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DYNAMIC SHORTEST PATH ANALYSIS OF ROUTING TECHNIQUE VIA GENETIC ALGORITHM

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Abstract: The performance and reliability of the internet depend in large part on properties of routing techniques. IP routing protocols nowadays compute paths based on the network configuration parameters and topology, missing view to the current traffic load on the routers and links. This paper discusses routing optimization using Genetic Algorithm (GA) then studies and analyzes the problems in order to increase routing performance in median networks. A genetic algorithm will be proposed in a detail to advise the performance of Open Shortest Path First (OSPF) routing Protocol. The simulated results show that the probability of convergence to shortest path has been superior via momentary using GA in OSPF protocol.

Keywords: *Routing, Routing Metrics, OSPF, Genetic Algorithm, Optimization.*

تحليل ديناميكي لأقصر الطرق في تقنية المسالك بواسطة ألخوارزمية ألجينية

الخلاصة : ان الكفاءة والفاعلية في الانترنت تعتمد بالدرجة الاساس على خصائص تقنية المسالك. و يعتبرال(IP) من بروتوكولات المسالك التي تحصي السبل حاليا وبحسب محددات الشبكة وتوبولوجيا الشبكة، مع ذلك تم معاينة فقدان بيانات بسبب الحمل الزائد في الشبكة على الرابط المسلكي والطرق . هذا البحث يناقش كيفية تفعيل الافضلية المسلكية باستخدام الخوارزمية الجينية ومن ثم دراسة وتحليل المعالجات لغرض زيادة اداء المسالك في الشبكات الكبرى. ان الخوارزمية الجينية تم طرحها بالتفصيل والإشارة الى اداء ال (OSPF) بروتوكول. نتائج المحاكاة تظهر ان الأرجحية للتقارب الى اقصر المسالك هي من خلال التضمين الوقتي للخوارزمية الجينية في بروتوكول المسالك (OSPF) .

1. Introduction

There is a lot of routing algorithms support routing tables and used to find the paths between sources and destinations. OSPF (Open Shortest Path First) is a periphery routing protocol in which relies on "Dijkstra algorithm ". This algorithm hits upon allocating shortest path from end to end depending on the cost that's the first parameter to calculate the path heuristic. While if congestion or an overloaded occur on a link in the path that figure out by this algorithm, this will lead to missing in the packets arrive at the desired destination or may be delayed.

Genetic Algorithm (GA) can jump out of a local minimum, that's the problem of Dijkstra algorithm [1]. That's why the importance to optimize the network based on many parameters rather than only the cost to make a chance of best solutions. Routing

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optimization is an important task in network planning and management. Chiefly in the case of growing the traffic loads or impermanent traffic variations cause localized link congestions [2].

The fine-tuning of the paths is the main idea, by pass through IP packets all over the network, to better employ obtainable network resources and, thus principal to enhanced Quality of Service (QoS) [3,7]. GA works out optimization problems of IP networks due to its evolutionary specialist to explain the problem.

Way out starts with finding alternative paths to alternate the overloaded path using GA approach to the Shortest Path (SP) routing problem. Variable-length strings being used for encoding the problem. The crossover operation exchanges partial parts at independent tripping sites, while the mutation maintains the population diversity by improving quality of the solution, also GA have repair function can treat infeasible paths [4].

The shortest path isn’t inevitably the fastest route every time because this pronouncement is a dynamic problem whose solution depends on the instant of day, the weather, accidents, and so on. The best solution was composite to solve by static problems, but the added dimension of time increases the challenge of solving the problem [5]. In this paper, the path cost will be taken under consideration to applying heuristic value to ruling the best path by GA.

In section 2 routing definition, metrics and some of its protocols discussed while the proposed algorithm (GA) covered in section 3 and the encoding of the suggested system and the analysis of the results clarified in section 4 with some points that concluded in section 5.

2. Network Routing and Route Metrics

The process of finding a path from a source to every destination in the network by reading the addresses and decides how to forward packets simply was the routing. Eventually, any packets need to be sent may be traversing many cross-points, similar to traffic intersections in road transportation network. Cross-points which are intermediate network hardware devices are known as routers, bridges, gateways, firewalls, or switches; the wide-ranging network architecture of multi routers connected by backbone area shown in "Fig. 1".The routing process generally directs the packets that forward by routing tables, which keep up all recorded routes to different network destinations. Therefore, constructing the routing tables, which have been held in the router's memory was high important for efficient routing. A large amount of routing algorithms use only one network path at a time. Multipath routing techniques enable the use of multiple alternative paths [2] and [6].

