Volume 2, Issue 10, October 2012 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

# Improving QoS in Adhoc Networks Using Fuzzy Network

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***ABSTRACT: A mobile ad hoc network (MANET) is a collection of self-organized mobile nodes that are capable of communicating with each other without the aid of any established infrastructure or centralized administration. Routing algorithm has been a challenge task in the wireless ad hoc network for a long time due to the dynamic nature of network topology. A recent trend in ad hoc network routing is the reactive on-demand philosophy where routes are established only when required. The on-demand routing protocol for ad hoc network is appealing because of its low routing overhead and its effectiveness when the frequency of route re-establishment and the demand of route queries are not high. However, considering the increasing demand of Quality-of-Service (QoS) requirements in many applications, the current on-demand routing protocols used for ad-hoc network should be adapted appropriately to effectively meet the stringent QoS requirements of specific multimedia traffic.***

***KEY WORDS: AODV; backup route; fuzzy logic; QoS***

## 1. INTRODUCTION

In recent years, the progress of communication technology has made wireless devices smaller, less expensive and more powerful. Such rapid technology advance has provoked great growth in mobile devices connected to the Internet. There are two variations of wireless network, which are infrastructure networks and ad hoc networks. In an infrastructure network, a mobile station must find the nearest base station within its communication range before it communicates with another as shown in Fig. 1, whereas an ad hoc network [1–2] is a collection of mobile nodes that are capable of communicating with each other without the aid of any established infrastructure or centralized administration. They are self-organized, dynamically changing multi-hop networks as illus-trated in Fig. 2.

Routing algorithm has been a challenge issue in a wireless ad hoc network for a long time due to the quick change of network topology. The routing protocols in ad hoc networks can be roughly divided into two categories, table driven and on-demand routing protocol. The on-demand routing protocol for ad hoc network is appealing owing to its low routing overhead and its effectiveness when the occurrences of route re-establishments and route queries are not frequent. Ad hoc On-demand Distance Vector (AODV) [3–4] and Dynamic Source Routing (DSR) [5] are two representative on-demand routing protocols. DSR and AODV have a common characteristic—they both initiate routing activities on an on-demand basis.

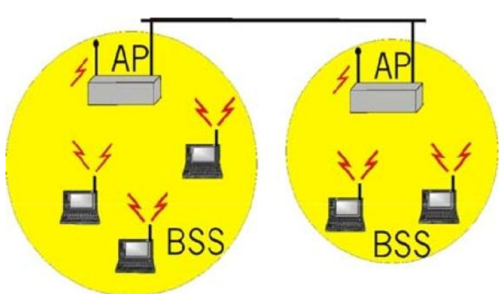



Fig. 1. An infrastructure network.

The reactive nature of these protocols is a major divergence from traditional proactive protocols, such as Destination-Sequenced Distance Vector (DSDV) [6], which find routes between all source-destination pairs regardless of the use of such routes. The key motivation behind the design of on-demand protocols is the reduction of the routing overhead since high routing overhead usually has a significant performance impact in low-band-width wireless links. Although DSR eliminates rout-ing tables by using source routing mechanism, it is not scalable to large networks and flooding of route reply introduces costly Media Access Control (MAC) layer overhead. AODV combines the use of destination sequence numbers in the DSDV with the on-demand route discovery technique in DSR to formulate a loop-free, on-demand, single path, dis-tance vector protocol.

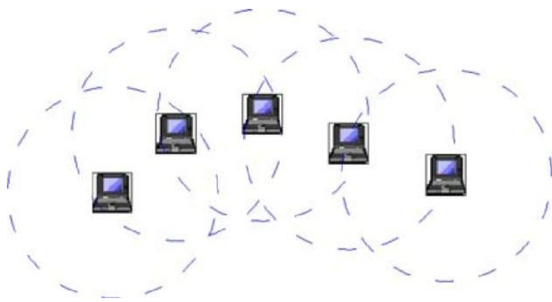


Fig. 2. An ad hoc network

In AODV protocol, nodes of the broken route simply drop data packets when a route fails because no alternate path to the destination is available until a new route is established. When the network traffic requires real-time delivery, dropping data packets at the intermediate nodes can be costly. Many on-demand protocols with multi-paths or backup routes [7–11] have been proposed in order to alleviate these problems. Multiple paths can be used to balance loads by forwarding data packets on multiple paths at the same time [7]. However, Perkins [2] pointed out that there are three possible difficulties:

- It is nontrivial to simultaneously manage the aging process for multiple routes between the same source/destination pair.
- If an alternate route is taken after a primary route has gone stale, it might be difficult to know whether the alternate route is still valid.
- Careful bookkeeping is required to ensure that two different routes do not actually utilize the same broken link.

