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MODIFIED GENETIC ALGORITHM FOR SUPPLY CHAIN DISTRIBUTION PROBLEM TO MINIMIZE THE TRAVELLING COST

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Abstract
RFID technology is used today in many applications, including security and access control, transportation and supply chain tracking. In this work, a RFID technique is proposed to optimize the supply chain distribution network. Short for radio frequency identification, RFID is a dedicated short range communication technology. The term RFID is used to describe various technologies that use radio waves to identify people or objects automatically**.** A modified Genetic Algorithms (GA) system approach, K- Means Cluster based Heuristic approach, Hybrid GA-Simulated Annealing (SA) approach, Hybrid K-Means Cluster based heuristic-GA and Hybrid K-Means Cluster based heuristic-GA-SA for travelling salesman problem is proposed. The study incorporated uniform crossover operator and combined crossover operator in GAs for solving supply chain distribution network problem. The algorithms are tested on 50 randomly generated data set and compared with each other. The results of the numerical experiments shows that the Hybrid K-means Cluster based heuristic-GA-SA, when tested on 50 randomly generated data set, shows superior performance to the other methods for solving the TSP.

1. Introduction

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also the transporters, retailers and even customers themselves. In the manufacturing organization, the supply chain includes all functions involved in receiving and filling a customer request interms of fast supply, proper maintenance and good response. Radio Frequency Identification (RFID) is a dedicated short range communication technology. Radio Frequency Identification (RFID) is a technology which allows contactless access to data on a transponder (also called tag or chip). Already in the late

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forties of the last century RFID was used to identify friendly aircraft. Ongoing miniaturization and advancements in technology have lead to smaller and cheaper tags, which have made widespread use of RFID possible in supply chains. The benefits of RFID in supply chains are well documented. Optimization is the act of obtaining the best result under given circumstances. In design, construction and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate goal of all such decisions is either to minimize the effort required or to maximize the desired benefit. Since the effort required or the benefit desired in any practical situation can be expressed as a function of certain decision variables. Optimization can be defined as the process of finding the conditions that give the maximum or minimum value of function. It can be seen from Figure 1 for sample factor of production rate.

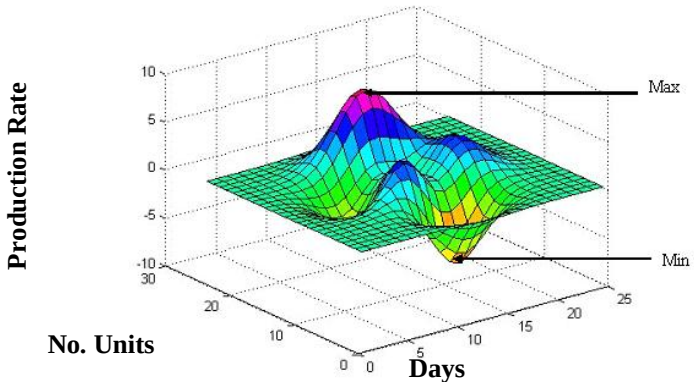

Figure 1 Minimum and maximum production rate

Dorigo et al (1991) have proposed the optimization technique involving the behavior of ants. Here the foraging behavior of ants for food using a pheromone substance is initiated. Chen et al (1995) have developed a simple genetic algorithm for the optimization of simple job exchanges of some of the individuals. Only the crossover operator is applied (no mutation) and the crossover used the partially mapped crossover.

