HYBRID ROUGH GENETIC ALGORITHM FOR SELECTING OPTIMAL ROUTES

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Abstract:

Routing protocols in most networks use the length of paths or the minimum-hops that can be achieved, as the routing metric. This led to the motivation to propose a new algorithm that satisfies multiple constraints for finding a feasible path and apply GA to reduce the time taken to find a feasible path. To achieve this, The Rough sets Theory (RST) is applied to reduce the Performance metrics successfully and decide the most effective ones. ROSETTA software is applied to deduce a QoS metric as a substitution for all routing metrics. This metric is used to select the optimal routes. The results confirm that the proposed metric is adequately suit for selecting the proper routes. Then, Genetic Algorithms (GA) is used to select the optimal routes with new coding and new operators. The proposed Quality of Service Routing Genetic Algorithm (QoSRGA) has been tested on a subnet case study.

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I. INTRODUCTION:

The current Internet is essentially supports best effort traffic. The data packets may follow different paths to their destination [8]. These applications force the network service provider to guarantee QoS. QoS refers to the collective effect of service performance that determines the degree of satisfaction [14] for a user service. Routing policy is to find feasible paths that meet specific QoS requirements.

The Rough sets Theory (RST) [26] can be applied to reduce these metrics successfully and decide the most effective ones. In this work, RST is applied to reduce the on-line metrics that are reported by Routing Information Protocols (RIP). The instance represents information about network elements (NE's: links, or nodes) to obtain the Quality of Service (QoS) core [27]. ROSETTA software is used to calculate the reduct. This is important to speed up the processes of learning, evaluate and decide the route with the proper quality. The work presented here is based on deciding the link-rank by a series of the link-state attributions. In this paper, the QoS metric for routing QoSMR is evaluated for different QoS requirements based on actual traffic measurements. RST attributes' reduct is a subset of attributes that are sufficiently joint and individually express a particular property of the information table. This paper concludes metrics reduced to reach a QoS requirements RQoSR which represents the most effective performance metrics.

Many GA based routing algorithms have been proposed to solve a network routing protocol problem. Shortest path Algorithms between the source and destination nodes had developed by [11,24,28] and QoS routing algorithms had developed by [15,19,20].The drawback in all these existing algorithms has been the time taken to find a feasible path and the consideration of single or single mixed constraint while computing the feasible path. This has been the motivation to propose a new algorithm that satisfies multiple constraints for finding a feasible path and apply GA to reduce the time taken to find a feasible path. The process of solution encoding for this problem is a different, because the chromosomes must be expressed in a sequence manner to represent a path from a source to a destination. This results in unequal chromosomes lengths. Genetic operators must be carried in different manner. The process of solution encoding for this problem is a different, because the chromosomes must be expressed in a sequence manner to represent a path from a source to a destination. This results in unequal chromosomes lengths. This paper proposes QoS Routing Genetic Algorithm (QoSRGA) with new coding. The proposed algorithm has been tested on a subnet case study. The rest of the paper is organized as follows: Section 2, gives overview of QoS routing Section 3, illustrates the QoS evaluation function using RST. Section 4, gives detailed description for the proposed QoSRGA. Section 5, analyzes test condition concerning network routes. Finally, section 6, presents the main conclusion.

II. AN OVERVIEW OF QOS ROUTING:

Routing in the current Internet focuses primarily on connectivity and typically supports only the ‘‘best-effort’’ datagram service. The routing protocols such as OSPF [17], use the shortest-path routing paradigm, where routing is optimized based on static metrics such as hop count or administrative weight. Some services such as IP telephony, video on-demand and teleconferencing, require stringent delay and bandwidth guarantees. The ‘‘shortest paths’’ chosen for the best-effort service may not have sufficient resources to provide the requisite service for these applications. Moreover, with explosive growth of Internet traffic, the shortest-path routing paradigm of current Internet also leads to unbalanced traffic distribution. Links on frequently used shortest paths become increasingly congested, while links not on shortest paths are underutilized [25].

