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**GJCST-E Classification :** C.2.2



QFSRD ORTHOGENESIS EVOLUTION BASED GENETICALGORITHM FOR QOS FITNESS SCOPE AWARE ROUTE DISCOVERY IN AD HOC NETWORKS

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# QFSRD: Orthogenesis Evolution based Genetic Algorithm for QoS Fitness Scope Aware Route Discovery in Ad Hoc Networks

M. L. Ravi Chandra <sup>α</sup> & Dr. P. Chandra Sekhar Reddy <sup>σ</sup>

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## I. INTRODUCTION

MANETs are wireless mobile Ad Hoc Networks that operate without any infrastructure, can be implemented quickly and are flexible to the connectivity and environment of the traffic and mobility patterns.

MANET is unlike a traditional wireless networks that have a wired network supporting them for providing data services to mobile users. The network can be setup anywhere for sharing data where there is no pre existing wired network. The applications of mobile Adhoc network vary such as, setting up a communications network in a local area for conferences, meetings, advertising, e-classes, media events, for communications used in battlefields, for telecommunication networks in traffic control [15], for communication in disaster recovery areas, etc.

In MANET the network communication is a peer-to-peer wireless connectivity between nodes with either a single hop between a mobile cell

and a base station or multi-hop wireless transmission without any base stations.

The nodes are mobile and act as hosts as well as routers. A node functions, as a host transmitting data to other nodes, as a destination node for receiving the data and also as a router for routing the data to other nodes.

The study in the field of routing in Mobile Ad hoc Networks has been extensive however is mostly based on the best effort data traffic [1, 2] that is not actually a Quality of Service. Similar studies based on QoS objective in wire line network routing [3, 4] devised algorithms for routing that face in MANETs implementation problems due to the networks dynamic topology and bandwidth constraints.

The increasing availability and use of mobile devices and requirement for wireless access of Internet, television, VOIP, multimedia audio/video, and especially real time audio and video streaming requires these services to be implemented in MANETs with Quality of Service (QoS) routing. The need for implementing MANETs is increasing parallel to the growth in access of mobile data.

The service quality is defined by efficiency of the data flow which can be measured with a set of constraints such as bandwidth, response time of service, end-to-end delay, interruptions, packet loss, etc.

In path discovery the algorithms for routing try to find a path having suitable QoS specified resources while minimizing the search, distance and traffic problems. A Mobile Adhoc network is depicted in the below Figure 1. A topology of a wireless paths is obtained from the Figure 1 and is depicted in the below Figure 2. The nodes that are mobile in nature are represented by A, B, C, K letters and the bandwidth available with the wireless links is represented adjacent to every edge with 1,2,3,4,5,6 numbers. If we require determining a path between source node A and destination node G, the path that is shortest according to a general technique of path finding would be "A-B-H-G". The selection of the QoS route is completely different from the general practice as criterions such as bandwidth etc are considered as QoS metric. If a path between node A and node G is required with minimum of 4 mbps bandwidth then path that is shortest "A-B-H-

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G” cannot offer the needed bandwidth and so the possible QoS aware path would be “A-B-C-D-E-F-G.”

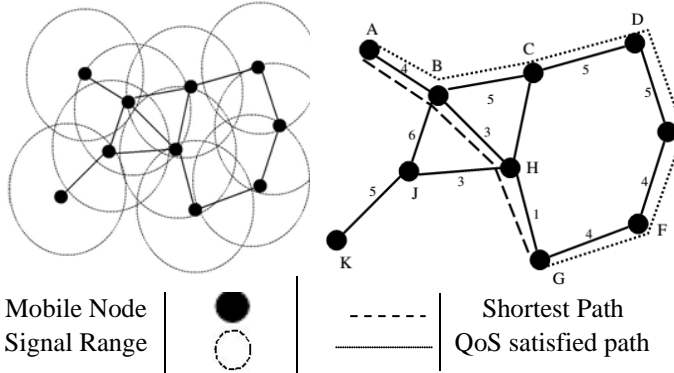


Figure 1 : An example Manet connectivity

The research work developed till date for QoS based routing of Mobile Adhoc Networks are, QoS models [5, 6], QoS resource reservation signaling [7], QoS Medium Access Control (MAC) [8], QoS scheduling [9], and QoS routing [10, 11, 12, 13, 14].