Lee et al. proposed a scheme to improve existing on-demand routing protocols by creating a mesh and providing multiple alternate routes called AODV-BR (Backup Route) [8]. The algorithm establishes the backup routes without transmitting any extra control message. Those multiple alternate paths are utilized only when the primary route is disconnected.

Most of multi-path and backup routes schemes in the literature establish the routes using ROUTE REQUESTs (RREQ) control signals. The established paths may be far from the main route. This will increase the difficulty of managing multi-paths since RREQ is a network flooding signal. AODV-BR uses ROUTE REPLY (RREP) signals to construct the backup route and make those alternate routes close to the main route. Thus, creation of multiple routes by using RREPs control signals makes the managing work much easier.

With the increasing demand for the provision of multimedia applications, such as Video on Demand (VoD), videoconference, and many WWW-based applications, a great deal of attention is being paid to provide seamless multimedia access in ad hoc networks. Since the multimedia applications are very sensitive to the available bandwidth, jitters or delays in the networks, some sorts of service quality guar-antees are desperately needed. The notion of Quality-of-Service (QoS) is a guarantee by the network to satisfy a set of predetermined service performance constraints for the user in terms of the end-to-end delay statistics, available bandwidth, probability of packet loss, and so on. The challenges increase even more for those ad hoc networks that support both best effort services and those with QoS guarantees. In recent years, there are several approaches proposed for addressing at different levels of QoS provision in mobile ad hoc networks. INSIGNIA [12], FQMM [13] and SWAN [14] provide some insight to these QoS issues in mobile ad hoc network environment.

## 2. AD-HOC ON-DEMAND DISTANCE VECTOR (AODV)

AODV routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It maintains these routes as long as they are needed by the source node. Operations of unicast routing in AODV can be simply divided into three parts: route request, route reply and route maintenance.

### 2.1. Route Request

Route discovery with AODV is purely on demand and follows a route request/route reply discovery cycle. When a node wishes to send a packet to some destination node, it checks its route table to determine whether it currently has a route to that node. If so, it forwards the packet to the appropriate next hop toward the destination. However, if the node does not have a valid route to the destination, it must initiate a route discovery process.

The source node broadcasts a flooding ROUTE REQUEST (RREQ) packet. The RREQ packet contains source node$_3$ s IP, destination node$_3$ s IP and broadcast ID. Broadcast ID is a sequence number which is maintained by the source node, and it is incremented each time the source node initiates a RREQ. In this way, the broadcast ID and the IP address of the source node form a unique identifier for the RREQ. The intermediate nodes can avoid processing the same RREQ by using this unique identifier. After broadcasting the RREQ, the source node sets a timer to wait for a reply. When the route request process completes, a reverse route is set up. Figure 3 indicates the propagation of RREQ across the network as well as the formation of the reverse route entries at each of the network nodes.

2.2. Route Reply

A node receiving the RREQ may send a ROUTE REPLY (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. If this is the case, it unicasts a RREP back to the source. Otherwise, it rebroadcasts

the RREQ. The intermediate nodes keep track of the RREQ$_3$ s source IP address and broadcast ID. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it. When the route reply process is done, a forward route is set up. In this way, the source node knows how to forward data packets to the destination later. Figure 4 indicates the transmission of a RREP from the destination to the source node.

2.3. Route Maintenance

As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically traveling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node$_3$ s routing tables. When a link break occurs in an active route, the node at the upstream of the link break propagates a ROUTE ERROR (RERR) message to the source node to inform it of the now unreachable destination. After receiving the RERR, if the source node still desires the route, it can reinitiate route discovery.

2.4. Local Repair

local repair mechanism had been added to AODV to improve the packet delivery ratios. When a link break occurs in an active route, the node at the upstream of that break may choose to repair the link locally if the destination was no farther than several hops away. To repair the link break, the node broadcasts a RREQ for that destination. The process involves the flooding of AODV control messages at every node within a radius of the length from the initiation node to the destination. If the first repair attempt is unsuccessful, the node will send a RERR to the source node, the source may then re-initiate a new route discovery process.

