

1 QFSRD: Orthogenesis Evolution based Genetic Algorithm for 2 Qos Fitness Scope aware Route Discovery in Ad Hoc Networks

3 Dr.P.Chandra Sekhar Reddy

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6 Abstract

7 Here in this paper we devised a novel orthogenesis evolution based GA technique for QoS
8 fitness scope aware routing in Mobile Ad hoc Networks. The past decade research towards
9 route discovery strategies for mobile ad hoc networks is continuing with magnitude speed.
10 However, the majority of the routing solutions devised in past are dealing only with the
11 optimality of the data transmission. QoS aware hop level connections in a given route are not
12 supported with the desired frequency. Hence the QoS aware routing in mobile ad hoc
13 networks is grabbing the attention of many researchers as this domain is on the hot edge of
14 the current research.

16 *Index terms*— othogenesis evolution, QOS fitness scope.

¹⁷ 1 Introduction

18 ANETs are wireless mobile Ad Hoc Networks that operate without any infrastructure, can be implemented quickly
19 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.

25 In MANET the network communication is a peer-to-peer wireless connectivity between nodes with either a
 26 single hop between a mobile cell and a base station or multi-hop wireless transmission without any base stations.

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

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

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

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

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

4 RELATED WORK

46 criterions such as bandwidth etc are considered as QoS metric. If a path between node A and node G is required
47 with minimum of 4 mbps bandwidth then path that is shortest "A-B-H-G" cannot offer the needed bandwidth
48 and so the possible QoS aware path would be "A-B-C-D-E-F-G."

49 2 Mobile Node Shortest Path Signal Range

50 QoS satisfied path Wireless Link Figure ?? : an example of QoS routing in Manet Figure ?? : An example Manet
51 connectivity

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

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

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

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

72 3 II.

73 4 Related Work

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

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

90 Here unlike the technique of re-routing, a completely new path is not found and instead the approach attempts
91 to adjust to the MANETs dynamic environment.

92 A routing approach based on QoS for Mobile Ad hoc networks of size in the range of small and medium
93 called "Core Extraction Distributed Ad hoc Routing (CEDAR)" [11]. The CEDAR approach involves 3 main
94 mechanisms. First, the Core Extraction mechanism selects a group of nodes based on the MANETs minimum
95 dominating group or links having large bandwidth of stable nature, to create the core that manages the nodes
96 local topology and computes the route based on the requirement and the state of local conditions. Next Link
97 State Propagation mechanism distributes to all the core nodes the information of the bandwidth available with
98 stable links. The routing based on QoS is attained by passing stable links related highbandwidth information
99 to distant nodes in the network and by containing dynamic links low bandwidth information in the area locally.
100 establishes a core route from the source node domain to the destination node domain. This data of the core path
101 is used to determine iteratively a partial route in the path that forms the core from the source to the farthest
102 domain node possible in terms of the demanded bandwidth. In the next iteration this node acts as the source
103 node.

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

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

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

127 Leonard Barolli, Makoto Ikeda et al., [19] devised a novel local search optimization strategy, which is an
128 extension to their earlier work GAMAN [18] that referred as E-GAMAN. The devised search space reduction
129 algorithm (SSRA) is mainly aimed to minimize the crossover complexity observed in GAMAN. So that the local
130 search become much faster, hence the time taken for optimal route selection will be low and the GAMAN can
131 find a feasible wireless path very fast. But the issue of considering the impact of QoS factors other than mobility
132 remains same and the evolutions count is still not in control for networks with nodes having QoS metric values
133 distribution with high skewness ??20].

134 In a gist, almost all of these benchmarking models including GAMAN [18] are specific to one or two QoS
135 factors. The GAMAN is also not confident when QoS metric values are distributed with high skewness ??20].
136 Henceforth, here in this paper we devised a novel orthogenesis genetic algorithm for optimal QoS aware route
137 selection for mobile ad hoc networks. Unlike GAMAN the said model is equally considering all QoS metric values
138 to assess the fitness of the resultant route. Since the GA that considered is following orthogenesis approach and
139 the statistical strategy used to fix the need and scope of further evolutions, the number of evolutions is in control,
140 which leads to minimize the search space. Unlike the traditional GA, the proposed model is constructing new
141 generations by progressive evolution strategy. The progressive evolution strategy generates the child elements
142 having more fitness than one or both of the parent elements. Hence the number of evolutions can be limited. The
143 other contribution in devised model is fitness assessment that considers the many metrics with equal priority and
144 the same time not losing the influence of prime QoS metric such as energy efficiency, connectivity or bandwidth
145 availability. The QoS fitness scope assessment strategy proposed in this paper is based on the QoS factors of
146 route and their earlier allocation impacts, which are described below:

147 ? A route can be rated best under a specific QoS factor, but might fail to deliver the same performance under
148 the consideration of multiple QoS factors. ? A route can be rated divergently with respect to its various QoS
149 factors. As an example, a route can be best with respect to bandwidth availability, but the same route might
150 be moderate in terms of packet delivery ratio scope, worst in the context of end-to-end delay scope. The QoS
151 metrics of each edge between hop level nodes of route are considered to assess the best fit route and these metric
152 are categorized as positive and negative, which is based on their value. The metrics with desired value as high
153 referred as positive metrics and the metrics with desired value low are referred as negative metrics. The scope
154 of the described metrics is assessed against the transmission of n packets. These metrics are described below. ?
155 Connectivity (+) = Due to the factor of mobility, the connectivity between the nodes is a sensitive metric towards
156 QoS aware Routing. This is an appositive metric, since connectivity with high value is desirable. This metric can
157 be assessed as follows The QoS factor () i.e. e is taken as prime metric (any QoS metric can be selected as
158 prime metric, which based on the routing context), which is used to order the routes. These QoS metrics of the
159 routes are categorized as positive and negative metrics. If the incremental values of the metrics are optimal then
160 those metrics are referred as positive metrics and if decrement values are optimal then those metrics are negative
161 metrics.

162 Henceforth the values of negative and positive metrics should be normalized, which is as follows:
163 Foreach route [] r r R ? ? begin For each QoS metric { () } k k m r m M r R ? ? ? of route r Begin () 0 k
164 m r = End For each edge{ } i i e e r ? ? Begin For each metric [() ()] k i k i m e m e M ? ? edge i e Begin //
165 here M represents values of selected edge of route r If () k i m e is value of +ve metric then 1 () 1 () k i k i m e
166 m e = ? Else If () k i m e is value of -ve metric then 1 () () k i k i m e m e = () () k k k i m r m r m e =
167 + End End For each QoS metric { () } k k m r m M r R ? ? ? of route r Begin () () || 1 k k m r m r r = ?
168 // each QoS metric value of each route , //which is an average of that QoS metric //value observed at all

8 CONCLUSION

edges in that route End Then the available routes R are ranked by their normalized metric scores $\{(\cdot)\} k k m r m M r R ? ? ? ?$ from maximum to minimum, such that each route r gets different rank for different metric $(\cdot) k m r$. Further these ranks will be used as input to measure the QoS fitness scope qfs .

Let Rank set of a route $[i i r r R ? ?]$ is $1 2 3 | | (\cdot) \{(\cdot), (\cdot), (\cdot),$

$\dots, (\cdot)\} i i i i M i$

$O r o m r o m r o m r o m r =$ (here $| | M$ indicates the total number of metrics) and then QoS fitness scope (qfs) of each route can be measured as follows. $|(\cdot)| 1 (\cdot) [(\cdot) (\cdot) (\cdot)] | (\cdot) | i i O r k i k i k O r i o m r o m r O r O r \mu = ? ? =$

$? //$ the above equation represents the average of the ranks obtained for different metrics of route $i r 1 2 | (\cdot) | (\cdot) (\cdot) (\cdot) | (\cdot) | O r i m r m r O r k i k i i O r i k q f s r i O r i \mu = ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?$

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, $(\cdot) i O r \mu$ represents the mean of the all ranks of different QoS metrics of the route $i r$. 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.

185 5 a) Exploration of Orthogenesis Genetic Evolution for QoS 186 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.

196 6 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

202 7 Global Journal of Computer Science and Technology

Volume XV Issue III Version I Year () 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. 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 ??), 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 $10 n =$) resultant routes from the QFSRD is low and optimal (see figure ??).