A network link that connects two cross points is restricted by amount of data it can transfer per unit of time, frequently referred to as the bandwidth or link ability; it is usually represent by a data rate [3].

Route metrics are the criteria have been used by a router to make routing decisions to determine if a route should be select instead of others. The routing table stores feasible routes, even as link-state or topological databases may perhaps store all other information as well. For instance, Routing Information Protocol (RIP) uses hop count to establish the best likely route. The direction of the default gateway with the lowest metric will be route trend. Router metrics can contain any number of values that help the router determine the best route among multiple routes to a destination [8, 15].

The most familiar metrics values based on information like path length, bandwidth, load, hop count, path cost, delay, Maximum Transmission Unit (MTU), reliability and communications cost [8].

Each path has been representing by a metric heuristic value of the tree of connection, and based on GA the goal will be finding the optimum path.

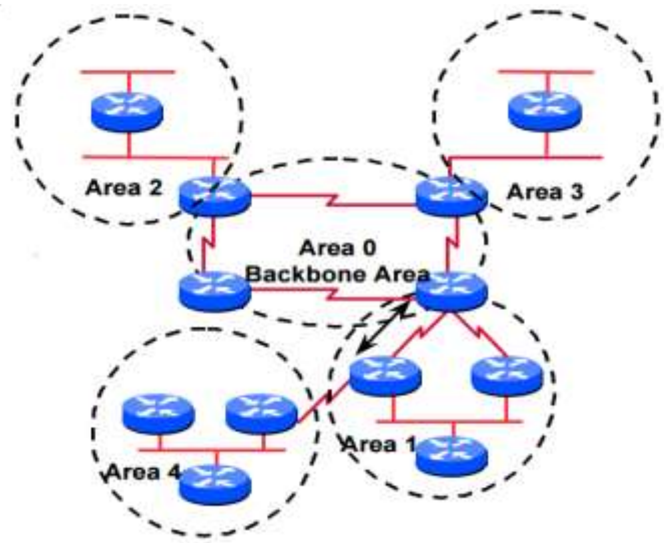

Figure 1. Network Architecture with multi routes

2.1. *Adapted New Open Shortest Path First Protocol (N-OSPF)*

The best path for packets to get ahead through a set of connected interior networks established by OSPF protocol which depends on Dijkstra's algorithm to determine the shortest path. Dijkstra's algorithm is optimization techniques, are most widely recognized types of evolutionary computation methods today which solves the distinct-source shortest path problem by its graph search algorithm specialty for nonnegative edge path costs. This algorithm was producing tree of a shortest path by lowest cost evaluation [8, 9], while working opinion of this algorithm was going earnest to the best neighbor point till achieving the goal (Depth _first _search), where the goal may be very neighbor the starting point with little bit large cost only in the beginning [16].

GA can achieve a dynamic choice for the shortest way as appropriate for best route finding and will check all the neighbored points breathily to reach a goal (Breadth _first _search). Simply using the network graph shown in "Fig. 2", with cost explanatory on each path, on the whole cost from source node to the destination depending on Dijkstra's algorithm that chooses the path (A-C-E-H-J-F) will be 20, while in GA finding the finest trail will be (A-B-F) of whole cost 11, this problem called local minima in artificial intelligent [10, 11].

In this paper we proposed to use GA instead of the original Dijkstra's algorithm in exceptional suitcases to overcome local minima by analyzing whole path costs then choose the best algorithm, therefore the new proposed version call as N-OSPF capable to employing both algorithms (Dijkstra, and Genetic).