QoS routing involves selection of paths for flows based on the knowledge at network nodes about the availability of resources along paths [14], and the QoS requirements of flows. Several QoS routing schemes have been proposed that differ in the way they gather information about the network status and select paths using these information. Most of these schemes can be categorized as best path routing where a source node selects the ‘‘best’’ path for each incoming flow based on its current view of the global network status. It has been shown that best path routing schemes require frequent exchange of network state, imposing both communication overhead on the network and processing overheads on the core routers. QoS based routing has been proposed [10] as a way to address these issues. A specific QoS can be guaranteed, regarding flow, and network state. It sends a setup request to reserve the requested bandwidth along the path. This request is accepted and the flow is admitted if sufficient bandwidth is available at all links along the path. Otherwise the request is rejected and the flow is blocked, i.e., no attempt is made to reroute the flow. The goal of a QoS routing scheme is then to minimize the overall flow blocking probability. A survey of various QoS routing schemes can be found in [9]. In QoS routing, some knowledge regarding the global network QoS state is crucial in performing judicious path selection. This knowledge can be obtained through a periodic information exchange among routers in a network. Under best-path routing approach, each router constructs a global view of the network QoS state by piecing together the QoS state information, obtained from other routers, and selects the ‘‘best path’’ for a flow based on this global view of the network state. The best-path routing approaches are various QoS routing schemes [5,6,12,13,18] based on QoS extensions to the OSPF routing protocol. Best-path routing schemes work well when each source node has a reasonably accurate view of the network QoS state. However, as the network resource availability changes with each flow arrival and departure, maintaining an accurate view of the network QoS state is impractical, due to prohibitive communication and processing overheads entailed by frequent QoS state information exchange. In the presence of inaccurate information regarding the global network QoS state, best-path routing schemes suffer degraded performance. When solving the route computation problem, several attributes and metrics need to be considered. Depending on the desired performance, each attribute and metric either enters as a parameter in the algorithm`s to be minimized, or is used as a constraint to eliminate solutions that do not meet practical limits. Some of these metrics are: Delay, Delay variation, Bandwidth, Authentication , Bit error ratio, Throughput, Hop count, etc.. QoS can be defined as the ability of the network to provide better or "special" service to a set of users. QoS routing tries to select a path that satisfies a set of QoS constraints, while also achieving overall network resource efficiency. Several experimental evidences [8] show that there are usually multiple-minimum hop-count paths, many of which have poor throughput. As a result, minimum-hop-count routing often chooses routes that have significantly less capacity than the best paths that exist in the network. Much of the reason for this is that many of the links between nodes have loss rates low enough that the routing protocol is willing to use them, but high enough that much of the capacity is consumed by retransmissions. These observations suggest that more attention must be paid to link quality when choosing the routes; Almes, et al.

[2,4] use single metric. She uses one-way delay metric, one way packet loss metric or round-trip delay metric. Wang and Crowcroft [27] prove that finding a shortest path in a network with multi-dimensional metrics is NP-complete, they choose that bottleneck bandwidth and propagation delay as the routing metrics. Since bottleneck bandwidth and propagation delay reflect some fundamental characteristics of a path width and the length respectively. Besides, they defined the precedence as bottleneck bandwidth and then propagation delay. This because the lack of bandwidth may have more severe consequences than the lack of overall delay. This contradicts that the delay is comparatively more important than the other metrics. Moreover, the precedence of bottleneck bandwidth and propagation delay is somehow application-dependent. However, in order to support a wide range of QoS requirements, routing protocols need to have a more complex model. The network is characterized with multiple metrics such as bandwidth, delay, jitters, loss rate, authentication, security,…etc. This complex model necessitates a long time to proceed.

III. QOS EVALUATION FUNCTION USING RST:

Routing protocols usually characterize the network with a single metric such as hop-count or delay [2,4], and use shortest path algorithms for path computation. In order to support a wide range of QoS requirements, routing protocols need to have a more complex model where the network is characterized with multiple metrics such as bandwidth, delay and loss probability. The basic problem of QoS routing is then to find a path that satisfies multiple constraints. As current routing protocols are already reaching the limit of feasible complexity, it is important that the complexity introduced by the QoS support should not impair the scalability of routing protocols. The problem of QoS routing is not a trivial one and finding a feasible path with multiple independent path constraints is a NP-complete (Nondeterministic Polynomial time) problems [27].

