QOS ROUTING PROTOCOL USING GAS

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Abstract:

Routing protocols in most networks use the length of paths or the minimum-hops can be achieved, as the routing metric and the QoS requirements. 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. This paper explores the potential of using genetic algorithm to solve the QoS routing protocol problem. The most critical task for developing a genetic algorithm to this problem is how to encode a path into a chromosome; new coding method has been used with new genetic operators. The evaluation function carried out using Reduced QoS Routing (RQoSR) evaluated by Ali A Sakr et.al. The proposed approach has been tested on a subnet case study. The experimental results are very encouraging and the algorithm can find the optimum solution rapidly.

Keywords: GAs, QoS, QoSRGA , RQoSR.

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1. Introduction:

With the growth of the Internet, Internet Service Providers (ISPs) try to meet the increasing traffic demand with new technology and improve utility of the existing resources. Routing of data packets can affect network utilization. Packets are sent along network paths from source to destination following a protocol. Open Shortest Path First (OSPF) is the most commonly used intra-domain Internet routing protocol (IRP). Traffic flow is routed along shortest paths, splitting flow at nodes with several outgoing links on a shortest path to the destination IP address. Link weights are assigned by the network operator. A path length is the sum of the weights of the links in the path; recent findings have revealed that the minimum-hop metric can not achieve the QoS requirements because it tries to reduce the number of hops by containing long range links, where packets need to be transmitted in a way satisfying high performance. QoS refers to the collective effect of satisfaction of a user of the service. QoS routing is to find a feasible path that meets specific QoS requirements. However, to find a feasible path satisfying multiple constraints is NP-complete. Many GA based routing algorithms have been proposed solve a network routing protocol problem. Shortest path Algorithms between the source and destination nodes had developed by [1-4] and QoS routing algorithms had developed by [5-9]. 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 focus of this paper is to develop a genetic algorithm to solve the QoS routing protocol problem. The proposed algorithm finds feasible paths which satisfy multiple constraints requirement. The most critical task for developing a genetic algorithm to this problem is how to encode a path from source to destination into a chromosome; new coding method has been used and genetic operators have been carried in a different manner. Chromosomes 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. Accordingly crossover operator 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 operator. The evaluation function takes a path in the population. It gets the QoS associatedto each link between each node pair in the path, by using the Reduced QoS Routing (RQoSR) evaluated by Ali A Sakr et.al [10]. The proposed QoS Routing GA (QoSRGA) has been tested on a subnet case study. The results showed that genetic algorithm can find the optimal solution. The experimental results are very encouraging, and the algorithm is able to find the optimum solution. The rest of the paper is organized as follows: Section 2, illustrates the QoS evaluation function. Section 3, gives detailed description for the proposed QoSRGA. Section 4, summaries the results. Section 5, presents the main conclusion.

2. QoS Evaluation Function:

In [10], RST is applied to reduce the on-line metrics that are reported by Routing Information Protocols (RIP). The instance represents information about network elements (links, or nodes) to obtain the Quality of Service (QoS) core [11]. 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.

The work [10] proposes a general purpose metric **QoSMR**, which evaluates the network performance. This metric sort the best paths regarding the on-line information about network elements. 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 [12]. 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. This is important for speeding up the processes of learning, evaluation and deciding 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 [10], the QoSMR is evaluated under different QoS requirements based on actual traffic measurements; available bandwidth, propagation delay, link jitter, bit error ration and connection possibility. RST attributes' reduct is a subset of attributes that are jointly sufficient and individually express a particular property of the information table. **QoSMR** according to metrics reduction is reduced to:

$$RQoSR= Max_J(Min\ (Bw_i + Cp_i\ ))$$

∀ link i within the route j. Accordingly, the two metrics, Bw and Connect possibility can supersede the QoS metrics presented by IS. Subsequently, the considered **RQoSR** metric can be employed as a fitness for routing. Accordingly, we can candidate the maximum three routes that accomplish the maximum **RQoSR** values.