Zegordi et al (1995) have demonstrated a hybrid technique by introducing problem domain knowledge into a SA algorithm. Their algorithm used a "Move desirability for jobs" table which incorporates several rules that facilitate the annealing process. This way, fewer control parameters are needed. Later Kennedy and Eberhart (1995) developed and presented Particle Swarm Optimization (PSO) depicting the behavior of swarms to solve optimization problems. Supply Chain Management (SCM) is a strategy through which such integration can be achieved (Shapiro 2000). Kennedy and Eberhart (2001) has formulated and published the intelligence in swarm. Chan et al (2007) have proposed a multiple ant colony optimization to design a balanced and efficient supply chain network that maintains the best balance of transit time and customer service. They focused on effective allocation of the customers to the Distributed Centers (DC's) with the two fold objective of minimization of the transit time and degree of imbalance of the DC's. The proposed technique shows better performance considering both negative and positive feedback in search of optimum results. In order to increase implementation success, the current acceptance theory must be adapted to reflect the iterative and dynamic structure of organization change (Orlikowski and Hofman 1997).

However, most existing decision models and supports in production planning and control are not capable of dealing with such real-time data (Chu et al 1997). The authors have reported on their previous work on applying RFID technology in a typical product assembly flow line. Barros et al (1998) have tackled the location allocation problem of regional depots and treatment facilities for the sand recycling network by using heuristic procedures. The work adopted meta-heuristics is discussed as follows. Ngai et al (2005) have argued that a system architecture integrating mobile commerce (m-commerce) and RFID applications in a container depot could keep track of the location of containers, provide greater visibility of the operation data, and improve the process control. He et al (2007) have suggested a combination of a fuzzy multi-objective programming and a genetic algorithm to determine the optimal locations and

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numbers of treatment facilities and transfer stations for municipal solid wastes. Chi et al (2007) have solved the problem of selecting proper collection sites and refurbishing sites on a 1000 × 1000 squared area for minimizing the total transportation cost by using a genetic algorithm with the help of multiple overlapped fitness functions. Pati et al (2008) have dealt with the multi-item, multi-echelon and multi-facility decision making problem involved the facility location, route and flow of different varieties of recyclable wastepaper in paper recycling system by using mixed integer goal programming technique. From the literature, it is observed that the past approaches consider mostly heuristic and very few nontraditional techniques for solving the supply chain distribution network problem. The integration of genetic algorithm with simulated annealing approach has not been given attention in the earlier approaches. Many studies have been carried out on applications of RFID system in supply chain management. Many investigators have used the RFID for the purpose of identifying and tracing the objects only. Studies on RFID applications to form the distance matrix of nodal points or cities have not been reported in the literature.

2. **Proposed Methodology – Modified Genetic Algorithm**

The objective of the work is to find the minimum travelling cost for covering all the given 'n' cities from a single depot and to return back to the same. The issue is many kind of operations management problem such as scheduling problem can be easily converted into the TSP matrix type and those problem can be solved nearer optimally using considered algorithms namely GA, SA, Hybrid GA-SA, K-Means Cluster based heuristic, Hybrid K-Means Cluster based heuristic-GA-SA.

The assumptions made are:

- Each city is visited once.
- There is only one vehicle for distribution.
- The problem is an asymmetric TSP.