The paper, proposes a general purpose metric QoSMR that evaluate the network performance. This metric sort the best paths regarding the on-line information about network characteristics. The QoSMR concludes many parameters, the RST is applied to reduce number of parameters and calculate a core metric. Usually, the link is classified by many parameters such as link propagation delay, available bandwidth, jitters, possibility of connection, effective load, queue length, and hop-counts [7]. While the node is classified by processing delay (segmentation and assembly), delay jitters, possibility of connection, effective load, queue length, and traffic check for accessibility. Concluding these metrics consumes a long time to decide the best route. So, the Reduced QoS for Routing (RQoSR) is a significant one. The decision system that produces a reduced performance attributes, is very important for data analysis and knowledge discovery. ROSETTA software is used to calculate the reduct [23]. This is important for speeding up the processes of learning, and deciding the route with the proper quality. In this work, the QoSMR is evaluated under different QoS requirements based on actual traffic measurements. RST attributes' reduct is a subset of attributes that are sufficiently and individually express a particular property of the information table. Measured values of the attributes have been collected for the described subnet which was proposed by Y. Liu et al.[16] shown in Fig. 1. The number on the link denotes link-num. Routes are identified by the link's attributes: available bandwidth, propagation delay, link jitter, bit described by I, II, ..., VI based on historical routing data. error ratio and connection possibility. We presume the link rank to be the core of classification, it can be The routing metric QoSMR will help in selecting the best path from A to D with the QoS attributes.

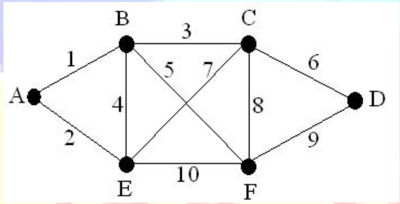

Fig. 1. A Subnet , Case Study

Information about the available bandwidth AB, propagation delay, link jitter, bit error ratio and connection possibility are gathered for each link. The application starts with an appropriate discrimination of the IS by translating the values to attributes $\{a1, a2, . . . ,a5\}$ and decision attribute $\{d\}$. Then, condition attributes and the decision attribute are coded. The condition attributes and the decision attribute are coded into number of qualitative terms, such as: very low, low, high and very high. The qualitative terms of the condition attributes are then coded using natural numbers, whereas, the qualitative terms of the decision attribute is coded into ranks that can be described by I, II, ..., VI . The coded IS is given in Table**1.**

Table 1. Information System of Links

Link no.	AB (c1)	Propagation delay (c2)	Link Jitter (c3)	Bit error tatio (c4)	Connection Possibility (c5)	Link rank {d}
1	4	4	1	5	3	IV
2	5	3	1	8	2	III
3	1	4	3	5	3	IV
4	1	4	3	5	1	VI
5	6	2	2	3	2	II
6	3	4	3	5	1	IV
7	5	1	1	3	1	V
8	3	1	0	3	3	I
9	7	5	4	1	3	III
10	8	1	1	2	3	I

The next relation is a proposed value for determining QoS for the route according to metric composition rules [7].

$$\mathbf{QoSMR = Max_j\ (Min\ (BW_i\ ) + Min\ (CP_i\ ) + (1/ \sum D_i\ ) + (1/ \sum J_i) + (1/ \prod BER_i))} \qquad \mathbf{(1)}$$

For every link i in the route j. This relation includes the main factors that affect the decision to identify the optimal route. This may necessitate many operations to compute the value of QoS, which must be computed for all routes between each node pair. So we have to reduce these parameters to reduce the time to decide the optimal route.

The next step of the RST is to construct minimal subsets of independent attributes, ensuring the same quality of classification, as with the whole set. ROSETTA software system [22] has been used in reducing the IS. ROSETTA supports the overall process: From preprocessing of the data, to reduct computation and rule synthesizing. Applying ROSETTA to the described IS in table 1, as shown in Fig. 2, these attributes are reduced as shown in ROSETTA case study in Fig. 3.

