a certain quantity of raw material are presented by the analysis.

5. Conclusion

The aid for further proficient transactions with markets and enhanced value for money are vitally offered by aggregating, or coordinating demand information mutually inside and among public sector organizations, one of the significant areas of supply chain management. In web-based demand aggregation, the web-based agent is taking the responsibility of aggregating the demand. Here the problem is in selecting optimal suppliers among large numbers of suppliers who are offering sundry raw materials with different slab rates for certain quantities. Our novel analysis for optimal suppliers based on GA performed efficiently in choosing the optimal suppliers so that all the manufacturers will be satisfied with the provided cost effective raw materials with optimal slab rates as well as the quantities which are closer to the aggregated demand. Our analysis performed well in attaining the ultimate intention of satisfying the buyers (manufacturers) by providing its assistance to the web-based agent. Utilization of our analysis will make efficient dealings with markets, the key objective of the material demand aggregation and hence the supply chain management will be more effective.

References

[1] Alfonso Sarmiento, Luis Rabelo, Ramamoorthy Lakkoju, Reinaldo J. Moraga, "Stability analysis of the supply chain by using neural networks and genetic algorithms," Proceedings of the 39th conference on Winter simulation, pp. 1968-1976, December 09-12, Washington D.C, 2007.

[2] J. A. Joines, D. Gupta, M. A. Gokce, R. E. King; and M. G. Kay, “Supply chain multi-objective simulation optimization,” in Proceedings of the 2002 Winter Simulation Conference, pp.1306-1314, 2002.

[3] P.Radhakrishnan, V.M.Prasad and M. R. Gopalan, "Inventory Optimization in Supply Chain Management using Genetic Algorithm," International Journal of Computer Science and Network Security, Vol. 9, No. 1, pp. 33-40, 2009.

[4] J. Sudhir Ryan Daniel and Chandrasekharan Rajendran, "A simulation-based genetic algorithm for inventory optimization in a serial supply chain", International Transactions on Operational Research, Vol. 12, pp. 101-127, 2005.

[5] Beamon BM, "Supply chain design and analysis: models and methods", International Journal of Production Economics, Vol. 55, No. 3, pp. 281–294, 1998.

[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] Keah Choon Tan, "A framework of supply chain management literature," European Journal of Purchasing & Supply Management, Vol. 7, pp. 39-48, 2001.

[8] Sanchoy K. Das and Hossam Shahin, "Models for supply chain vendor selection in e-markets," Journal of the Chinese Institute of Industrial Engineers, Vol. 20, No. 3, pp. 231-239, 2003.

[9] Jan C. Fransoo, Marc J.F. Wouters, "Measuring the bullwhip effect in the supply chain," An International Journal of Supply Chain Management, Vol. 5, No. 2, pp. 78-89, 2000.
[10] Ge Wang, Samuel H. Huang, and John P. Dismukes, “Product-driven supply chain selection using integrated multi-criteria decision-making methodology,” Journal of International Production Economics, Vol.91, pp. 1-15, 2004.
[11] Argon Chen, C.H. Hsu and J. Blue, “Demand planning approaches to aggregating and forecasting interrelated demands for safety stock and backup capacity planning,” International Journal of Production Research, Vol. 45, No. 10, pp. 2269–2294, 2007.
[12] Kefeng Xu, Philip T. Evers, "Managing single echelon inventories through demand aggregation and the feasibility of a correlation matrix," Computers and Operations Research, Vol. 30, No. 2, pp. 297 - 308, 2003.
[13] Real Carbonneau, Rustam Vahidov and Kevin Laframboise, "Machine learning-Based Demand forecasting in supply chains," International Journal of Intelligent Information Technologies, Vol. 3, No. 4,pp. 40-57, 2007.
[14] Ioannis Kontogounis, Kyriakos C. Chatzidimitriou, Andreas L.Symeonidis and Pericles A. Mitkas, "A Robust Agent Design for Dynamic SCM Environments," In Fourth Hellenic Conference on Artificial Intelligence, Heraklion, Greece, 2006.
[15] 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 International Journal on Science and Technology, vol. 12, no. 2, 2007.
[16] 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..
[17] Thomas Butter, Franz Rothlauf, Jorn Grahl, Hildenbrand Jens Arndt, Thomas Butter, Franz Rothlauf, Jorn 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 Mannheim, 2006.
[18] 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.
[19] Qureshi, S.A.irza, S.M. Arif, M., "Fitness Function Evaluation for Image Reconstruction using Binary Genetic Algorithm for Parallel Ray Transmission Tomography," International Conference on Emerging Technologies, pp. 196-201, November 13-14, 2006.
[20] 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.
[21] 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, 2006.
[22] Raju, C.V.L.Narahari, Y. Shah, S., “Procurement auction using actor-critic type learning algorithm,” Proceedings of IEEE International Conference on Systems, Man and Cybernetics, pp. 4588- 4594, Vol.5, October 5-12, 2003.
[23] Schmidt, RS, "Impact of Information Sharing and Order Aggregation Strategies on Supply Chain Performance, Proceedings of the 5th International Conference on Supply Chain Management and Information Systems, pp. 39-48, Melbourne, 2007
[24] Samuel H. Huang, Sunil K. Sheoran and Harshal Keskar, "Computer-assisted supply chain configuration based on supply chain operations reference (SCOR) model," Computers & Industrial Engineering, No.2, pp.377–394, 2005, Doi: 10.1016/j.cie.2005.01.001
[25] Sunil Chopra, Peter Meindl, “Supply Chain Management,” Pearson Education, International Edition, 3rd Edition, 2008, ISBN13: 9780132086080 ISBN10: 0132086085
[26] Alonso J. Juvinao Carbono, Ivan F. M. Menezes, Luiz Fernando Martha, "Mooring Pattern Optimization using Genetic Algorithms," 6th World Congresses of Structural and Multidisciplinary Optimization, pp. 1-9, 30 May - 03 June, Brazil, 2005.
[27] A.John Sanjeev Kumar, J.Arunadevi, V.Mohan, "Intelligent Transport Route Planning Using Genetic Algorithms in Path Computation Algorithms," European Journal of Scientific Research, Vol. 25, No. 3, pp.463-468, 2009.

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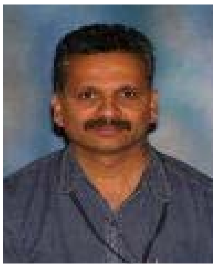

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