A key element of what is assumed to be intelligences the capability to learn from past experience. Especially when things are done repeatedly, intelligent behavior would avoid doing a mistake more than once and would prefer making advantages decision again. For optimization a class of today's most popular heuristic approaches is known as GAs. Due to its widespread use and vast amount of literature dealing with GAs, a comprehensive review of research activities is doomed to failure; thus we stick to outline of the fundamental ideas. The adjective genetic reveals the roots of these algorithms. Adapting the evaluation strategy from natural life form, the basic idea is to start with a set of (feasible) solutions and to compute a set of new solutions by applying some well defined operations on the old ones. Then, some solutions (new and/or solutions) are selected to form a new set with which another is started, and on until some stopping criterion is met. Solutions are represented by sets of attributed and different solutions are met by different collections of attribute values. The decision that solutions are dismissed and which is taken over to form a new starting point for the next iteration is made on the basis of priority rule. GAs is adaptive heuristic search algorithm promised on the evolutionary ideas of natural selection and genetic. The basic concept of GAs is designed to simulate processes in natural system necessary for evolution, specifically those that follow the principles first laid down by Charles Darwin of survival of the fittest. As such they represent an intelligent exploitation of a random search within a defined search space to solve a problem. First pioneered by John Holland in the 60s, GAs has been widely studied, experimented and applied in many fields in engineering worlds. Not only does GAs provide alternative methods to solving problem, it consistently out performs other traditional methods in most of the problems link. Many of the real world problems involved finding optimal parameters, which might prove difficult for traditional methods buy ideal for GAs. However, because of its outstanding performance in optimization, GA has been wrongly regarded as a function optimizer. In fact, there are many ways to view Gas. Perhaps most user come to GAs looking for a problem solver, but this is a restrictive view. GA can be used as problem solvers, challenging technical puzzle, basis for competed machine learning, computational model of innovation and creativity, computational model of other innovating system and guiding philosophy. Many scientists have tried to create living programs. These programs do not merely simulate life but try to exhibit the behaviors and characteristics of real organisms in an attempt to exist as a form of life. Suggestions have been made that a life would eventually evolve into real life. Such suggestion may sound absurd at the moment but certainly not implausible if technology continues to progress at present rates.

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Nearly everyone can gain benefits from GAs, once he can encode solutions of a given problem to chromosomes in GA, and compare the relative performance (fitness) of solutions. An effective GA representation and meaningful fitness evaluation are the keys of the success in GA applications. The appeal of GAs comes from their simplicity and elegance as robust search algorithms as well as from their power to discover good solutions rapidly for difficult high-dimensional problems. GAs is useful and efficient when,

i. The search space is large, complex or poorly understood.
ii. Domain Knowledge is scarce or expert knowledge is difficult to encoded to narrow the search space.
iii. No mathematical analysis is available.
iv. Traditional search methods fail.

The advantage of the GA approach is the ease with which it can handle arbitrary kinds of constraints and objectives; all such things can be handled as weighted components of the fitness function, making it easy to adapt the GA scheduler to the particular requirements of a very wide range of possible overall objectives. GAs has been used for problem solving and for modeling. GAs are applied to many scientific, engineering problems, in business and entertainment, including: optimization, automatic programming, machine and robot learning, economic models, immune system models, ecological models, population genetics models, interactions between evolution and learning and models of social systems.

Procedure of Genetic Algorithms

The algorithm operates through a simple cycle:

1. Creation of a population of strings.
2. Evaluation of each string.
3. Selection of the best strings.
4. Genetic manipulation to create a new population of strings.

Figure 5.1 shows how these four stages interconnect. Each cycle produces a new generation of possible solutions (individuals) for a given problem. At the first stage, a population of possible solutions is created as a start point. Each individual in this population is encoded into a string (the chromosome) to be manipulated by the genetic operators.

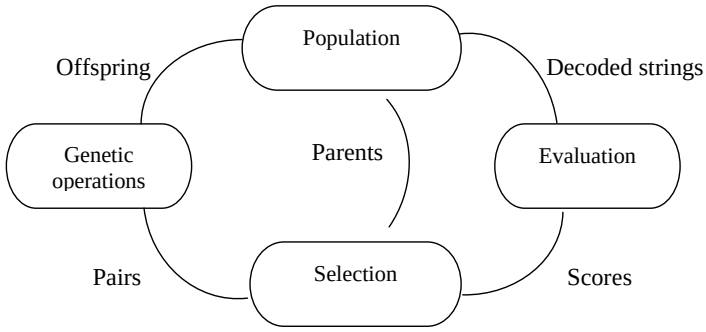

Figure 2 The reproduction cycle

The manipulation process applies the genetic operators to produce a new population of individuals, the offspring, by manipulating the genetic information possessed by the pairs chosen to reproduce. This information is stored in the strings (chromosomes) that describe the individuals. Two operators are used: Crossover and mutation. The offspring generated by this process take the place of the older population and the cycle is repeated until a desired level of fitness is attained or a determined number of cycles is reached. Crossover is one of the genetic operators used to recombine the population genetic material. It takes two chromosomes and swaps part of their genetic information to produce new chromosomes. This operation is similar to sexual reproduction in nature. Figure 2 shows after the