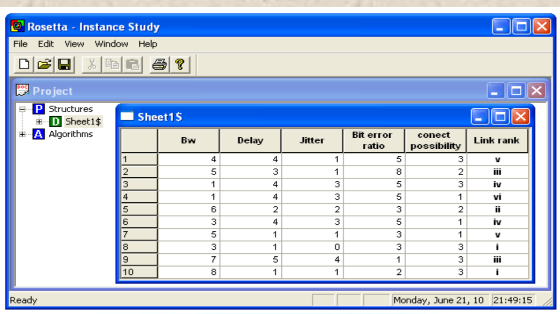

Fig. 2. The ROSETTA IS

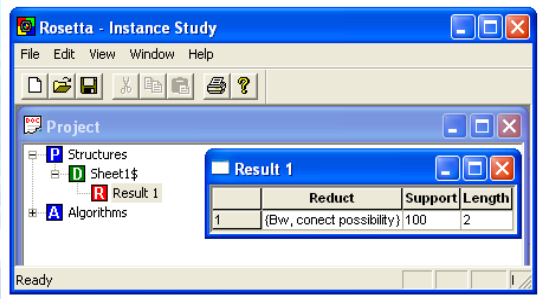

Fig. 3. The reduct computed by ROSETTA

Thus, table 1 can be reduced to form table 2.

Table 2.The Reduced Information Table for Table 1.

Link Num.	AB (c1)	Connection Possibility (c5)	Link rank {d }
1	4	3	IV
2	5	2	III
3	1	3	IV
4	1	1	VI

5	**6**	**2**	**II**
6	**3**	**1**	**IV**
7	**5**	**1**	**V**
8	**3**	**3**	**I**
9	**7**	**3**	**III**
10	**8**	**3**	**I**

Analysis of Results:

Each row in this table describes one elementary set, where the whole table describe the studied IS. The notation U/A means that we are considering elementary sets of the universe U in the space A, .i.e corresponding to the whole set of attributes {c_1,c_2,c_3,c_4,c_5}. Let us group all the five characteristics considered in table 1, as shown in Table 3.

Table 3. The Elementary Sets of U/A

U/A	c_1	c_2	c_3	c_4	c_5
{x_1}	4	4	1	5	3
{x_2}	5	3	1	8	2
{x_3}	1	4	3	5	3
{x_4}	1	4	3	5	1
{x_5}	6	2	2	3	2
{x_6}	3	4	3	5	1
{x_7}	5	1	1	3	1
{x_8}	3	1	0	3	3
{x_9}	7	5	4	1	3

$\{x_{10}\}$	8	1	1	2	3

The ROSETTA results in Fig.3, indicate that the most important attributes are $\mathbf{c_1}$ and $\mathbf{c_5}$ as shown in table 2. The indiscernibility is limited to the subset B= $\{\mathbf{c_1}, \mathbf{c_5}\}$, the resulting elementary sets are shown in Table 4.

Table 4. The Elementary Sets of U/B

U/B	c1	c5
{x1}	4	3
{x2}	5	2
{x3}	1	3
{x4}	1	1
{x5}	6	2
{x6}	3	1
{x7}	5	1
{x8}	3	3
{x9}	7	3
{x10}	8	3

It is inherent that table 3, gives the same information of table 4 but with reduced attributes. This conclusion is shown in table 5, i.e removing attributes $\mathbf{c_2}$, $\mathbf{c_3}$ and$\mathbf{c_4}$, we obtain the information system identical with that presented in Table 3.

Table 5. The Conclusion of Tables 3 and 4

Removed attribute	C_2, C_3, C_4
Number of elementary sets	**10**

Elimination of the superfluous attributes results in a simplified information set. This result in

Reduct (A) = $\{c_1, c_5\}$,

which are the most significant one`s for classification and therefore, it cannot be eliminated from the set of attributes without decreasing the approximation quality of classification.

Aaccording to metrics reduction described by equation (1), the reduced QoS metric for routing is as:

$$\mathbf{RQoSR = Max_J(Min\ (BW_i + CP_i\ ))} \qquad \mathbf{(2)}$$

∀ links i within the route j. Accordingly, the two metrics, BW and Connection possibility can supersede the QoS metrics presented by IS. The considered RQoSR metric can be employed as a fitness for routing. We can candidate the maximum three routes that accomplish the maximum RQoSR values. The route with maximum RQoSR is chosen as the optimal route. The route with the second RQoSR value is chosen as the Alternative route, and the route with the third value is chosen as the Risky route.

IV. THE PROPOSED QOSRGA:

GA is a global optimization technique derived from the principle of nature selection and evolutionary computing or technique. GA has been theoretically and empirically proven to be robust search technique. Each possible point in the search space of the problem is encoded into a representation suitable for applying GA. GA transforms a population of individual solutions, each associated with a fitness value into a new generation of the population, using the Darwinian principle of the survival of the fittest. By applying genetic operators such as crossover and mutation, GA produces better approximations to the solutions. At each iteration, the process of selection and reproduction creates a new generation of approximations.