The route with maximum capacity of bandwidth and maximum possibility of connection 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**.

3. Implementation of GAs in Selecting Optimal Routes:

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 solve a network routing protocol problem. Shortest path Algorithms between the source and destination nodes had developed by [1-4] and QoS routing algorithms had developed by [5-9].

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 proposed algorithm has been tested on a subnet case study Figure 1.

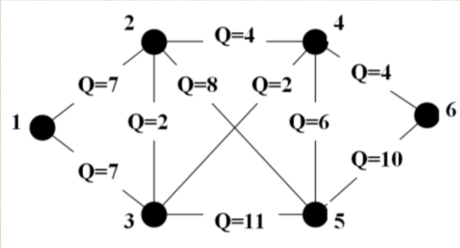

Figure 1: Subnet case study

The results showed that genetic algorithm can find the optimal solution. The experimental results are very encouraging, and the algorithm is able to find the optimum solution.

3.1 The proposed GA algorithm

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

3.1.1 Initialization of Chromosomes

Encoding is one of the problems found when GA is used for finding a solution. Encoding depends on the problem for which GA is applied. For the problem of path encoding Chromosomes 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.

A chromosome is subdivided into genes. 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 in different manner. To explain the encoding procedure, the subnet case study is given in Figure 4-8. Node 1 is the source node and 6 is the destination node. Table 1 gives the gene coding for the network in Figure 4-8.

Table 1: 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 user may want to pick another node as the starting point. The algorithm selects one of the neighbours see Table 2, provided that it has not been picked before.

Table 2: 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. Like SOURCE, DESTINATION is also a constant that user may change as they wish.

A Population of chromosomes, is given in Table 3

Chromosome 1 **1→2→4→6**

Chromosome 2 **1→3→5→6**

Chromosome 3 **1→2→3→4→6**

Table 3: Initial population

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

3.1.2 Evaluating the fitness of each individual in the population

The choice of a fitness function is usually very specific to the problem under condition. The evaluation function of a chromosome measures the objective quality of service function. The QoS of a path indicated by the chromosome is used to calculate its fitness. It gets the quality of service between each node pair in the path, by calling a function to read from the quality array see table 4. Composes them together and returns the overall quality of the path.

Table 4: 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 in them represent that there is no direct link between those nodes. Because, 999 is too big compared to other small qualities, therefore my implementation ignore those big numbers.

The fitness function used in this algorithm is the function that was computed and reduced using rough sets[10]

$$\textbf{RQoSR} = \textbf{Max}_J(\textbf{Min}\ (\textbf{Bw}_i + \textbf{Cp}_i\ )) \qquad \textbf{(1)}$$

Reduced quality of service routing, for every link i within the route j. where, Bw is the bandwidth capacity and Cp is the connection possibility.

3.1.3 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, etc. In this work, 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 5 represents the sorted and selected list of chromosomes for the given example.

Table 5: 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

3.1.4 New Crossover Operator

According to this problem, Crossover Operator is carried out in different manner.

With some probability, the program mates the two individuals as shown in Figure 2.

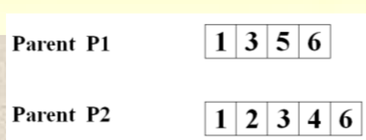

Figure 2: Two individuals chromosomes to mate

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 Figure 3.

Figure 3: The Point selected for crossover

After that, combination is performed based on the parts values, contrary to traditional crossover which based on random combination, this replaces mutation operator, as shown in figure 4.

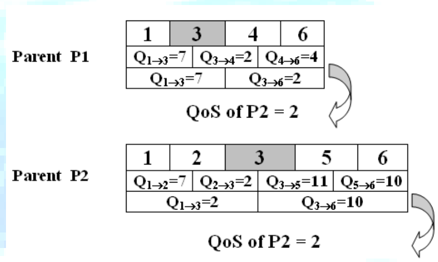

Figure 4: QoS of the before and after crosspoint

Then, swapping performed after common point; we get results in figure 5

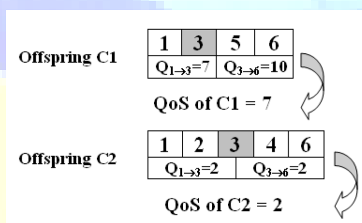

Figure 5: Offsprings obtained

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 cut off. Some correction then required because it might be the case that the child is not admissible solution.

