Multi-Niche Crowing in a Steady State Evolutionary Algorithms for Dynamic Multicast Routing

Dadmehr Rahbari [1], Saeed Toosizadeh [2]
1 Artificial Intelligence Group of Mashhad Azad University,

2 Electrical Engineering Group of Mashhad Azad University,

Abstract
One of the most important problems in computer networks is the path finding of multi-destination mobiles in a dynamic environment by minimizing cost and delay, as well as maximizing bandwidth. In this paper, first a routing table is constructed by a local search and subsequently optimized by a hybrid of a steady state evolutionary algorithm, simulated annealing, and multi niche crowding. Simulations in a dynamic environment confirm our proposed combination ultimates to the superior solutions as compared to individual methods. Our performance evaluation includes fitness values of solution, run time and change in parameters.
Keywords
Dynamic multicast routing, Genetic algorithm, Simulated annealing, Multi Niche crowding.

1. Introduction

Multicast routing is one of the most important types of network addressing. In contrast to unicast routing (delivery of a packet to only one node), multicast routing handles routing of information between one source node and several selected destination nodes. Figure 1 illustrates multicast routing in comparison to the other network routing cases, i.e. unicast, broadcast, and anycast.
Multicast Routing: Sending a message to a group is called multicasting, and its routing algorithm is called multicast routing. In fact multicast routing is done by sending one packet to several destinations (those destinations were announcing their interest by joining the multicast group)[24,25].
This paper implies that dynamic multicast routing optimizes paths by minimum cost and delay, as well as maximizing bandwidth for sending packets in network. The strategy that is used to improve the genetic algorithm is the changes of mutation rate as the diversity of population is increased at start and gradually decreased to the end and this causes that speed of convergence is increased.
The Combination methods of genetic algorithm and simulated annealing are based on this idea that diversity rate and convergence to goal in genetic algorithm caused to general optimization. Simulated annealing have a key parameter - called temperature - that if it is low then algorithm would be close to goal.

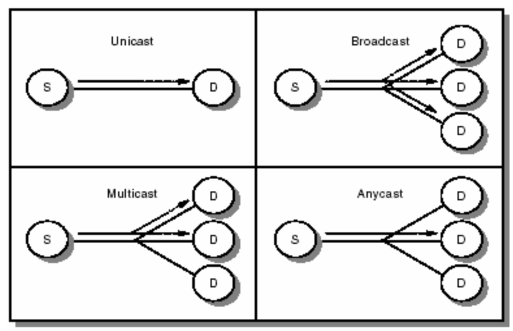

Figure 1. Datagram delivery methods

Heuristic function for the combination this two algorithms is use of coordination in decreasing of temperature and mutation rate while reach to optimal goal[4]. Another method for combination this two algorithms is using of suitable scheduling for temperature annealing for the people generation in the new generation also using of another idea whereas temperature calculation function in simulated annealing algorithm and fitness in the genetic algorithm [3].
Another method for the maintenance of diversity in population is use of Crowding strategy method in selection operation and replace of the chromosomes. This strategy is based on group selection of chromosome as number of people in the population randomly selects and the most similar of member in of the population with member out of it select as parent and on after stage execute mutation and crossover operations on its that generated two child. Niching is the another method based on selection of members of population that is include by multi groups and most similar of each group with worst fitness will be candidate for the replacement. The most done research on the combination this strategy with

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genetic algorithms prove the maintenance in population [5].
In this work have prevented of miss paths of destinations and the basic goal of this project is the execution of genetic algorithm, simulated annealing and use of Multi Niche Crowding idea and combination of this methods for reach the shortest paths to goals that ultimately compared with the Another.

2. Construction of routing table

The paths conduce to destinations maintenance in the routing table that construction process done by local search algorithm. This table is include columns for each destination and rows for maintenance any tree, like the Figure 2.

Routing Table	Destination 1	Destination 2	. . .	Destination M
Path 1	Chromosome 1	Chromosome 2	. . .	Chromosome M
Path 2	Chromosome 1	Chromosome 2	. . .	Chromosome M
. . .	. . .	. . .	. . .	. . .
Path N	Chromosome 1	Chromosome 2	. . .	Chromosome M

Figure 2. Routing Table

3. Genetic Algorithm

Genetic algorithm is a generalized search and optimization technique. It works with populations or chromosomes of "individuals", each representing a possible solution to a given problem. Each individual is evaluated to give some measure of its fitness to the problem from the objective functions. Three basic operations namely: reproduction, crossover, and mutation are adopted in the evolution to generate new offspring[20,21,22].
To optimization of multi paths to destinations will construct one routing table that shows all finding paths in network. In this problem, each path assumed as a chromosome that first gene is source node and last gene is destination node and each row of table show multi path to destinations.