Many GA based routing algorithms have been proposed to solve the network routing problem. B. Gonen [11], N. Selvanathan and W. J. Tee [24] and C. WookAhn and R. S. Ramakrishna [28] had developed GA algorithms that identify the shortest path algorithms between the source and destination nodes. R. Leela and S. Selvakumar [15], M. R. Masillamani et.al [19] and M. Munetomo, Y .Takai, and Y. Sato [20] also developed GA algorithms that identify the QoS routing algorithms.

The drawback in all these existing algorithms has been taken to find a feasible path considering a single or mixed constraint (s) for computing the feasible path. This has been the motivation to propose a new algorithm that satisfies multiple constraints for finding a feasible path and apply GA to reduce the time taken to find a feasible path. This paper develops a genetic algorithm to solve the QoS routing problem. The most critical task for developing a GA is how to encode a path from source to destination into a chromosome; genetic operators have been carried in a different manner. Genes must be expressed in a sequence manner to represent a path from a source to a destination. Besides, chromosomes may be of different lengths. For this, Value Coding method has been used for representing the paths. Crossover operation carried out in a different manner; combination is performed based on the parts values, contrary to traditional crossover which based on random combination, this replaces mutation operation. The evaluation function takes a path in the population. It gets the QoS associated to each link between each node pair in the path, using the RQoSR, the RQoSR associated to each link between each node pair is shown in Figure4.

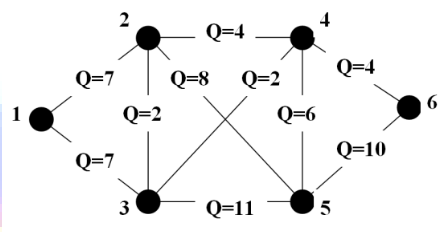

Fig. 4. Subnet case study with RQoSR associated to each link

The steps of QoS Routing Genetic Algorithm (QoSRGA) are explained in the following section.

A. Initialization of Chromosomes

For the problem of path encoding , genes must be expressed in a sequence manner to represent a path from a source to a destination. Chromosomes may be of different lengths. A gene is the GA's representation of a single node in the path.

Chromosome $1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 6$.

By this coding method the length of each chromosome is not same and the genetic operations are carried out. To explain the encoding procedure of the subnet case study in Fig. 4, assuming node

1 is the source node and 6 is the destination. Table 6 gives the gene coding for the proposed network.

Table 6: Gene coding

Gene 1	Gene 2	Gene 3	Gene 4	Gene 5
1	2	3	4	6

When initializing the population, the algorithm starts from the SOURCE. SOURCE is a constant in the program, so the network administrator may pick another node as a starting point. The algorithm selects one of the neighbours see Table7, provided that it has not been picked before.

Table 7: Adjacency matrix

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
Neighbours	2	3	2	2	3	4
	3	5	1	3	2	5
	0	1	5	5	4	0
	0	4	4	6	6	0

It keeps doing this operation until it reaches to DESTINATION. DESTINATION may also be changed. A Population of initial chromosomes, is given in Table 8

Table 8: Initial population

Population	**Chromosome 1**	**1 2 4 6**
	Chromosome 2	**1 3 5 6**

	Chromosome 3	1 2 3 4 6

B. Evaluating the fitness of each individual in the population

The RQoSR of a path indicated by the chromosome is used to calculate its fitness. It gets the RQoSR between each node pair as in table 9.

Table 9: Quality array between each pair in the network

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
Node 1	999	7	7	999	999	999
Node 2	7	999	2	4	8	999
Node 3	7	2	999	2	11	999
Node 4	999	4	2	0	6	4
Node 5	999	8	11	6	999	10
Node 6	999	999	999	4	10	999

In this table, the cells with 999 represent that there is no direct link between those nodes. Because, 999 is too big compared to other small qualities, therefore the implementation ignore those values. The fitness function used in this algorithm is RQoSR given by equation (2).

C. Chromosome Selection

Chromosomes are selected from the initial population to be parents. According to Darwin's evolution theory the best one should survive and create new offspring. There are many methods available for selecting the chromosomes such as roulette wheel selection, steady state selection, tournament selection, elitism selection, [18]. In this paper, the elitism selection method is used. Elitism is the method, which copies the best chromosomes to new population. The chromosomes are selected for genetic operation by sorting the chromosomes in the initial population by their fitness value and then selecting the first two in the list. Table 10 represents the sorted and selected list of chromosomes for the given example.