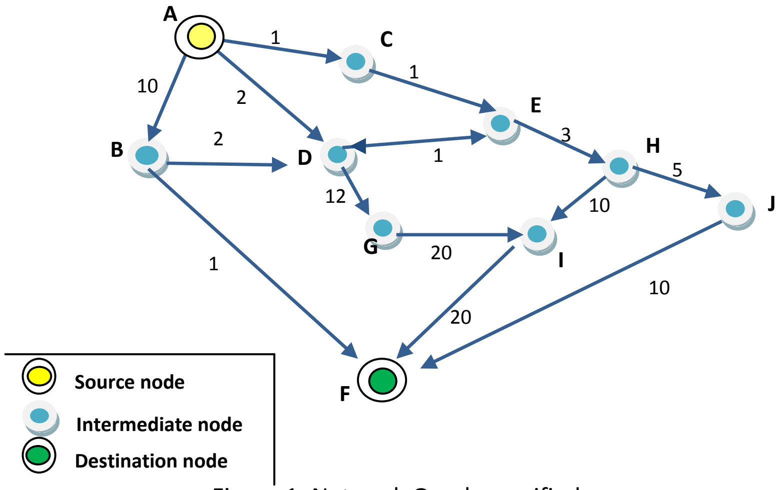

Figure 1. Network Graph specified

3. Genetic Algorithm

Each node Ni of the network graph such as a router proposed as gene in biological model of GA and use network path from source to goal as advised chromosome (candidate).

The initialization of the population will be done randomly for the offspring candidates, each link between the nodes have a heuristic cost applied by network metrics for candidate process where $C(ni, ni+1)$ was the cost from node ni to neighbor nodes ni+1, for K paths in the whole network.

There are many methods for the selection process to get higher chance such as {Random pairing, Roulette-wheel, Tournament selection, etc} [13], the proposed method for selection in this paper was Roulette-wheel. The flow chart of applied genetic algorithm applied in "Fig. 3".

GA has major three processes {fitness evaluation, crossover and mutation}, where fitness found by the inverse of summation cost till it achieving the goal as in (1), crossover was the process of combining parts of two or more parental solutions to create new better solutions (off springs) [11, 12, 13]. There are many ways of accomplishing this and competent performance depends on a properly designed recombination mechanism whereas the principle of the solution was cutting point(s) boundaries for swapping the nodes of the chromosome as in "Fig. 4".

$$Fi = \begin{cases} \dfrac{1}{\sum_{i=1}^{N} C(ni, ni+1)} & feasible\ path; \\ 0 & un\ feasible\ path \end{cases} \tag{1}$$

Then some correction required because it might be the case that the child is unfeasible solution [13].

The mutation was the optional operation performed on bit-by-bit basis relying on verifying the probability of mutation on new individuals (Pm) where it's in this approach are (0.1- 0.9). The mutated node selected randomly to accomplish the new generation. The chromosome generated by this process shown in "Fig. 5".

Then the offspring population created by selection, crossover, and mutation replaces the original parental population, these processes repetitively occurs by many iterations till the goal appears which best shortest path is [4, 13].