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crossover point has been randomly chosen, portions of the parent's chromosome (strings) **Parent 1** and **Parent 2** are combined to produce the new offspring **Son.**

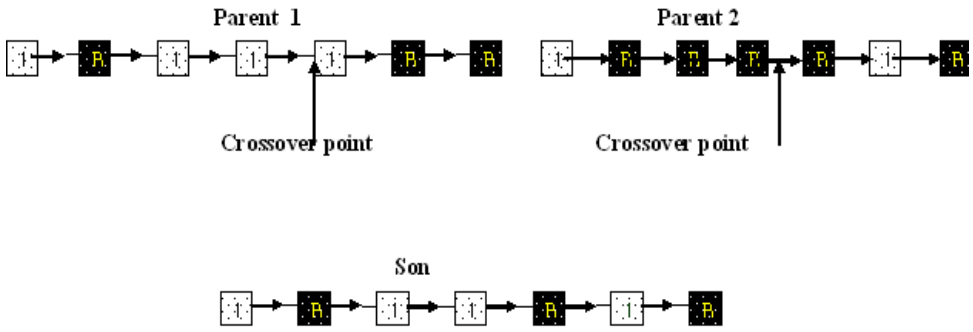

Figure 3 Crossover process

Figure 3 mutation is implemented by occasionally altering a random bit from a chromosome (string), it shows the operator being applied to the fifth element of the chromosome.

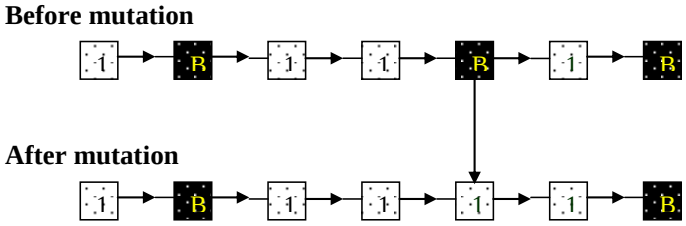

Figure 4 Mutation

A number of other operators, other than crossover and mutation, have been introduced since the basic model was proposed. They are usually versions of the recombination and genetic alterations processes adapted to constraints of a particular problem. Examples of other operators are: inversion, dominance and genetic edge recombination. Figure 4 provides the details of flowchart for general procedure of Genetic algorithm.