Table 10: Sorted chromosomes

Route no.	route	Fitness
1	1→3→5→6	7
2	1→2→4→6	4
3	1→2→3→4→6	2
4	1→3→2→5→6	2

D. The Crossover Operation

Crossover Operator is carried out in the next manner, with some probability, the program mates the two individuals as shown in Fig.5.

Fig. 5. Two individuals chromosomes to mate

Next, seek for a common point in the two parents; the common nodes are where these two paths intersect. Among the common points, the program selects one of them randomly. It makes the crossover from that point which might be at different locations as shown in Fig. 6.

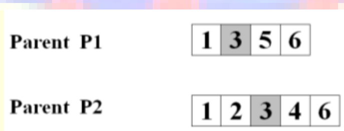

Fig 6.The Point selected for crossover

After that, a combination is performed based on the parts values, contrary to traditional crossover which based on random combination, this replaces mutation operator, as shown in Fig. 7.

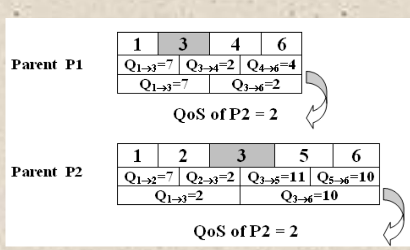

Fig. 7.QoS of the before and after cross point

Then, swapping is performed after common point; we get results in Fig8.

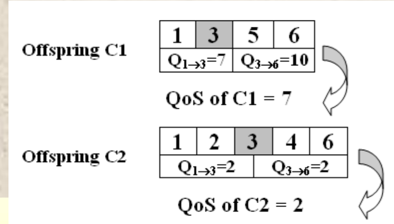

Fig 8.Offsprings obtained

Finally, scans for repeated nodes. After crossover has been achieved; children are checked to determine whether each string has repeated number. If so, the part of string between the repeated numbers is omitted. Some correction then required because it might be the case that the child is not admissible solution or a repeated chromosome. The new offsprings are sent to the evaluation function to get their fitness. Individuals always adjusted in increasing of fitness order. So, the algorithms keeps the best ones and worst individuals are deleted. The terminating condition is a predefined number of iterations , regarding number of nodes , the maximum path length. There reason is that in the network topology, the goal is to find a path with a reasonable QoS in a limited time.

E. The Pseudo-code

The code of the proposed algorithm Shown inFig. 9.

BEGIN

Initialize *the start and destination points*

Generate *randomly the initial population using the connectivity of the network*

While *(Destination not reached)* ***DO***

  Evaluate *the fitness for each chromosome in current population using equation (2)*

  Rank *the population using the fitness values*

__Eliminate__ the lowest fitness chromosome

__Keep__ the highest fitness chromosome

__Apply__ crossover process between current parents, keeping the start and end nodes without change

__Generate__ the new population

END while

save the best individual found

END

Fig. 9.Pseudo-code of the Proposed Algorithm

V. ANALYZING TEST CONDITIONS CONCERNING NETWORK ROUTES:

The proposed GA has been tested on a subnet with 6 nodes and 10 links to test the proposed technique. Each link has a quality value associated with it. The proposed GA could find a path between source and destination with the highest RQoSR value. Table 9 show output results regarding number of iterations until reaching new and unique chromosomes.

Table 9: Routes Generated

Initial population		
[1]	route:1→2→3→5→4→6	fitness=2
[2]	route:1→3→2→4→6	fitness=2
[3]	route:1→2→4→6	fitness=4
[4]	route:1→3→4→5→6	fitness=2
Iteration number (1)		
[1]	route:1→2→4→6	fitness=4