3.1 Chromosome structure

The chromosome length in this problem is equal size of logical longest path that is include 39 genes (2*column or row – 1 = 39).
In grid environment, data packet will moved of current position to eight next positions that have shown in Figure 3.
So the paths to destinations is chromosome include sequence of digits that is sample in Figure 4:

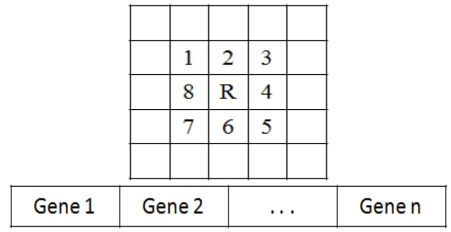

Figure 3. Chromosome structure

(R) 4 2 7 3 3 3 . . . 3 4 5 6 6 1 (Destination 1)
(R) 4 3 4 5 5 6 . . . 6 7 7 8 1 1 (Destination 2)
. . .
(R) 1 2 2 2 2 5 . . . 4 4 4 7 7 5 (Destination N)

Figure 4. Sample of paths of a source to destination

3.2 Population

The population in this problem is routing table that explained its structure in section 2 as each row show the multi paths of one source to multi destinations that will optimized in duration of generations. In initialization step the population size (PS) of chromosomes assigned by 100. The repeated chromosomes are removed in the initialization phase (all chromosomes are different from each other). This work decrease search space at different places (randomly) which increases the convergence rate[23,24,26].

3.3 Fitness function

The High Fitness value demonstrator optimal chromosome , so used of cost inverse until path cost have decreasing rate.

$$\text{Fitness} = \frac{1}{\text{Cost}_T} * \text{Delay}_T * \text{BandWidth}_T$$

CostT: Total of path costs (The cost of move between two nodes in network) to destination of source in routing table , DelayT: Total of delay of source in routing table, BandwidthT: Total of bandwidth of source in routing table. Path cost: Total of link costs on paths in routing table.
For the normalization of values this parameters used of range [0,1] as zero value disconnect link or delete node and one value show maximum performance of links.

3.4 Crossover

Crossover is used to cross breed the individuals, Using crossover operator, information between two chromosomes are exchanged which mimic the mating process. This operator exchange half of two parent chromosomes and generate two childs with by condition that paths to destination not miss. For the exchange each of gene checked before and after genes in parent chromosome that not cause missing of paths. Figure 5 show the crossover operator on two parents.

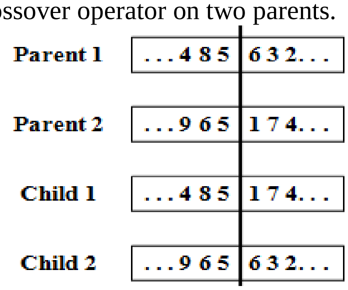

Figure 5. Crossover operator

we would like maintenance population diversity in preliminary generations and increase the convergence in end generations, at result assume crossover rate in first half generations equal 5.0% and in the second half generations equal 44.0%.

3.5 Mutation

Mutation operator changes 1 to 0 and vice versa with small probability Pm. The mutation operator introduces new genetic structures in the population by randomly modifying some of the genes, helping the search algorithm to escape from local loop. The values of gene is digit between one to eight and mutate gene had been different with pervious gene also had select that not miss path to destination.

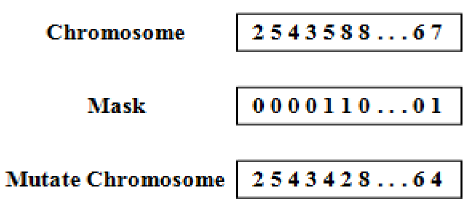

Figure 6. Mutation Operator

Mutation operator maintenance the diversity in population so in the start of generations maintenance high diversity and in the end generations decrease this rate, at result this rate on the first half generation is equal 54% and on the second half is equal 15%.

4. Multi Niche Crowding strategy in genetic algorithms

In crowding, selection and reproduction are the same as in the SGA, but replacement is different. Niching was introduced into GA primarily to maintain population diversity.