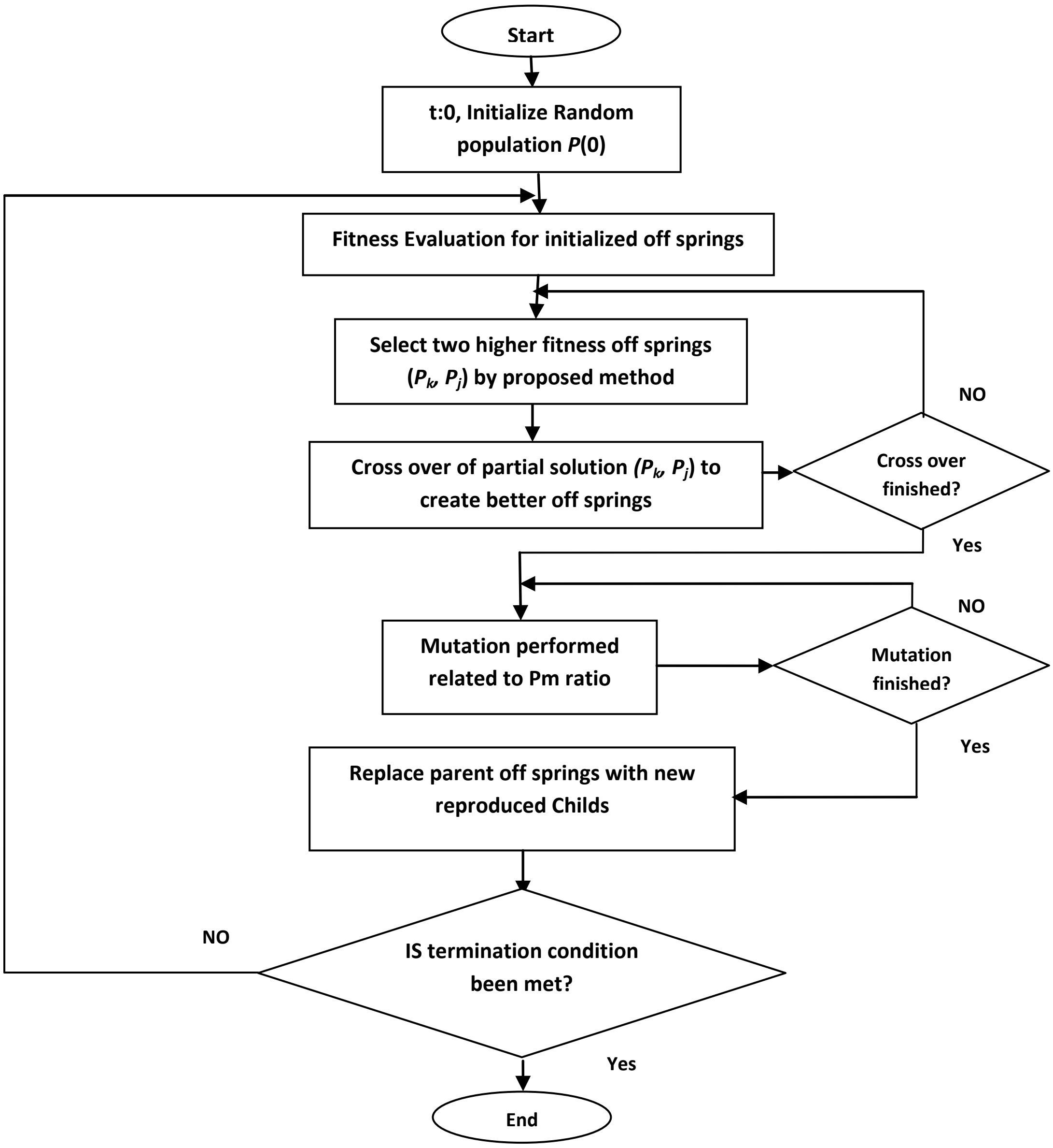

Figure 3. Flowchart of Genetic Algorithm

4. Method of Encoding

The suggestion of network given *G(N, E)* with *N* nodes and *E* is the set of paths connecting the nodes regarding the source node S and destination node D, suppose the path *P(0)* as $\{ S, N_0, N_1, N_2, \ldots\ldots\ldots N_m, D \}$ depending on fully connecting network with different network size of *(N=5),* with multiple of 5 till attaining *(N=50)* to cover LAN local area network or may be WAN wide area network requirements. The chromosome (path) applied by a string of nodes with different lengths. Obviously, a chromosome represents candidate solutions from the entire population problem in the network will guarantee the shortest path.

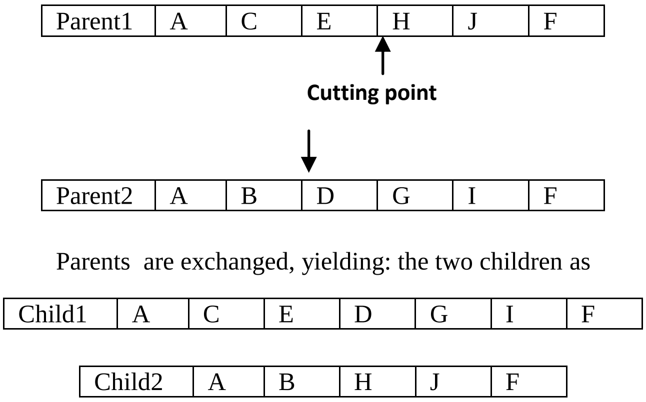

Figure 4. Cross over process

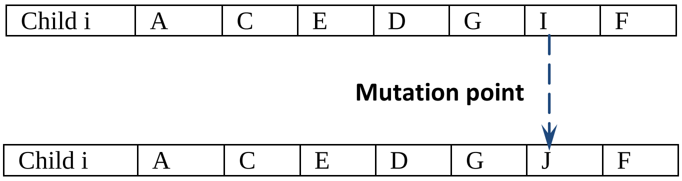

Figure 5. Mutation process

4.1. *Simulation Result and Discussion*

In this approach, we have been relying on the process of changing probabilistic of mutation values Pm to see its impact on finding the shortest way through changing its value by (0.1, 0.3, 0.5, 0.7 and 0.9).

The selection of best mating pool at the beginning has been done by the elitism, while other solutions are chosen using roulette wheel selection strategy and added to the mating pools. The two parents must be different to produce new child by crossover process where the steady state strategy used to avoid duplicate in off springs set, in selection mean the best solution of higher fitness always survived for the next generation.