## 3. Fuzzy Logic(FL) and Genetic Algorithm (GA)

a) Fuzzy Logic (FL)

FL is a simple but powerful methodology in logic building. It was originally conceived in the context of building control systems based on micro-controllers. FL incorporates a simple, rule-based *IF X AND Y THEN Z* approach to solve a control problem. In the context of modeling protocol for an Ad Hoc Network, most of the parameters are imprecise or not so-well defined.For example, mobility can be expressed in vague terms by means of a motion vector (precise values will never be known and not essential either). Similarly, distance limitations, power available at the nodes, traffic density etc. is parameters where determination of precise values are not practical and not important either. A fuzzy model helps us to work with imprecise values in a very predictable way.

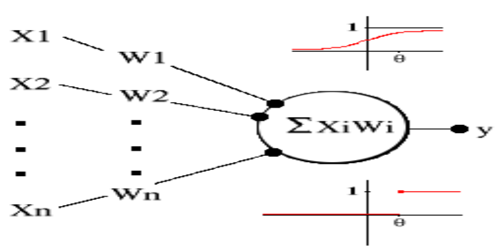



Fig. 3. Threshold logic unit, with sigma function (top) and cutoff function (bottom)

b) Genetic Algorithm (GA)

The basic purpose of genetic algorithms (GAs) is optimization. Since optimization problems arise frequently, this makes GAs quite useful for a great variety of tasks. As in all optimization problems, we are faced with the problem of maximizing/minimizing an objective function **f(X)** over given space X of arbitrary dimension. A brute force which would consist in examining every possible x in X in order to determine the element for which f is optimal is clearly infeasible. GAs give a heuristic way of searching the input space for optimal that approximates brute force without enumerating all the elements and therefore bypasses performance issues specific to exhaustive search.
We will first select a certain number of inputs, say, x1,x2,x3,…xn belonging to the input space X. In the GA terminology, each input is called an organism or chromosome. The set of chromosomes is designated as a colony or population. Computation is done over epochs. In each epoch the colony will grow and evolve according to specific rules reminiscent of biological evolution.

c) Neuro-Fuzzy-Genetic Based Network

Based on the previous discussion of the three essential ingredients, our ANN acts like a powerful inference engine, drawing all the inference rules from an extensive knowledge base. Our hybrid Neural Network functions with the cooperation of Fuzzy Logic, operating on inputs (which are
fuzzy in nature) and generating a set of solutions in the solution space with minimal searching using Genetic algorithms.A representative schema of the proposed networkis as shown in Fig.4.

## 4. IMPLEMENTATION OF THE NEURO-FUZZY-GENETIC NETWORK

Some amount of introduction on the design of our routing protocol will be in order at this point. The aim of the protocol is to establish the best possible route within the minimum time possible and the appropriate approach to this problem is the use of soft-computing technologies such as Neural Nets to reduce the dimensionality of the problem, Fuzzy Logic to deal with imprecise inputs and Genetic Algorithms to find an optimum solution in the solution space by search and related heuristic techniques.
The problem therefore reduces to finding an acceptable solution in an optimal sense. Linear Programming is not appropriate when the inputs to the system are not crisp. A judicious combination of Neural Network with Fuzzy Logic and Genetic Algorithms appears to be the ideal solution.
By examining the input layers of the Neural Network (there are many of them), it is obvious that the proposed NFG Network has many input layers as opposed to conventional NeuralNetworks.

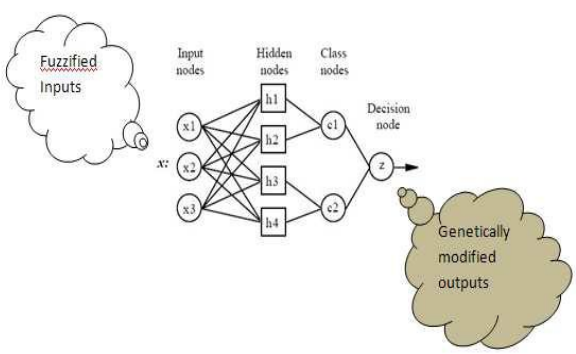
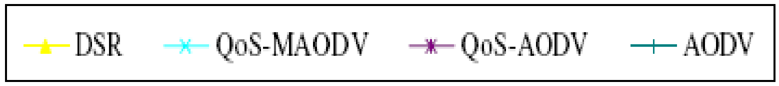



Fig. 4. Neuro – Fuzzy– Genetic Based Network

A Bayesian estimator is pressed into service at this stage to find the optimal solution. This estimator is an essential ingredient of the Fuzzy-Genetic component of the system.
The Neural Network gives a number of feasible solutions, the Bayesian Estimator picks up the best possible solution out of the solution space. The results have led us to conclude that substantial redesigning of protocols will be essential to make Ad Hoc Networks really useful. There are more of documentation bugs in NS2 and simulation on NS2 is somewhat unpredictable under certain conditions. In consideration of the above limitations, we have used HyperNet. This simulator has better functionalities than NS2.Simulation of various existing and user-defined Protocol Stacks has been performed.