3.1.5 Fitness ranking

The new offsprings are sent to the evaluation function to get their fitnesses. Individuals always adjusted in increasing of fitness order.

So that, the algorithms keeps the best ones and worst individuals are deleted.

3.1.6 Repeat Until <terminating condition>

The terminating condition is a predefined number of iterations. There reason is that in the network topology, the goal is not to find the global optimum, but to find a path with a reasonable QoS in a limited time.

3.2 The Pseudo-code

The pseudo-code of the proposed algorithm Shown if Figure 6:

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 (1)*

Rank *the population using the fitness values*

Eliminate *the lowest fitness chromosome*

Keep *the highest fitness chromosome*

Apply *crossover process between current parents, while keeping the start and end nodes without change in the population*

Generate *the new population*

END while

Output the best individual found

END

Figure 6:Pseudo-code of the Proposed Algorithm

4. Experimental Results:

The proposed Genetic Algorithm 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. I set two nodes as source and destination. The goal of GA application is to find a path between source and destination with the higher quality of service.

Table 6 show output results of undefined number of iterations until reaching new and unique chromosomes.

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

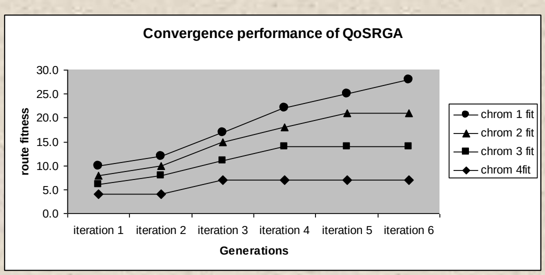

Figure 7: Convergence performance of QoSRGA

Table 7 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 7: 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 Figure 8.

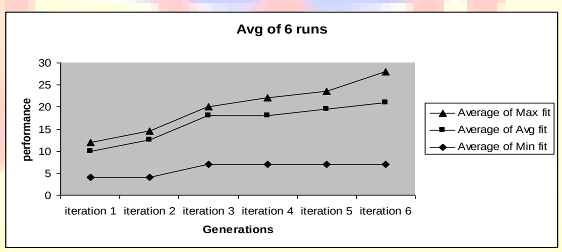

Figure 8: Average values of runs

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. Figure 9, 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.

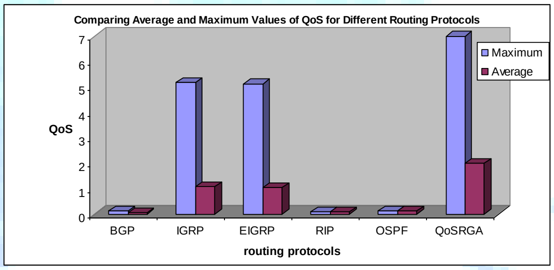

Figure 9: Comparison between The Proposed Protocol and The Standard Routing Protocols

5. Conclusion:

The complication of traditional solving schemes to QoS Routing is NP completeness. Genetic Algorithms (GAs) that uses the computational strategies inspired by natural processes is used to select the optimal routes. The proposed QoSRGA with new coding and new operators based on the suggested metric is intelligent enough to make a fast decision. 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 QoS for QoSRGA is much higher.The instance proved that the method is good at selecting the best route in network. The proposed routing algorithm is supposed to be used by the network management protocol to decide the optimal route based on the best current QoS. The current QoS as based on the online characteristics of network elements.

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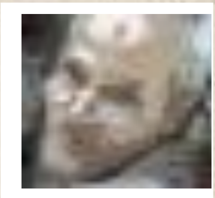

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