The variety of Pm is static that would be checked with fitness function of a routing protocol to find the finest path for all iterations, the Pm range is taken (0.1-0.9) as shown in "Table 1" low Pm values is lead to goal divergent, while highest value taking more time to find the best path to the destination.

Today an internet of everything's that will make many loads in transmission media made urgent criteria taking into consideration was the time. Therefore for good performance to the proposed algorithm, the best fitness appear in most of the network size in the middle points of Pm, i.e. at Pm = 0.3, 0.5 and 0.7 as clarified in "Fig. 6", the effect of mutation probability on fitness value for the different size of networks.

The paths have been checked if *Pi* less than Pm elsewhere randomly swapping the node with the adjacent one and repeatedly search for the solution. In the case of reach to an infeasible solution that is undefined firstly in the population, the simulator must leave this path and start again to search for other parents.

Table 1. Fitness variation through many network sizes depending on mutation probability

Trail	Network size (N)	Probabilistic of Mutation				
		Pm= 0.1	*Pm= 0.3*	*Pm= 0.5*	*Pm= 0.7*	*Pm= 0.9*
1	5	0.0856	0.0852	0.0852	0.0852	0.0852
2	10	0.1388	0.156	0.156	0.136	0.158
3	15	0.199	0.205	0.205	0.205	0.1745
4	20	0.2	0.2	0.2	0.2	0.1795
5	25	0.154	0.158	0.158	0.154	0.15
6	30	0.235	0.24	0.24	0.235	0.24
7	35	0.154	0.158	0.156	0.156	0.158
8	40	0.463	0.466	0.466	0.449	0.449
9	45	0.192	0.192	0.192	0.192	0.192
10	50	0.11	0.11	0.11	0.11	0.11

Because of the treatment duration have imperative in networking techniques to select the optimum path so that the time delay will be taking under consideration for the network applying.

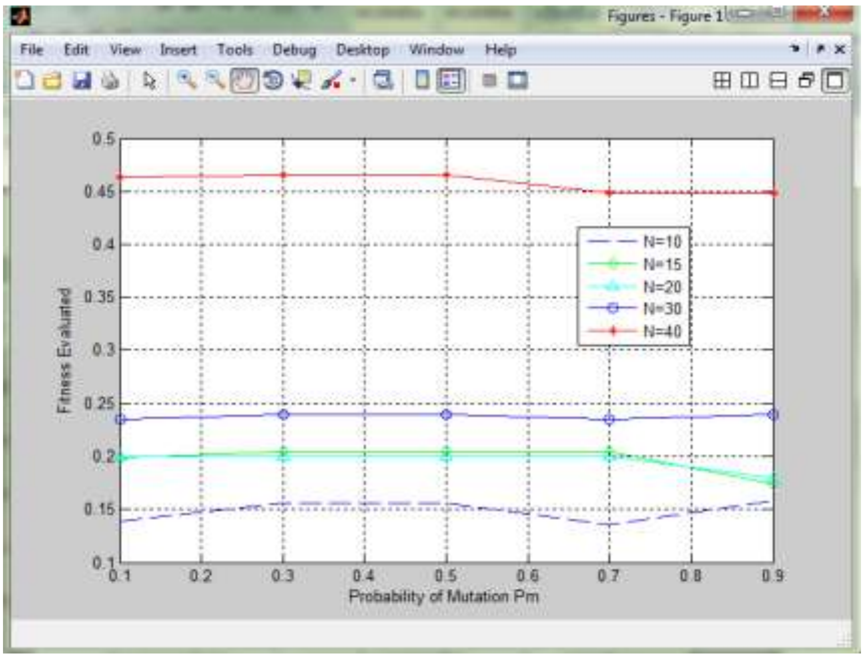

Figure 6. Comparison of Mutation Probability effect on Fitness value for different Networks size

The average processing time for several net sizes of the range [5,50] calculated in "Fig. 7", with trace to maximizing network size five node in each occasion (using the proposed above *Pm* values).

It was noticeable that the finest case of fastest response be *Pm*=0.1 which taking as a maximum 20 msec to find the shortest path while it's not convergence to goal every time as mentioned in "Fig. 6". Since this value of Pm have low fitness rate in some net size, while if *Pm*=0.9 was the slowest which is unacceptable in networking. Therefore for best logical decision to choose Pm value through interval [0.3, 0.7].