213 8 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,

225 9 Global Journal of Computer Science and Technology

226 Volume XV Issue III Version I Year () the fitness scope assessing and progressive evolution strategies are used
227 first in the class of QoS aware routes discovery. The experimental results concluding the magnified scalability,
228 optimality and robustness of the proposed model that compared other benchmarking strategies called GAMAN
229 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. ^{1 2 3}

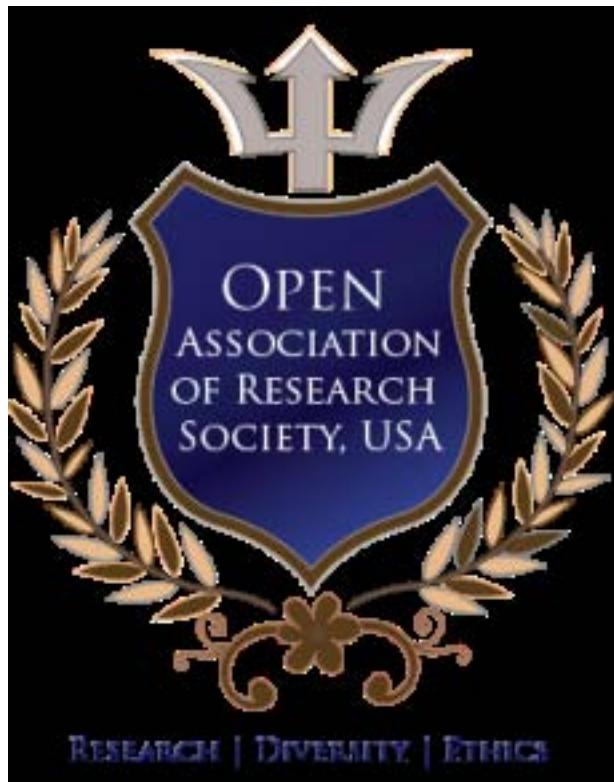


Figure 1:

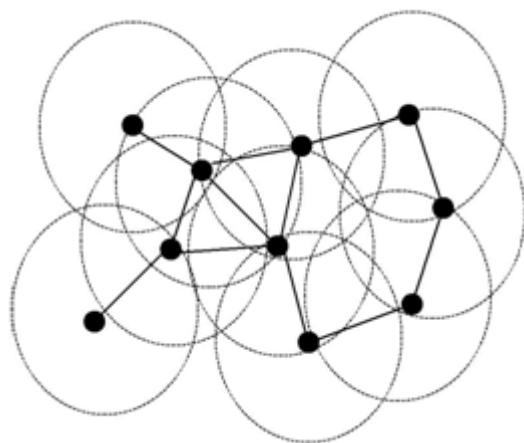


Figure 2: R

230

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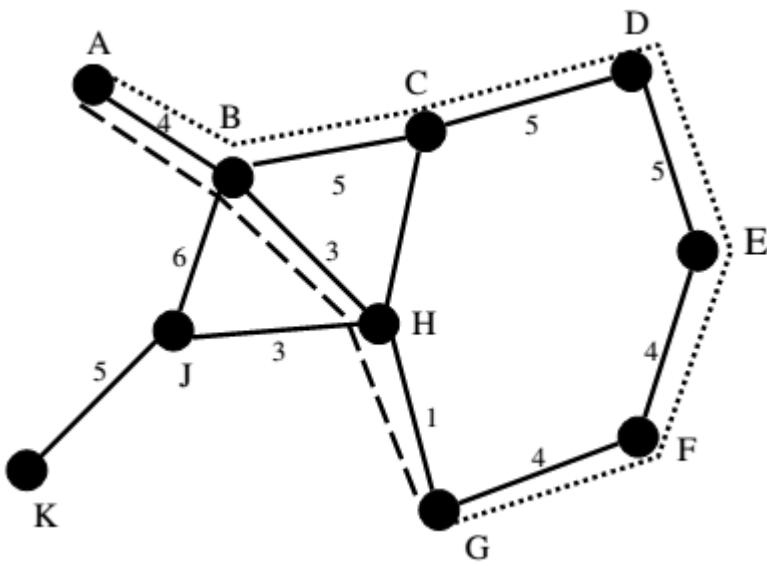


Figure 3: 1 8?Here in the above equation 4 m represent the fourth moment of the qfs distribution
 $4 =$

4

Figure 4: Figure 4 :

55

Figure 5: Figure 5 : 5 :

? Input: All possible routes as routes set R ? Fitness factors: o connectivity (+), bandwidth (+), end-to-end delay (-), reputation (+) , energy usage(-) and other metrics if any ? QoS Fitness Scope (qfs) calculation: o 1 mv , here mv is metric value o normalization of positive factor will be 1 1 mv ? o o 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

[Note: ? 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 III.Orthogenesis number of routes from the resultant routes set R]

Figure 6:

1

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

Figure 7: Table 1 :

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