The complex QoS functionality involved in MANET implementation is limited by available resources and dynamic network topology. The flow could be inelastic i.e. uni or multicast, elastic involving TCP or the QoS may have multiple client requirements making the QoS routing very difficult [12, 14] as determined in previous research. In a dynamic environment as the nodes are mobile the addition and deletion of nodes makes the creation of routing paths very complicated. To handle the sudden changes affecting the MANET topology and delivering a multi-path QoS routing requires designing approximated solutions and efficient routing algorithms with various techniques and the latest techniques such as Fuzzy Logic (FL), Artificial Intelligence (AI), Neural Networks (NNs), Genetic Algorithm (GAs) etc.

In this paper an orthogenesis GA based QoS fitness scope aware route selection strategy for MANETs called QFSRD is presented. This technique is devised with the motivation gained from the earlier model called GA based routing method GAMAN [18]. The objective of the proposed model is, unlike GAMAN and other benchmarking models it should consider many QoS factors along with other contextual QoS metrics and also should achieve the optimality in evolution complexity. The performance of the method is assessed with simulations based tests in different network topologies.

The paper is structured as below. Section 2 shows the confirmed contemporary related work. The devised model is explored in Section 3. The results of the simulation tests are shown in the Section 4. The conclusions are finally presented in Section 5.

## II. RELATED WORK

In this section a review of the routing techniques based on QoS in MANETs are given as follows,

A QoS-aware routing path discovery approach called “ticket-based probing algorithm” by Nahrstedt et al [10] is based on controlling with a calculated number of tickets the total messages flooded in a route. A message for probing comprises of minimum one ticket and a message on arrival at a node if it does not contain only one ticket may be divided into several probes and routed to other nodes. In this way every child probe consists of tickets subset to its parent. The probe carrying the hop-by-hop path or the delay/bandwidth data is used in reserving the resources based on the QoS requirements. The developers of the ticket based algorithm have built the technique on an imprecise model. Unlike wire line networks, Mobile Adhoc networks are constantly affected by link breakages resulting in the information transmitted being of imprecise type. So for the ticket-based probing algorithm is based on a plain model of imprecise nature where the history and current (estimated) delay variations are computed to determine the current delay depicted in a range  $[\text{delay} - \delta, \text{delay} + \delta]$ . This algorithm applies route redundancy at various levels by including in route maintenance the techniques of path-repairing as well as re-routing. Here in the process, a node on detecting a path that is broken notifies the source node. The source node then uses the technique of path-repair for repairing the old path using local reconstructions. The transmission is rerouted with a new possible route while notifying the subsequent release of resources at the nodes existing between in the old route. Here unlike the technique of re-routing, a completely new path is not found and instead the approach attempts to adjust to the MANETs dynamic environment.

A routing approach based on QoS for Mobile Ad hoc networks of size in the range of small and medium called “Core Extraction Distributed Ad hoc Routing (CEDAR)” [11]. The CEDAR approach involves 3 main mechanisms. First, the Core Extraction mechanism selects a group of nodes based on the MANETs minimum dominating group or links having large bandwidth of stable nature, to create the core that manages the nodes local topology and computes the route based on the requirement and the state of local conditions. Next Link State Propagation mechanism distributes to all the core nodes the information of the bandwidth available with stable links. The routing based on QoS is attained by passing stable links related high-bandwidth information to distant nodes in the network and by containing dynamic links low bandwidth information in the area locally. Finally in the Route Computation mechanism, the computation of the path

Figure 2 : an example of QoS routing in Manet

establishes a core route from the source node domain to the destination node domain. This data of the core path is used to determine iteratively a partial route in the path that forms the core from the source to the farthest domain node possible in terms of the demanded bandwidth. In the next iteration this node acts as the source node.

In the strategy of CEDAR, the core mechanism offers a capable and cost effective platform for routing and the state propagation guarantees link-state information accessibility to core nodes with minimal expenses.