The simulator that has been programmed using JavaScript and figure out by MATLAB of average speed processor equal Cori5 (2.4 GHz), the processing time no more than 0.25 sec, therefore the processor that program this method to focus on the best path must be very higher in speed.

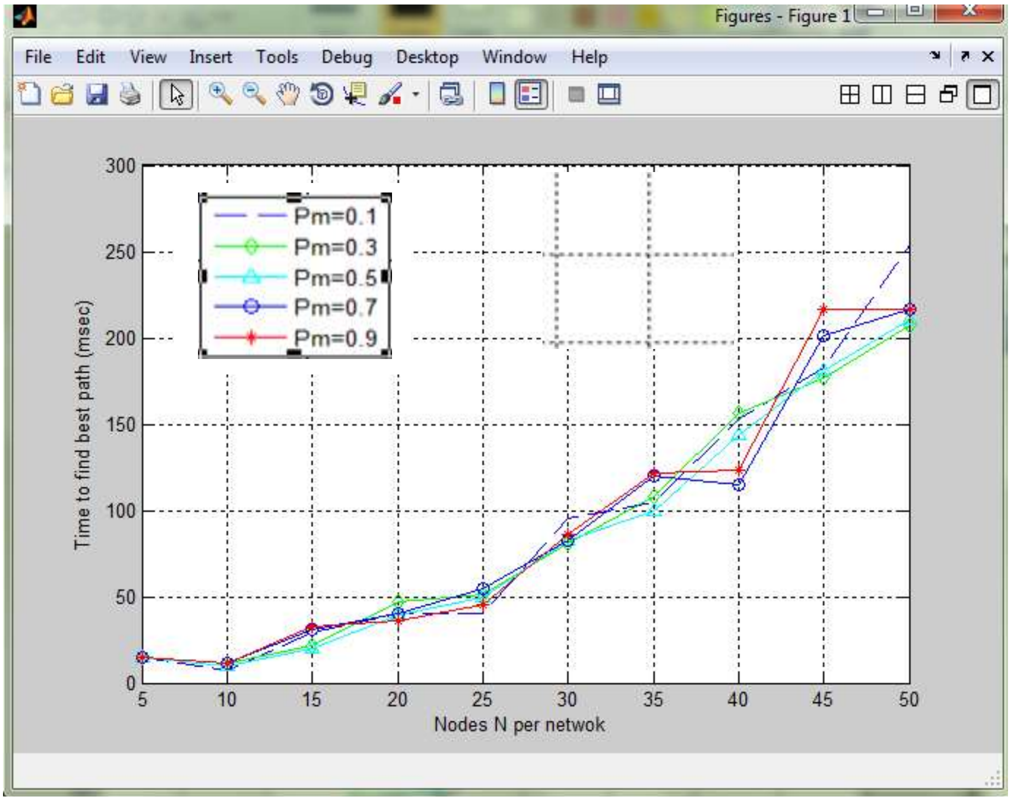

Figure 7. Average times to find shortest path of different network using GA

The delay period we consider very important to estimate the time needed to make a decision as well as to achieve the optimal way to pass data on the internet especially with current technology offers. Meanwhile, the fitness of each network wide have been calculated where as shown in "Fig. 6" no rapid jump in every net for different Pm ranges and the best probability of mutation when its middle value as possible that accomplish higher speed as in "Fig. 7". Due to the analysis of "Fig. 6" and "Fig. 7" there are a comparison between different Pm values accomplished for selecting best path on multiple network size as shown in "Table 2", while generally the average best fitness Pm was 0.5 for a network consist of {5,10,…50} nodes.

Table 2. Comparison between different Pm values to select best path

Probabilistic of Mutation (Pm)	Best path analysis
{0.1}	Diverting the network to the goal (shortest path finding) because of the low fitness values for most of a network size.
{0.3,0.5, 0.7}	Better performances due to the higher fitness calculation, and small average time evaluated the best path.
{0.9}	Slower in response, taking more time to finding the best path as compared with other Pm values in different network size.

5. Conclusions

The paper suggests GA to find shortest paths instead of Dijkstra algorithm in OSPF protocol in the casing of overloaded occurrence, didn't arriving of packet to destination or (and) if congestion figure out these problems have been overcome via GA, by jumping out of local minima points through analyzing all the paths firstly that's overcome the problem of Dijkstra's algorithm.

It was noticed that when the network gets complex it needs more time to search and the fitness depend on the path metrics values between source and destination.

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