In a nutshell, all steady state genetic algorithms have three basic steps: selection, recombination (or, reproduction) and replacement. During the selection step, a decision is made as to who, in the population, is allowed to produce offspring. During the recombination step, offspring are produced via the operations of crossover and mutation. During the replacement step another decision is made as to which of the members in the current population are forced to perish (or vacate a slot) in order to make room for an offspring to compete (or, occupy a slot) in the next iteration. These steps are applied until a suitable condition is satisfied, say, the number of function evaluations. Various versions of steady state GA's differ from each other in the details of how these steps are implemented.

In the MNC GA both the selection and replacement steps are modified by some type of crowding (De Jong) [18]. The idea is to ameliorate the selection pressure caused by fitness proportionate reproduction (FPR) (Holland)[19] and allow the population to maintain diversity throughout the search. This objective is achieved in part by encouraging mating and replacement within members of the same Niche while allowing some competition for the population slots among the niches. The result is an algorithm that maintains stable subpopulations within different niches, maintains diversity throughout the search, and converges to multiple local optima.

No prior knowledge of the search space is needed and no restrictions are imposed during selection and replacement thus allowing exploration of other areas of the search space while converging to the best individuals in different niches.

This strategy have emphasis on group selection and replace of chromosomes. This approach is include two stage that in first stage the population divide by Cs chromosomes, also select one chromosome as parent of out of each group and based on most similar this chromosome with each chromosome in the group select another chromosome then does mutation and crossover operators on the two parent chromosomes and generate two childs. Second stage does for the each childs.

As in the Figure 7 is shown, the total population divide by Cf group and select most similar in the group with one of the child of before stage as create one vector include f members that chromosome by minimum fitness replace with generated chromosome in before stage.

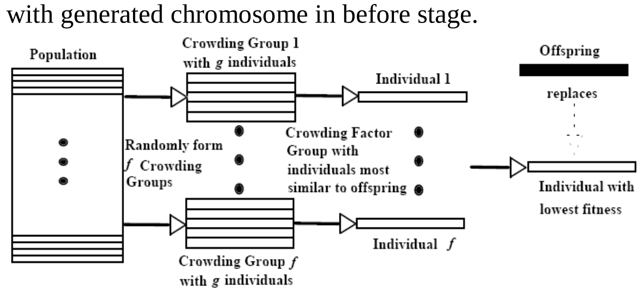

Figure 7. Parent replacement with most similarity and minimum fitness

Members of group selected by minimum fitness and maximum similarity (The child of each of group).
The Chromosome similarity is based on Euclidean distance is the following :
X = (x1, x2, . . . ,xn), Y=(y1,y2, . . . , yn), n=Chromosome length

$$d(x,y) = \sqrt{\sum_{t=1}^{n} \left(\frac{x_i - y_i}{x_i^u - x_i^l}\right)^2}$$

For the normalization of distance d(x , y), difference value of gene divide by chromosome length.
This strategy is useful for maintenance of diversity in the population also optimized convergence to very much value. The notable note in this strategy is regulation of low mutation rate cause not scape population of each niche.

5. Simulated annealing algorithm

Simulated annealing algorithm (SA) is a general-purpose optimization technique and has been applied to many combinatorial optimization problems . The main idea behind SA is an analogy with the way in which liquids freeze and crystallize. When liquids are at a high temperature their molecules can move freely in relation to each other. As the liquid's temperature is lowered, this freedom of movement is lost and the liquid begins to solidify. If the liquid is cooled slowly enough, the molecules may become arranged in a crystallize structure. The molecules making up the crystallize structure will be in a minimum energy state. If the liquid is cooled very rapidly it does not form such a crystallize structure, but instead forms a solid whose molecules will not be in a minimum energy state. The fundamental idea of SA is therefore that the moves made by an iterative improvement algorithm are like the re-arrangement of the molecules in a liquid that occur as it is cooled and that the energy of those molecules corresponds to the cost function which is being optimized by the iterative improvement algorithm. Thus, the SA aims to achieve a global optimum by slowly convergence to a final solution, making downwards moves with occasional upwards moves and thus hopefully ending up in a global optimum [3].
SA algorithm is the following steps:
1. Create the decrease list of temperature with value in range [0,1]. (Annealing Cooling schedule)
2. Initializing population called by Path0 and assignment maximum value to path0.(Objective function)
3. Change in the population and create Path.
4. If fitness of path is great than maximum fitness then go to 5 else go to 6.
5. New Path equal Path0 and maximum fitness is for Path.
6. If T[i] > Random(0,1) then (Acceptance function)
Path0 = Path .
7. If end of generation go to 3 else go to 8.
8. End
Simulated annealing algorithm is useful method than genetic algorithm because of cause scape of local optimum goal. Also runtime of this algorithm is very lower of genetic algorithm.