A protocol for routing given in [14] is built on QoS criteria and based on the estimation of the bandwidth. This bandwidth assessment is done by disseminating with "Hello" messages the information of the bandwidth. A contrast of two dissimilar approaches of bandwidth estimation is given here. When the criterion of bandwidth release is primarily essential, the functionality of the estimation method based on "Hello" bandwidth is efficient in comparison to the assessment approach based on "Listen" bandwidth. When the criterion of topologies of static nature using huge weight factors to minimize the congestion as well as the incorrect signaling of broken routes by lost "Hello" messages is considered the methods "Hello" and "Listen" show good functionality that is mostly same. When the criterion of mobile topology is considered "Hello" strategies functionality is more effective with respect to end-to-end throughput whereas the "Listen" strategies functionality is good with respect to the packet delivery ratio.

Genetic Algorithm-Based QoS Routing Protocol for MANETS (GAMAN) [18] for ad hoc networks is the most recent and best of its kind. The GAMAN is devised to identify optimal routes that are specific to two QoS factors called end-to-end delay and max transmission success ratio. The GAMAN is aimed to define QoS aware optimal routes for mobile ad hoc networks (MANETS). Under the impact of mobility, the Quality of Service is proportionate to the node connectivity. The GAMAN is based on single point crossover and mutation and fitness function is assessing only the end-to-end delay and max transmission success ratio. The GAMAN evolutions are elitist that maintains best fit route remains unchanged in further evolutions. The experimental results explored by the authors concluding that it is optimal and robust for sparse to lower range of dense size networks. Moreover the fitness assessment is specific to a particular QoS factor; hence the route discovery is not optimal in regard to other QoS factors. The elitist model is optimal, but evolutions count is not in control for networks with nodes having QoS metric values distribution with high skewness [20].

Leonard Barolli, Makoto Ikeda et al., [19] devised a novel local search optimization strategy, which is an extension to their earlier work GAMAN [18]

that referred as E-GAMAN. The devised search space reduction algorithm (SSRA) is mainly aimed to minimize the crossover complexity observed in GAMAN. So that the local search become much faster, hence the time taken for optimal route selection will be low and the GAMAN can find a feasible wireless path very fast. But the issue of considering the impact of QoS factors other than mobility remains same and the evolutions count is still not in control for networks with nodes having QoS metric values distribution with high skewness [20].

In a gist, almost all of these benchmarking models including GAMAN [18] are specific to one or two QoS factors. The GAMAN is also not confident when QoS metric values are distributed with high skewness [20]. Henceforth, here in this paper we devised a novel orthogenesis genetic algorithm for optimal QoS aware route selection for mobile ad hoc networks. Unlike GAMAN the said model is equally considering all QoS metric values to assess the fitness of the resultant route. Since the GA that considered is following orthogenesis approach and the statistical strategy used to fix the need and scope of further evolutions, the number of evolutions is in control, which leads to minimize the search space

### III. ORTHOGENESIS EVOLUTION BASED GENETIC ALGORITHM FOR QoS FITNESS SCOPE AWARE ROUTE DISCOVERY

Unlike the traditional GA, the proposed model is constructing new generations by progressive evolution strategy. The progressive evolution strategy generates the child elements having more fitness than one or both of the parent elements. Hence the number of evolutions can be limited. The other contribution in devised model is fitness assessment that considers the many metrics with equal priority and the same time not losing the influence of prime QoS metric such as energy efficiency, connectivity or bandwidth availability. The QoS fitness scope assessment strategy proposed in this paper is based on the QoS factors of route and their earlier allocation impacts, which are described below:

- A route can be rated best under a specific QoS factor, but might fail to deliver the same performance under the consideration of multiple QoS factors.
- A route can be rated divergently with respect to its various QoS factors. As an example, a route can be best with respect to bandwidth availability, but the same route might be moderate in terms of packet delivery ratio scope, worst in the context of end-to-end delay scope.
- The importance of the QoS factors might vary from one routing context to other.
- According to the impact of QoS factors of the routes described, it is evident that the best ranked route under single QoS factor is not always the optimal



towards ad hoc routing. The route that performed well under some prioritized QoS factors are always need not be the best fit under other prioritized QoS factors. In regard to this the devised QoS fitness scope aware strategy finds the best fit route, which is based on QoS fitness scope and one or more prioritized QoS factors opted. This process is labeled as QoS fitness scope evaluation. Further routes are ranked according to their QoS fitness scope and will be used in the same order to finalize a route towards selection and scheduling. The algorithmic exploration of the model proposed is follows:

- ✓ Input: All possible routes as routes set  $R$
- ✓ Fitness factors:
  - connectivity (+), bandwidth (+), end-to-end delay (-), reputation (+) , energy usage(-) and other metrics if any
- ✓ QoS Fitness Scope ( $qfs$ ) calculation:
  - The QoS factors that are optimal with high values are considered as positive factors
  - The QoS factors that are optimal with low values are considered as negative factors.
  - Initially normalize the QoS factors values such that all are optimal with high values...
  - To do that normalization of a negative factor will be  $\frac{1}{mv}$ , here  $mv$  is metric value
  - normalization of positive factor will be  $1 - \frac{1}{mv}$
  - Choose any of the QoS factor as prime factor, which is according to routing context
  - Extract all node to node connections as edges available for each input route.
  - Find QoS metric values of all these edges
  - Find QoS metric values of route, which are the mean of QoS metric values of all edges found in that route
  - Prune routes that are not justifying the prime QoS metric
  - Rank the rest available routes for each QoS factor (highest normal form of the QoS factor value will be ranked best in order)
  - Find variance between ranks of QoS factors for each connection (This indicates the discrepancy of the ranks), the distance of this variance value from 1 gives the nearness of these ranks, which we refer as QoS fitness scope ( $qfs$ ).
- ✓ Orthogenesis Evolution
  - Find crossover points of each pair of routes, which are common nodes in both routes
  - For each crossover point
    - Intersect these pair of routes at crossover point and form new route such that left part of the first route

connected to right part of the second route through the crossover point, and also form another route such that connect the right part of the first route to left part of the second using crossover point.

- Find  $qfs$  of these two new routes and verify that the  $qfs$  of the new route is greater than the  $qfs$  of any of the parent, if so accept that, if not discard that route.
  - New routes if any, add to routes set  $R$
  - Prune the unqualified routes from '  $R$  ', which is based on the prime QoS factor.
  - Continue the above Orthogenesis evolution process for max evolution threshold given.
  - Verify the kurtosis of the  $qfs$  distribution among the resultant routes, if kurtosis is leptokurtic, and then continue Orthogenesis evolution for next max evolution count given. If kurtosis is mesokurtic or platykurtic then stop evolutions and select  $n$  number of routes from the resultant routes set  $R$

The QoS metrics of each edge between hop level nodes of route are considered to assess the best fit route and these metric are categorized as positive and negative, which is based on their value. The metrics with desired value as high referred as positive metrics and the metrics with desired value low are referred as negative metrics. The scope of the described metrics is assessed against the transmission of  $n$  packets. These metrics are described below.

- Connectivity (+) = Due to the factor of mobility, the connectivity between the nodes is a sensitive metric towards QoS aware Routing. This is appositive metric, since connectivity with high value is desirable. This metric can be assessed as follows

$$cs(e_i) = pct(e_i) - rct_n(e_i)$$

Here in the above equation  $pct(e_i)$  is representing the possible lifetime (this decides by the nodes mobility direction and speed) of edge  $e_i$  and  $rct_n(e_i)$  representing the required connected time for  $n$  packets transmission.

- Bandwidth compatibility (+ve metric): This factor is also one of the prime QoS factors, since the sufficient bandwidth is essential to perform routing with minimum guarantee. It comes under either positive. The bandwidth available at a route must be greater than the required bandwidth of the current transmission requirements. The measuring of bandwidth compatibility is as follows:

$$bc(e_i) = ba(e_i) - br(e_i) \dots \dots \dots (8)$$

- o Here in the above equation  $bc(e_i)$  is indicating the bandwidth capacity of edge  $e_i$ ,  $ba(e_i)$  is indicating the bandwidth available at edge  $e_i$  and the ' $br(e_i)$ ' is the bandwidth required at  $e_i$
- End-to-End delay (-) = The elapsed time of the n packet transmission, which indicates the positive difference between time taken to transmit n packets and actual time expected to transmit. This can be measured as follows:

$$eed(e_i) = ttt(e_i) - ett(e_i)$$

- o Here in above equation  $eed(e_i)$  represents the end to end delay observed for n packet transmissions on edge  $e_i$ ,  $ttt(e_i)$  indicates the time taken to transmit and  $ett(e_i)$  represents the expected time to transmit.
- energy usage(-) : The nodes in ad hoc network are self energized, hence the minimal usage of energy towards routing is precious, which leads the nodes to survive maximum life time that helps to maximize the network life time. The energy usage is negative factor since the minimal values are desirable. This can be measured as follows:

$$eu(e_i) = fr_n(e_i) * er_{hz}(e_i)$$

- o Here in above equation  $eu(e_i)$  energy used at  $e_i$ ,  $fr(e_i)$  represents the frequency required in HZ for n packets and  $er_{hz}(e_i)$  represents energy required in joules per hz