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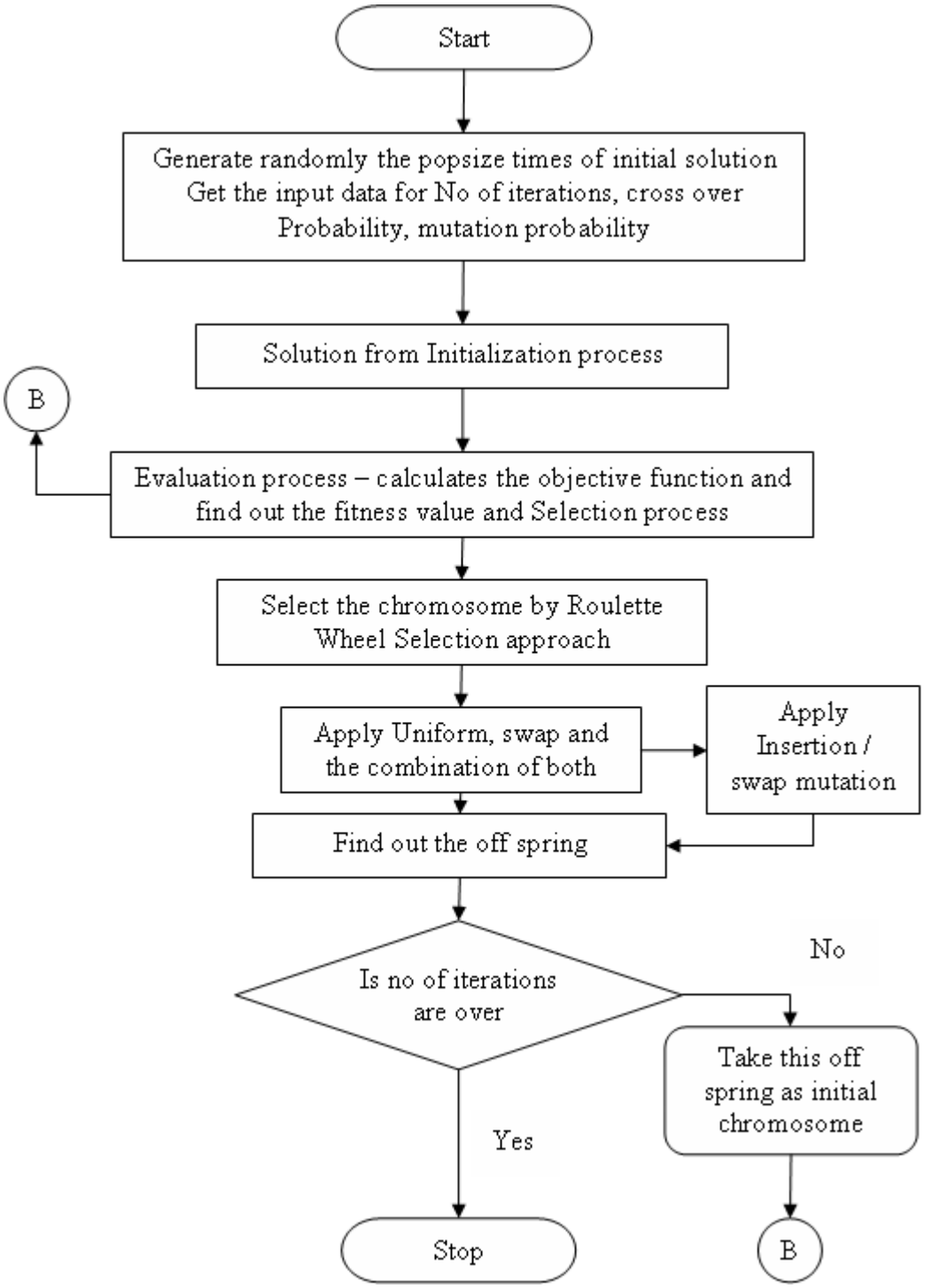

Figure 5. Flow chart for genetic algorithm

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3. Results and Discussion

The proposed work of supply network chart will be formulated using RFID technique with the help of distance matrix. RFID helps to form the distance matrix as well as cost matrix. Designed dynamic RFID system can generate both distance matrix and cost matrix. In this illustration cost matrix is taken as input data.

Algorithm Steps for cost matrix:

Step 1: Cost matrix is taken as input (Table 1)
Step 2: Calculate F = N/2
Step 3: Calculate S = ∑ (N - (i-1) solution spaces
Step 4: Calculate K = N-F Locations
Step 5: Initialization and Each solution space will have (N-F)! Sequences. From each solution space K sequences are taken and solution values are averaged to get Average Objective Function Value (A_{OFV})
Step 6: Select the solution space with minimum A_{OFV}.
Step 7: OFV is calculated using the below equation:

$$\text{Min Cost}(C) = \sum_{i=1}^{n} \sum_{j=1}^{n} f_{ij}\, c_{ij}\, d_{ij} \qquad (6.1)$$

where f = frequency of movement of salesman from i to j

c = Transportation cost

d = Distance between i to j

N = Number of cities

Table 1. Seven Nodes cost matrix

Cities	1	2	3	4	5	6	7
1	0	441	352	183	284	235	389
2	441	0	381	282	273	424	571
3	352	381	0	261	142	134	249
4	183	282	261	0	141	202	621
5	284	273	142	141	0	157	245
6	235	424	134	202	157	0	321
7	389	571	249	621	245	321	0

F = N/2 = 7/2 = 3.5 = Rounded off lower integer value 3
S = (N-1) (N-2) = (7-1) (7-2) = 30 Solution spaces

Flow chart for the above algorithm is shown in Figure 6.5.