[2]	route:1→2→4→5→6	fitness=4
[3]	route:1→2→3→5→4→6	fitness=2
[4]	route:1→2→3→5→6	fitness=2
Iteration number (2)		
[1]	route:1→3→5→6	fitness=7
[2]	route:1→2→4→6	fitness=4
[3]	route:1→2→4→5→6	fitness=4
[4]	route:1→2→3→5→4→6	fitness=2
Iteration number (3)		
[1]	route:1→3→5→6	fitness=7
[2]	route:1→2→4→6	fitness=7
[3]	route:1→2→4→5→6	fitness=4
[4]	route:1→3→5→4→6	fitness=4
Iteration number (4)		
[1]	route:1→3→5→6	fitness=7
[2]	route:1→2→5→6	fitness=7
[3]	route:1→2→4→6	fitness=4
[4]	route:1→2→4→5→6	fitness=4
Iteration number (5)		
[1]	route:1→3→5→6	fitness=7
[2]	route:1→2→5→6	fitness=7
[4]	route:1→2→4→6	fitness=4

Iteration number (6)		
[1]	route:1→3→5→6	fitness=7
[3]	route:1→2→5→6	fitness=7

The results show that optimal solution is the route **1→3→5→6** and the alternative is **1→2→5→6** see Fig. 9.

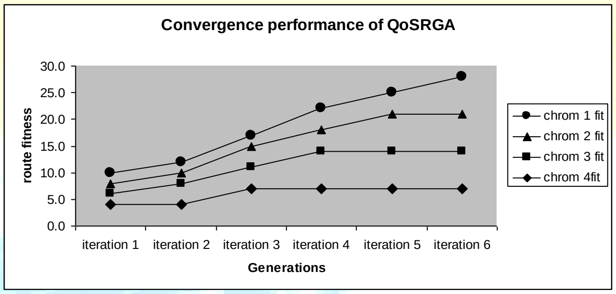

Fig. 9.Convergence performance of QoSRGA

Table 10 shows the average of maximum numbers of 6 runs, the average of minimum numbers of 6 runs, and the average of average numbers of 6 runs.

Table 10: The Average Max, Average and Min of Runs

Average of 6 runs			
Iterations	**Average of Max fit**	**Average of Avg fit**	**Average of Min fit**
iteration 1	**4**	**6**	**2**
iteration 2	**4**	**4.25**	**2**
iteration 3	**7**	**11**	**2**
iteration 4	**7**	**11**	**4**
iteration 5	**7**	**12.5**	**4**
iteration 6	**7**	**14**	**7**

Average of 6 runs illustrated by Fig. 10.

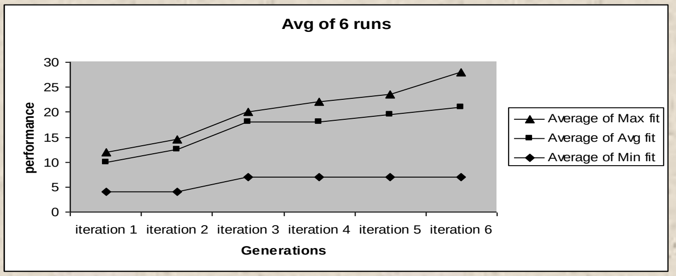

Fig. 10.Average values of runs

The alternative route is selected and used, in case of instantaneous traffic problems with the optimal route. **Risky route** is selected in case traffic problems with optimal and alternative routes. Traffic problems may be: network congestion, spatial fail, or spatial spam flood. Alternative path routing[18] has been well-explored in telecommunication networks as a mean of decreasing the blocking rate and increasing network utility. Table 11, indicates the computed values for QoSMR and the RQoSR for the eight routes available for the subnet of Fig. 1.

Table 11. Values of QoSMR and RQoSR for Subnet, Fig. 1

Route no.	route	QoSMR	RQoSR
1	A→E→F→D	7.3395	7
2	A→B→F→D	6.294	6
3	A→E→C→D	4.3333	4
4	A→B→C→D	2.334	2
5	A→B→E→C→D	2.203	2
6	A→B→E→F→D	2.2021	2
7	**A→E→B→F→D**	**2.1793**	**2**
8	A→E→B→C→D	2.167	2

In this table, route no. 1 is the optimal route, no. 2 is the alternative route and no.3 is the risky route. It is apparent that the optimality states of both QoSMR and RQoSR are at the same routes, i.e. they select the same route.

Network protocols which compensate packet loss, propagation delay, and jitters, keep the same network state, even after reducing these metrics. Thus, networks using the proposed protocol RQoSR can exhibit same state under the same level of load, with the difference in the computing time for route decision. Fig. 11.indicates that both QoSMR and RQoSR have maximum value for the same route, this results in selecting the same route. This is accomplished also for both alternative and risky routes.