The QoS fitness of a given route is assessed under the context of multiple QoS factors and then ranked them based on the selective prime QOS factor. This strategy explored in following section

#### a) Assessing QoS fitness scope

Let  $R$  be the set of routes such that  $R = \{r_1, r_2, r_3, \dots, r_n\}$ , found in route request process. The set of nodes  $N$  such that  $N = \{n_1, n_2, n_3, \dots, n_c\}$ , are the nodes available in the scope of target ad hoc network. Each route  $\{r_i \forall r_i \in R\}$  can be defined as set of nodes such that  $\{r_i \forall r_i \in R\} = \{n_s, n_{h1}, n_{h2}, n_{h3}, \dots, n_{hj}, n_{hj+1}, \dots, n_d \forall n_{hj} \in N\}$ . Here  $\{n_{hj} \forall j : 1..m \wedge n_{hj} \in N\}$  is the node involved to form the route  $r_i$  between source node  $n_s$  and destination node  $n_d$ .

Let connectivity scope, bandwidth capacity, end to end delay, energy usage, and other such metrics as a set of QoS metrics  $M = \{[cs(e_i), bc(e_i), eed(e_i), eu(e_i), \dots] \forall i = 1..x\}$  of available set of Routes  $R$  between source node  $n_s$  and destination node  $n_d$ .

The QoS factor  $eu(e_i)$  is taken as prime metric (any QoS metric can be selected as prime metric, which based on the routing context), which is using to order the routes. These QoS metrics of the routes are categorized as positive and negative metrics. If the incremental values of the metrics are optimal then those metrics are referred as positive metrics and if decrement values are optimal then those metrics are negative metrics.

Henceforth the values of negative and positive metrics should be normalized, which is as follows:

For each route  $[r \exists r \in R]$  begin

For each QoS metric  $\{m_k(r) \forall m_k \in M \wedge r \in R\}$  of route  $r$  Begin

$$m_k(r) = 0$$

End

For each edge  $\{e_i \forall e_i \in r\}$  Begin

For each metric  $[m_k(e_i) \forall m_k(e_i) \in M]$  edge  $e_i$  Begin

// here  $M$  represents values of selected edge of route  $r$

If  $m_k(e_i)$  is value of +ve metric

$$\text{then } m_k(e_i) = 1 - \frac{1}{m_k(e_i)}$$

Else If  $m_k(e_i)$  is value of -ve

$$\text{metric then } m_k(e_i) = \frac{1}{m_k(e_i)}$$

$$m_k(r) = m_k(r) + m_k(e_i)$$

End

End

For each QoS metric  $\{m_k(r) \forall m_k \in M \wedge r \in R\}$  of route  $r$  Begin

$$m_k(r) = \frac{m_k(r)}{|r| - 1}$$

// each QoS metric value of each route, //which is an average of that QoS metric //value observed at all edges in that route

End

Then the available routes  $R$  are ranked by their normalized metric scores  $\{m_k(r) \forall m_k \in M \wedge r \in R\}$  from maximum to minimum, such that each route  $r$  gets different rank for different metric  $m_k(r)$ .

Further these ranks will be used as input to measure the QoS fitness scope  $qfs$ .