## 4. SIMULATION AND ANALYSIS

The simulation results by using AODV



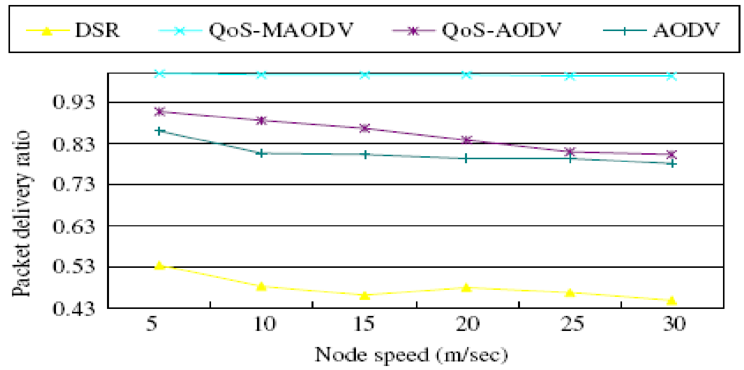




Fig. 5. Packet delivery ratio for AODV, DSR, QoS-AODV and QoS-MAODV schemes under different moving speed

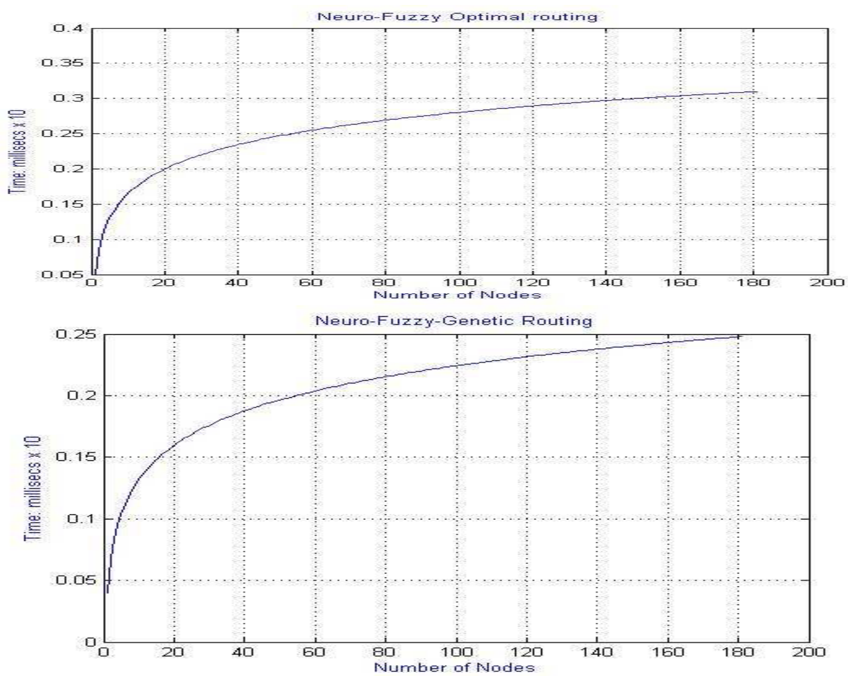



Fig. 6: A plot of Link Establishment time and Number of nodes using various protocols

## 5. CONCLUSIONS

A few observations on the results can be made:

• The performance of routing is approximately logarithmic in nature and Connection time increases with increase in the number of nodes.

• The best performance is to be found in Neuro-Fuzzy and Neuro-Fuzzy-Genetic cases.

The superior performance of Neuro- Fuzzy- Genetic Routing Algorithms comes with a price : a substantial overhead in preparation of training sets and training the simulator to achieve an equilibrium point. But this is really not an issue as the training phase is a one time effort.

In conclusion, it appears reasonable to assume that the essential ingredients of ANN with Fuzzy Logic and Genetic Algorithms go a long way in improving the performance of protocol in very dramatic terms.
A careful study of the above graphs shows a superior performance of our protocol in establishing route over shorter periods of time and the results are encouraging.

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