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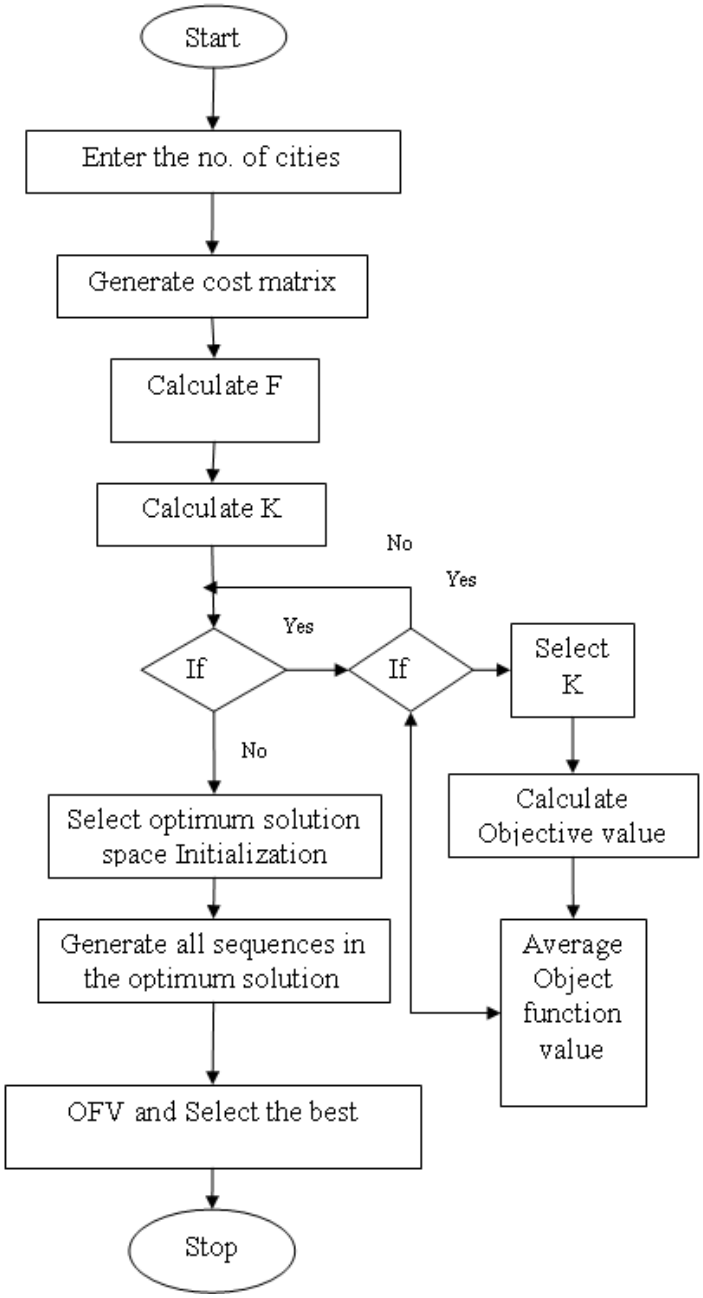

Figure 2 Flow chart for the cluster based heuristic algorithm for cost matrix

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Table 3 Average Objective Function Value (A_{OFV}) (Initialization process)

S.No	Sequence solution route	A_{OFV}
1	1- - - - - - - - - - - -	3768.4
2	2- - - - - - - - - - - -	4124.5
3	**3- - - - - - - - - - - -**	**3121.1**
4	4- - - - - - - - - - - -	3645.4
5	5- - - - - - - - - - - -	4012.0
6	6- - - - - - - - - - - -	4172.3
7	7- - - - - - - - - - - -	3467.6

In initialization process the Table 2 indicated serial number 3 is shown minimum value. Then Table 3 indicated the average objective function value for all the possible routing.