Let Rank set of a route  $[r_i \exists r_i \in R]$  is  $O(r_i) = \{om_1(r_i), om_2(r_i), om_3(r_i), \dots, om_{|M|}(r_i)\}$  (here  $|M|$  indicates the total number of metrics) and then QoS

fitness scope ( $qfs$ ) of each route can be measured as follows.

$$\mu_{O(r_i)} = \frac{\sum_{k=1}^{|O(r_i)|} [om_k(r_i) \forall om_k(r_i) \in O(r_i)]}{|O(r_i)|}$$

// the above equation represents the average of the ranks obtained for different metrics of route  $r_i$

$$qfs(r_i) = 1 - \left[ \frac{\sqrt{\left( \sum_{k=1}^{|O(r_i)|} (\mu_{O(r_i)} - [m_k(r_i) \forall m_k(r_i) \in O(r_i)]) \right)^2}}{|O(r_i)|} \right]^{-1}$$

The above equation is derived from the process of calculating variance between given number of attribute values. Subtracting variance observed, from 1 gives fitness scope. Here in above equation,  $\mu_{O(r_i)}$  represents the mean of the all ranks of different QoS metrics of the route  $r_i$ .

Then these routes will be ordered based on the prime QoS metric. Among the ordered routes, the best routes in regard to prime QoS factor will be selected,

and then they will be ordered from maximum to minimum of their  $qfs$  value.

a) *Exploration of Orthogenesis Genetic Evolution for QoS Fitness Scope Aware Route Selection*

The devised orthogenesis GA performs progressive evolution process. In the context of optimal QoS aware route discovery, these progressive evolutions will be applied on set possible routes  $R$  found between source and destination nodes. The number of evolutions is initially limited to max evolution count given, further, the kurtosis [20] of the  $qfs$  distribution across the routes in resultant  $R$  is assessed.

(i) If the kurtosis of the  $qfs$  distribution is mesokurtic (kurtosis is equal to 3), which indicates that the variation of  $qfs$  distribution is reflecting moderate then the further evolutions continues by adjusting the max evolution count to half of its current value . (ii) If distribution is reflecting leptokurtic, which indicates the variation of the  $qfs$  distribution is high then the further evolutions continues for max evolution count number of times. If distribution is platykurtic, which indicates that the  $qfs$  distribution is with negligible variation, hence stop further evolutions.

**The evolution approach**

$ord \leftarrow false$  //route discovery process completion state

$optr \leftarrow \phi$  //optimal route set;  $ec = 0$

$ect = 0$  //represents maximum evolutions threshold

While (! $ord$ ) Begin

$nR \leftarrow \phi$

    For each route  $r_i$  find crossover points Begin

        For each route  $\{r_j \exists (r_j \in R \wedge j \neq i)\}$  Begin

$nR \leftarrow \text{Orthogenesis\_Evolution}(r_i, r_j)$

//progressive evolution, leading to the development of a improved form, as can be seen through successive generations

        End

    End

$R \leftarrow nR$  //adding new routes to  $R$

$ec \leftarrow ec + 1$

    If ( $ec \geq ect$ ) Begin

$R = \text{pruneR}(R)$

$ks = \text{find\_kurtosis\_of\_qfs\_distribution}(R)$  //is finding the kurtosis state of the fitness distribution across the evolutions

        If ( $ks = 3 \ \&\ \&ect > 1$ ) Begin //mesokurtic 



$$ect = \frac{ect}{2}$$

$$ec = 0$$

        //continues evolutions for further  $ect$  times



```

    End
    Else if (  $ks > 3$  ) Begin//leptokurtic 
         $ec = 0$ 
    End
    Else if(  $ks \leq 3$  ) Begin //platykurtic 
         $ord \leftarrow true$ 
    End
End
End
End

```

**Orthogenesis\_evolution( $r_i, r_j$ ) BEGIN**

$r_{ij} \leftarrow \phi$  //is a set routes formed from crossover of  $r_i, r_j$

For each node  $\{n_{hk} \forall n_{hk} \in r_i\}$  Begin

$cop \leftarrow \phi$

For each node  $\{n_{hl} \forall n_{hl} \in r_i\}$  Begin

If  $(n_{hk} \cong n_{hl})$  Begin

End  $cop \leftarrow n_{hk}$

End

For each  $\{cp \forall cp \in cop\}$  Begin

$\overline{qfs} = 0$

$\overline{r}^i = \phi$

// $\overline{r}^i$  is left part of cross point  $cp$  in route  $r_i$ ,

Intersect  $r_i$  at cross point  $cp$  and form  $\overline{r}^i$  and  $\overline{r}^i$

// $\overline{r}^i$  is right part of cross point  $cp$  in route  $r_i$

// $\overline{r}^j$  is left part of cross point  $cp$  in route  $r_j$ ,

Intersect  $r_j$  at cross point  $cp$  and form  $\overline{r}^j$  and  $\overline{r}^j$