6. Hybrid Genetic and simulated annealing algorithm

Each of the above approaches to hybridize GA and SA described in Section II.A has its own strengths, because some good characteristics of GA and SA are maintained when combining GA and SA together. In this paper, a new GA and SA hybrid, GSA, is presented.
After crossover and mutation for a couple of individuals, there are four chromosomes: two parents and two offspring. In conventional GA, two parents are replaced by their offspring.
But in GSA, two chromosomes are chosen to form the next generation from these four individuals. The selection criterion is based on the fitness values of these four individuals.
Individuals with higher fitness values have a greater probability of surviving into the next generation. Those with less fitness values are not necessarily discarded. Instead, a local selection strategy of SA is applied to select them with a probability related to the current temperature (as in simulated annealing). In this selection process, a Markov chain is executed, which is composed of two offspring. Four parameters (fbest, fworst, Tt, fi) are involved to describe this selection process:
fbest — the best fitness value of two parents;
fworst — the worst fitness value of two parents;
fi — the fitness value of one offspring (i= 1, 2);
Tt — control temperature;
During the course of the Markov chain at temperature Tt, the fitness value fi (i =1, 2) of the trial chromosome is compared with fworst. Chromosome i is accepted to replace the worst individual, if the following requirement is met:

$$\min\{1, e^{\frac{f1 - f_{worst}}{T_t}}\}$$

where r is a randomly generated number between 0 and 1. If chromosome i is accepted, the worst chromosome and the best one are updated and then the course of the Markov chain continues until completion. After the implementation of the Markov chain, the best and the worst individuals are survived into the next generation.
In SGA, mutation simply changes the value for a particular gene with a certain probability. It helps to maintain the vast diversity of the population and also

prevents the population from stagnating. However, at later stages, it increases the probability that good solutions will be destroyed. Normally, the mutation rate is set to a low value (e.g., 0.01) so that accumulated good candidates will not be destroyed. This negative effect of mutation has been eliminated for GSA, because the local selection of SA is applied after mutation, such that at the later stage, only better solutions are retained after mutation. Therefore, the initial value of mutation probability can be larger than the recommended values in [17].

In this study, the mutation probability pm of GSA is initially set to a higher value, and a simple annealing process is then used to adjust pm. After every certain generations, the mutation probability pm is updated with (pm×α) until it reaches to a certain value, where α is the cooling rate of SA. Thus, at the initial stage, when manipulating the cooling schedule of SA properly, the initial higher temperature can ensure that parents will be replaced by their offspring after crossover and mutation whether they are much fitter or not. More importantly, the initial higher mutation probability is capable of improving population diversity greatly, which can eliminate the premature convergence problem of conventional GA. On the contrary, at the later stage the mutation probability and the temperature become lower, and the chances for the fitter parents to be replaced decrease greatly. In this way, the current best individuals may continue to remain in the next generation. Thus, the possibility of removing potentially useful individuals in the last generation because of the mutation operation can be reduced. The pseudo-code of GSA is illustrated in following, where P(t) is the population of individuals at generation t, and n is the string length of chromosome.

Combination algorithm (GSA):

```
t = 0
initialize P(t) and temperature Tt
evaluate P(t)
while not termination-condition do
  t = t + 1
  select P(t) from P(t-1)
  select individuals for reproduction from P(t)
  repeat
    select two unused individuals P1, P2
   crossover & mutation; generate two children C1,C2
    evaluate C1,C2
    for all i = 1 to 2 do
          if min{1, exp((fi-fworst)/Tt)}> random[0,1) then
       accept Ci and replace the corresponding parent
        update the new best and worst points
      end if
    end for
    until all selected parents finish reproduction
    Tt+1 = Tt × α ; 0 < α < 1
   if the modulus of t divided by 10 == 0&& pm > 1/n then
          pm = pm× α
   end if
end while
```

T: temperature parameter, α : decrease temperature coefficient and mutation rate, Pm: mutation rate.