Table 4 Average Objective Function Value (A_{OFV})

S.No	Sequence solution route	A_{OFV}	S.No	Sequence solution route	A_{OFV}
1	3-2-1- - - - - - - -	3342.1	16	3-5-2- - - - - - - -	2769.5
2	3-2-4- - - - - - - -	3124.2	17	3-5-1- - - - - - - -	3952.6
3	3-2-5- - - - - - - -	3651.4	18	3-5-4- - - - - - - -	2948.5
4	3-2-6- - - - - - - -	3231.4	19	3-5-6- - - - - - - -	3233.0
5	3-2-7- - - - - - - -	3568.4	20	3-5-7- - - - - - - -	3167.5
6	3-1-2- - - - - - - -	3004.5	21	3-6-2- - - - - - - -	3121.6
7	**3-1-4- - - - - - - -**	**2342.4**	22	3-6-1- - - - - - - -	3222.6
8	3-1-5- - - - - - - -	2846.0	23	3-6-4- - - - - - - -	3022.0
9	3-1-6- - - - - - - -	2765.3	24	3-6-5- - - - - - - -	3965.5
10	3-1-7- - - - - - - -	3457.1	25	3-6-7- - - - - - - -	2522.4
11	3-4-1- - - - - - - -	3213.1	26	3-7-2- - - - - - - -	2651.6
12	3-4-2- - - - - - - -	3272.4	27	3-7-1- - - - - - - -	3122.0
13	1-4-5- - - - - - - -	3072.7	28	1-7-4- - - - - - - -	2891.2
14	1-4-6- - - - - - - -	3541.4	**29**	1-7-5- - - - - - - -	2965.1
15	1-4-7- - - - - - - -	3210.2	**30**	1-7-6- - - - - - - -	2435.3

1. K= Average Number of Sequences = N-F = 7-3 = 4

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2. Number of Sequences = (7-3)! = 24
3. Optimal Sequence = 7th Item = 3-1-4- - - - - - - - (Generate all 24 possible generations)
4. Best optimal route = 3-1-4-6-5-7-2 = Minimum OFV = 2297.1.
5. The proposed algorithm gives the better results when compared with the optimal layout sequence of 4-6-5-1-7-2-3 obtained by Lee et al (2001) with an OFV of 3198.

In this numerical illustration, the performance and computational efficiency of the proposed algorithm are analyzed. Also a discussion on the factors influencing the results of the algorithm is provided.

4. Conclusion

RFID is a dedicated short range communication technology. The term RFID is used to describe various technologies that use radio waves to identify people or objects automatically**.** A modified Genetic Algorithms (GA) system approach, K- Means Cluster based Heuristic approach, Hybrid GA-Simulated Annealing (SA) approach, Hybrid K-Means Cluster based heuristic-GA and Hybrid K-Means Cluster based heuristic-GA-SA for travelling salesman problem is proposed. The study incorporated uniform crossover operator and combined crossover operator in GAs for solving supply chain distribution network problem. The algorithms are tested on 50 randomly generated data set and compared with each other. The results of the numerical experiments shows that the Hybrid K-means Cluster based heuristic-GA-SA, when tested on 50 randomly generated data set, shows superior performance to the other methods for solving the TSP. RFID should be considered for any application that could realize a clear benefit in terms of efficiency, reduced loss, or improved service. As per the proposed algorithm, in this paper RFID technique with Hybrid algorithm are adopted to optimize the supply chain distribution network.

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