// $\overline{r}^j$  is right part of cross point  $cp$  in route  $r_j$

Form route  $r_k$  as

$r_k \leftarrow \phi$

$r_k \leftarrow \overline{r}^i$

//forming route by connecting left part of  $r_i$  and

$r_k \leftarrow cp$

right part of  $r_j$

$r_k \leftarrow \overline{r}^j$

If  $(qfs(r_k) > \overline{qfs})$  Begin

$\overline{qfs} = qfs(r_k)$

$r_z = r_k$

End

$r_k \leftarrow \phi$

Form route  $r_k$  as

$r_k \leftarrow \overline{r}^j$

//forming route by connecting left part of  $r_j$  and

$r_k \leftarrow cp$

right part of  $r_i$



```

                                rk ← ri
                                if (qfs(rk) > qfs) Begin
                                    qfs = qfs(rk)
                                    rz = rk
                                End
                                rij ← rz
                                End
                                For each new route {r ∀ r ∈ R } Begin
                                    If ( qfs(r) < qfs(ri) & qfs(r) < qfs(rj) ) Then delete r from R
                                End
                                End
                                END
    
```

```

Kurtosis_of_qfs_distribution(R) BEGIN
    Find mean of the qfs of all routes
    
$$\mu(QFS) = \frac{\sum_{i=1}^{|R|} qfs(r_i)}{|R|}$$

    Here in the above equation  $\mu(QFS)$  is the mean of qfs distribution over all routes in R
    Find standard deviation (square root of variance)
    
$$\sigma_{QFS} = \sqrt{\frac{\sum_{i=1}^{|R|} (qfs(r_i) - \mu(QFS))^2}{|R|}}$$

    Here in the above equation  $\sigma_{QFS}$  standard deviation of qfs distribution across the routes in R
    Find kurtosis of the qfs distribution across the routes in R
    In regard to this, first find the 4th moment of the qfs distribution
    
$$m4 = \frac{\sum_{i=1}^{|R|} (qfs(r_i) - \mu(QFS))^4}{|R|}$$

    Here in the above equation m4 represent the fourth moment of the qfs distribution
    
$$g(R) = \frac{m4}{\sigma_{QFS}^4}$$

    Here in the above equation g(R) is representing the kurtosis of the qfs distribution across the routes
    in R
    Return g(R)
    END
    
```

#### IV. EMPIRICAL ANALYSIS AND RESULTS EXPLORATION

The empirical analysis was done by a simulated mobile ad hoc network environment, which is build by using NS2 to visualize and TCL to control The network

environment build on the simulation is considering the randomized node placement with random waypoint mobility. The opted QoS metric values observed at hop level edges on an event of time was randomly distributed under the context of poison distribution. The simulation environment was bounded to the parameters

explored in table1. The simulation was opted to AODV strategy to discover the possible routes between given source and destination nodes. Further to obtain the QoS fitness scope aware routes from the discovered routes was done by using the expression language called R. The experiments were done on simulated network environment with divergent count of nodes range from 50 (sparse) to 250 (dense). In other dimension the experiments were done under nodes with divergent mobility speeds.

Table 1 : Network constraints for simulation environment

The range of Nodes	50 to 250
The range of mobility speed	0.5m to 3m/sec
Communication Strategy	MAC 802.11 DCF
Network Occupancy	1000 X 1500 m2
Node transmission frequency scope	100 meter
Packet type	CBR & FTP
Node Mobility Strategy	Random way point
Simulation Time	100, 300 Sec

The results observed from experiments indicating that the proposed Orthogenesis GA for QoS fitness scope aware route discovery (QFSRD) is scalable and robust that compared to GAMAN [18] and E-GAMAN [19]. The completion evolution completion time is considerably low and scalable (see figure 3), the evolution complexity observed at proposed QFSRD scalable and stable (see figure 4). The skewness observed for QoS fitness distribution over top  $n$  (here in experiments  $n = 10$ ) resultant routes from the QFSRD is low and optimal (see figure 5).