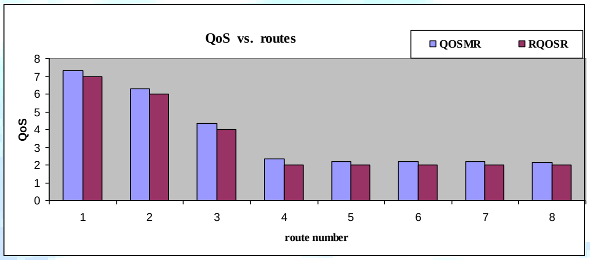

Fig. 11.The Optimal Routes using QoSMR and RQoSR

Fig. 12. indicates that BER, Jitter have little effect than Delay, BW and CP. The effect of Delay is little than the effect of BW and CP. These two attributes form the effective value in RQoSR and QoSMR.

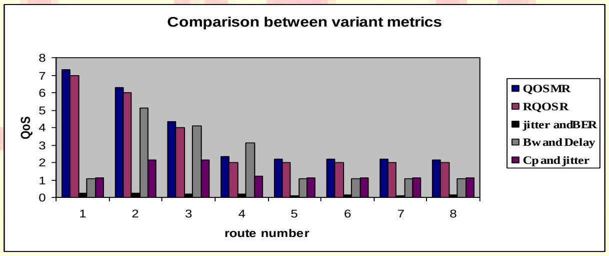

Fig. 12.**Comparison between Effects of Metrics**

By comparing the proposed algorithm with the algorithms of the standard routing protocols on a subnet case study. The instance proved that the proposed algorithm is good at selecting the best routes in network with a higher QoS than that of standard routing protocols[24,26]. Fig. 13, indicates that the proposed QoSRGA, IGRP and EIGRP in selecting routes are alike. IGRP has less QoS in selecting routes as a result of not considering connection possibility, admissibility, access control, sustainability, authorization, and authentication since access can be granted or denied according to a wide variety of criteria. Traffic sometimes may be not allowed to be transit over a specific element. IGRP not considers jitter which is important to know maximum latency and minimum latency to resend packets. EIGRP neglected the connection possibility, admissibility, access control, sustainability, authorization, and authentication which resulted in a bit lack in its QoS. BGP disregarded both bandwidth and connection possibility metrics, however they are crucial in selecting routes and neglecting them results in insufficient QoS requirements. Both OSPF and RIP considers a single metric which in not sufficient at all to satisfy the QoS requirements.

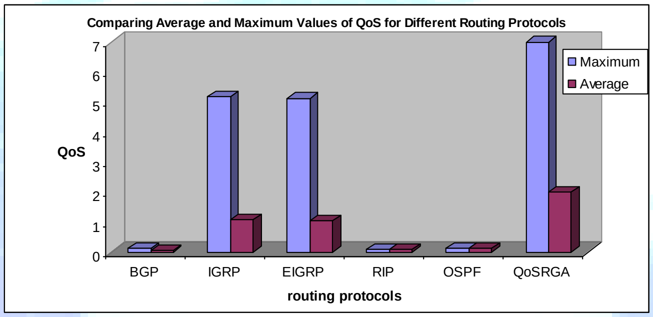

Fig.13.Comparison between The Proposed Protocol and The Standard Routing Protocols

VI. CONCLUSION:

The proposed technique for QoS routing based on RST has been presented in this paper. RST reduced metrics successfully and decided the most effective ones. ROSETTA software is applied to deduce a QoS metric as a substitution for all routing metrics. This metric is used to select the optimal routes. The results confirm that the proposed metric RQoSR is adequately suit for selecting the proper routes as in Fig. 11. It is evident that the RQoSR is adaptive, flexible and universal metric to be considered. GA's is used to select the optimal routes. The proposed QoSRGA with new coding operations based on the suggested metric is intelligent enough to make a fast decision. The solution is self-adaptive and the optimal quality is reached after few steps. The proposed algorithm has been tested on a subnet case study. Comparing the results attained by the QoSRGA and other used routing protocols; the results show the QoSRGA is much higher. The instance proved that the method is good at selecting the best route in network. This routing algorithm is supposed to be used by the network management protocol to decide the optimal route based on the current on line characteristics of NET`s.

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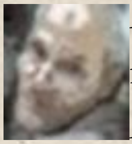

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