7. Genetic simulated annealing with Multi Niche Crowding strategy

MNC GA execute with attention to MNC assumptions like parent selection, mutation and crossover operations also generate of twochilds and replacement with parents and continue similar to genetic algorithm.

In MNC GSA combination method of genetic and simulated algorithm is similar to befor section and main difference is in the selection method for replacement. As MNC strategy that based on group of members, in the second stage the presented hybrid algorithm select the two parents by use of MNC method then mutate and crossover and continue algorithm.

As important properties in MNC algorithm each combination methods caused to maintenance diversity in population in duration generation.

8. Simulation Setting

For the test of algorithm performance designed a dynamic environment by 20 columns and rows that each cell is a node in network, each node maybe destroy and disconnect the relation between nodes. For the implementation of another dynamic in this work, bandwidth ,delay and cost values randomly changes between defined values.

Also destination nodes move and destroy and or add to dynamic network. To create a dynamic environment executes a synchronic procedure with presented algorithms that changes above items in the Network.

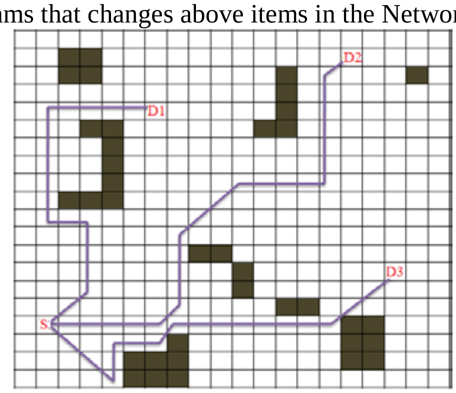

Figure 8. View of dynamic environment

Algorithm parameters is the following:
Population size is 100, number of generations is 100, chromosome length is 40 and destination count is 3.
The Selection of genetic operations with suitable rate have most efficacy in maintenance of diversity and convergence speed. In this work have tested different values for mutation and crossover rate that after study of simulation results outcome best rates.
For the Multi Niche Crowding strategy Cs: Number of population for the first parent is 20, Cf: Number of group is 10, S: Number of group members is 10.
Also α : temperature decrease coefficient and mutation rate for the combination of genetic and simulated annealing algorithm is 0.85.

9. Results

By use of done simulation and based on explained assumes we studied performance of used methods of many aspects that is the following:
Fitness value in duration generations
Maximum of fitness value
Runtime of algorithms
Result comparison by change of algorithms parameters
Average of fitness value in duration of generation
First study is fitness value in duration generations:

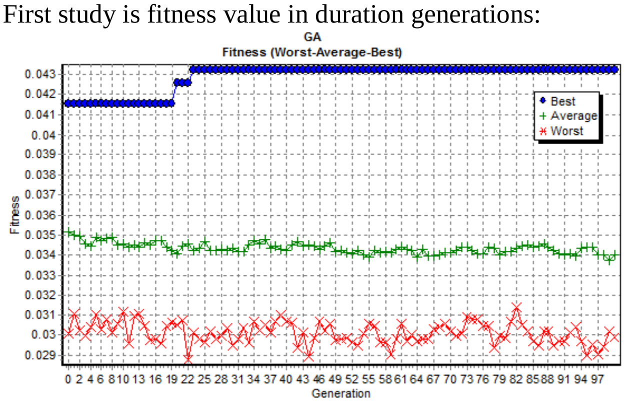

Figure 9. Fitness value in duration of genetic algorithm generations

Table 1. Efficacy of Flixible Genetic Operation

Mutation Rate	Crossover Rate	Diversity Rate	Convergence Speed
0.54	0.05	High	Low
0.15	0.44	Low	High