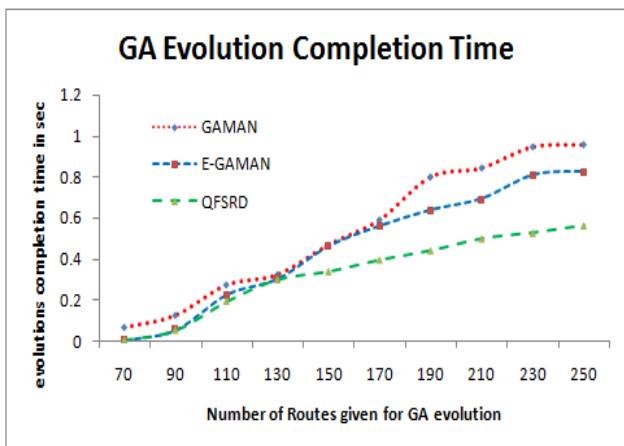


Figure 4 : The completion time observed for evolutions under GAMAN,E\_GAMAN and QFSRD

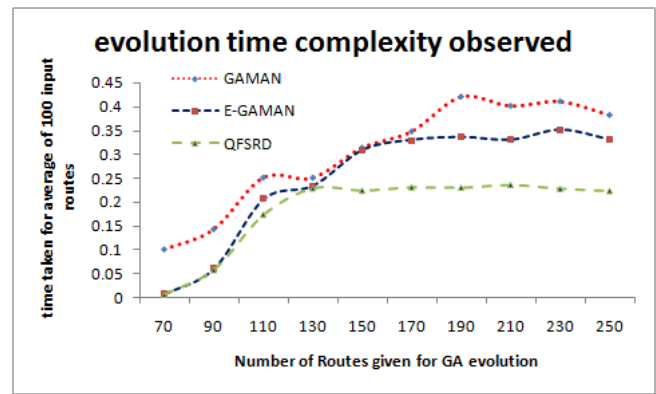


Figure 5 : The computational complexity observed for evolutions under GAMAN, E-GAMAN and QFSRD

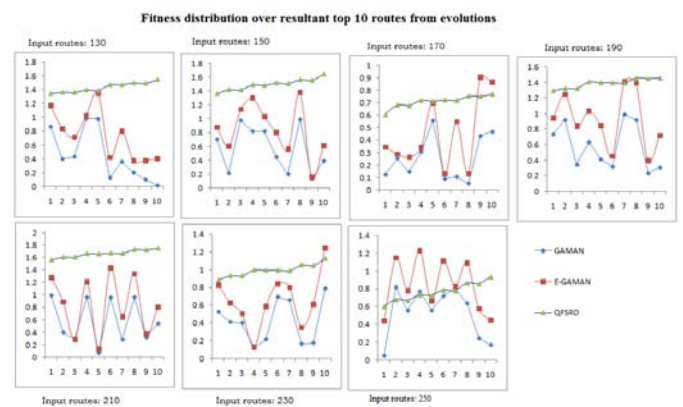


Figure 5 : Fitness distribution over best n resultant routes from GAMAN, E-GAMAN and QFSRD

## V. CONCLUSION

Orthogenesis based Genetic algorithm has been devised here in this paper, which is in the context of QoS fitness scope aware route discovery for mobile ad hoc networks. The limits observed in earlier GA based QoS aware routing discovery strategies called GAMAN [18] and E-GAMAN [19], motivated us to devise this Orthogenesis based Genetic Algorithm for QoS fitness scope aware route discovery. Unlike these two models[18][19], the devise model is assessing the fitness of the route by considering all QoS factors along with prime QoS metrics such as connectivity, bandwidth. The progressive evolution strategy of orthogenesis approach is another key contribution of the proposed model. This progressive evolution minimizes the number of evolutions compared to the traditional GA with elitist (best fit remain unchanged) strategy. The major contribution this paper is the QoS fitness scope assessment strategy, unlike any existing benchmarking strategies that considers a specific QoS metric, the devised fitness scope assessment model considers many QoS factors along with prime QoS metrics that are related to the routing context. In the best our knowledge,

the fitness scope assessing and progressive evolution strategies are used first in the class of QoS aware routes discovery. The experimental results concluding the magnified scalability, optimality and robustness of the proposed model that compared other benchmarking strategies called GAMAN and E-GAMAN. This work is inspiring us for further research. One future direction of research would be finding hybrid soft-computing strategies for QoS aware route discovery.

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