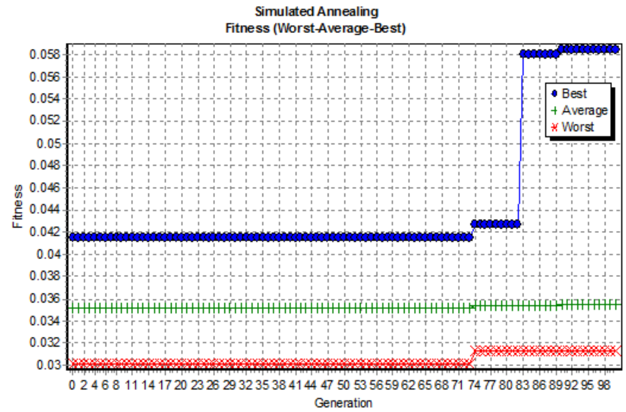

Figure 10. Fitness value in duration of simulated annealing

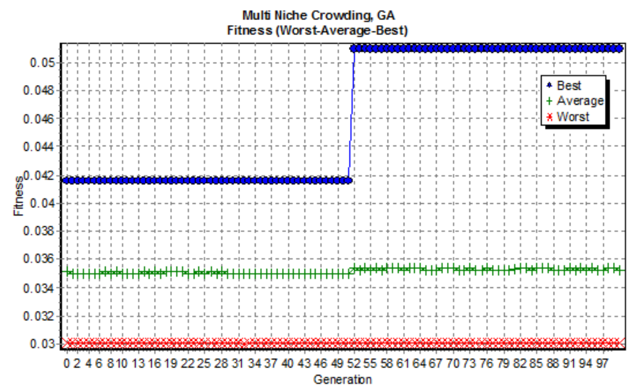

Figure 11. Fitness value in combination of MNC genetic algorithm

The another one of criterions for performance study in combination of MNC and genetic algorithm is MNC factor or group count that results of fitness value compared by three values 5, 10, 15.

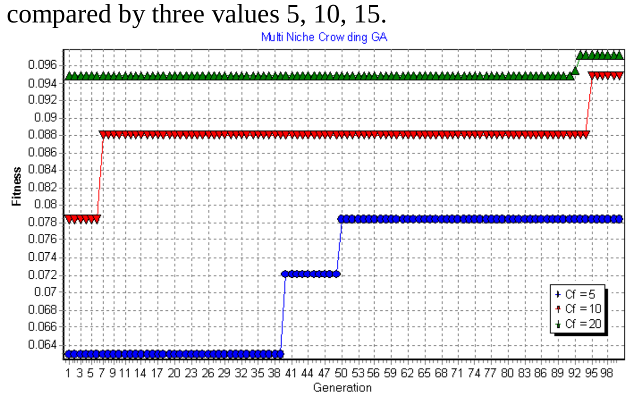

Figure 12. Fitness values based on MNC group count

In multi niche crowding strategy, group counts is effective factor in fitness values. As Figure 12 and assumption of simulation 20 groups of 100 members have good results toward 5 groups. So relation of between Fitness value and Group count is straight.

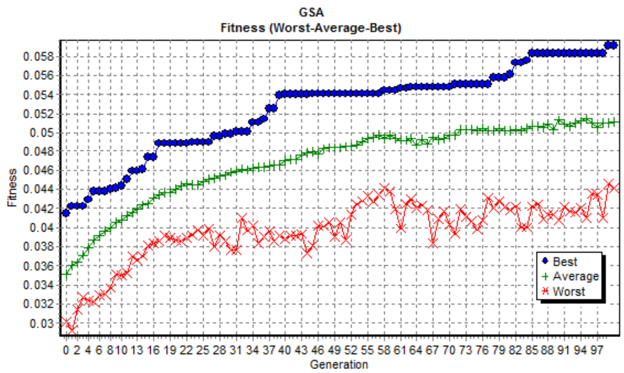

Figure 13. Fitness value in combination of genetic and simulated annealing algorithm

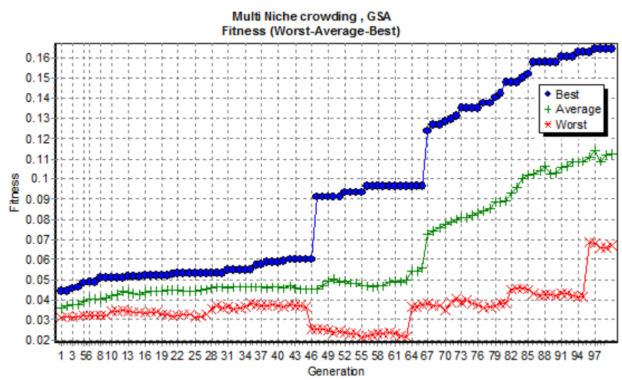

Figure 14. Fitness value in combination of genetic and simulated annealing algorithm with MNC

As Figure 15, Noticeable note is low runtime for combination genetic and simulated annealing algorithms for scape of local optimum in problem. Also maximum runtime is relation to MNC GSA that got because use of elitism with high rate and reach to best results.

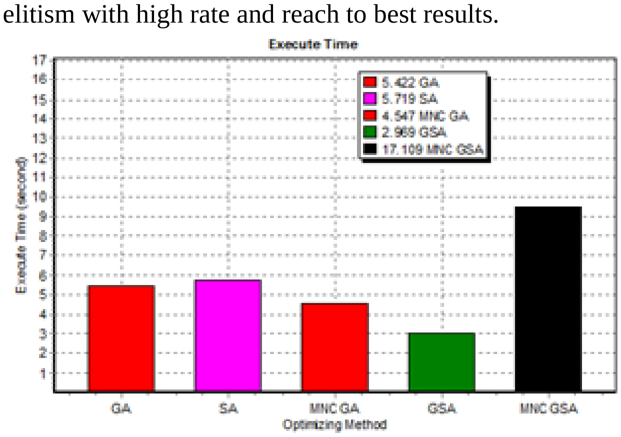

Figure 15. Runtime of algorithms

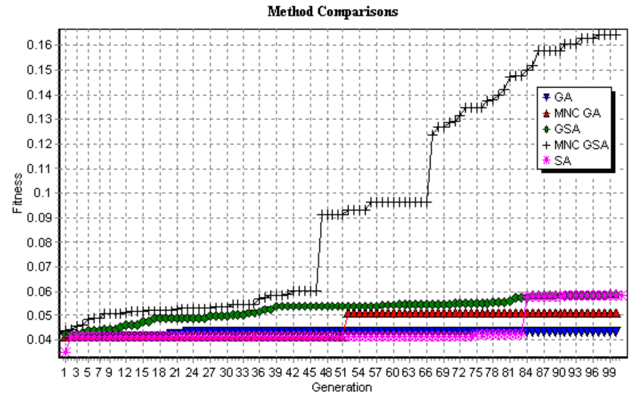

Figure 16. Comparison of best fitness value in different methods

By 30 times of simulation execution of the best of fitness average is for MNC method with 0.16 and then GSA method with 0.15 and combination methods have lower fitness.

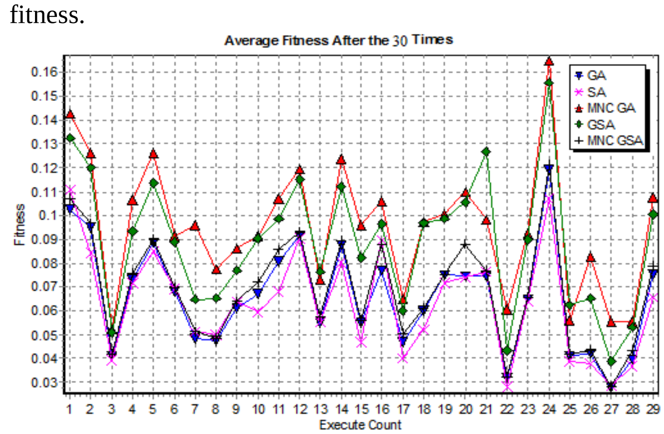

Figure 17. Fitness average diagram then of 30 times of execution

As the results, combination of genetic algorithm, simulated annealing and Multi Niche Crowding strategy will caused finding best paths with minimum cost, maximum bandwidth and minimum delay. In fact, combination of this methods maintain its good properties. So simulated annealing algorithm cause to scape of local optimum and Multi Niche Crowding idea maintain diversity in population.

10. Conclusion and discussion

Computer networks with dynamic nodes and links that can added, deleted and moved is caused data packets can't finds the useful paths.

The computer networks or Corresponding systems can converted to intelligent system as in this article use of evolutionary algorithms caused to finding the optimal paths to destinations. The variant versions of genetic algorithm have good properties but also local optimum is

serious problem in those, selection of fitness function, mutation and crossover rate and type those is very important that by use of this properties can have a extended algorithm as work in the dynamic environment.
Simulated annealing algorithm used in this work cause scape of genetic algorithm of local optimum, for hybrid this two algorithm use of coordination temperature and mutation is good selection better that another methods.
Selection operator in genetic algorithm is the one of important stages that for the optimization it used of Multi Niche Crowding strategy to maintain diversity in population of course with flexible mutation and crossover rate. This method improved results of GA to 97.3%.

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