Quality of Service Routing in Mobile Ad-hoc Networks Using Multiple Parameters

Mie Mie Thaw, Thinn Thu Naing
University of Computer Studies, Yangon
miemiethaw@gmail.com,thinnthu@gmail.com

Abstract

Mobile Ad-hoc network is an autonomous system of mobile wireless nodes connected dynamically without any preexisting infrastructure. Since the nodes are mobile, the network topology changes rapidly and unpredictably over time. The QoS routing has challenging problems due to the network's dynamic topology and limited resources. If only one single constraint condition is considered when making routing decision, QoS can't be guaranteed because the constraint conditions may change during a session and other factors can also affect network performance. In this paper, hop-count, bandwidth, and mobile speed are considered for routing decision. Accounting for the uncertainty of route information in ad-hoc networks, fuzzy logic is adopted. The simulation is based upon Ad-hoc on demand Distance Vector and considers that data are always transmitted through the route with the lowest delay for real-time traffic. The performance of proposed scheme is evaluated with NS-2 simulator in-terms of packet delivery ratio, and end-to-end delay.

1. Introduction

Mobile ad hoc networks (MANET) consist of mobile nodes that autonomously establish connectivity via multi hop wireless communications. There is no use of a static network infrastructure such as base station or any centralized administration in MANET. In ad hoc network, if two nodes are not within radio range, all message communication between them must pass through one or more intermediate nodes. All the nodes are free to move around randomly, thus changing the network topology dynamically [1]-[9]. These type of networks have many advantages, such as self reconfiguration and adaptability to highly variable mobile characteristics like the transmission conditions, propagation channel distribution characteristics and power level. They are useful in many situations such as military applications, conferences, lectures, emergency search, and rescue operations. However, such benefits come with new challenges which mainly reside in the unpredictability of the network topology due to mobility of nodes and the limited available bandwidth due to the wireless channel. These characteristics demand a new way of designing and operating these types of networks. For such networks, an effective routing protocol is critical for adapting to node mobility as well as possible channel error to provide a feasible path for data transmission [1]-[9].AODV is an on-demand distance vector routing protocol [2]. The protocol is well known for the use in ad hoc networks.

Due to the special characteristics of MANET, the shortest path decided by the number of intermediate hops is not necessarily the most reliable or durable path since the topology of MANET is determined by many factors such as link stability and nodal mobility. All of these factors are correlated. Thus, consideration of only one or two factors is not sufficient for choosing an optimal path. The peculiarities of MANET bring more uncertain factors under which MANET routing decisions are made, i.e. latency, unknown node mobility leading to unpredictable topology changes, and inaccurate network state known by each node [9]. In this paper, we will investigate three important parameters: (1) The number of intermediate hops in a route. (2)Mobile speed and (3)Bandwidth. However, selecting a route which satisfies all multiple constraints is an NP complete problem. There is no accurate mathematical model to describe it. Additionally, the transformation of dynamic topology causes the change of QoS parameters, and finally results in the uncertainty of QoS information. Fuzzy logic exploits the pervasive imprecision, uncertainty and partial truth of the real world using simple linguistic statements and thereby achieves tractability, robustness, and low solution cost [7],[8].So adopting fuzzy logic to solve the problems in ad hoc networks is an appropriate choice. This paper addresses lowest delay path for real time traffic by proposing a simple and effective protocol called fuzzy multi-constraints QoS Routing Protocol based on ad-hoc on demand routing protocol (AODV).Which considers the multiple correlated selection parameters, based on fuzzy set theory and evolutionary computing. The goal of our proposed protocol is for selecting a feasible path to satisfy the QoS constraints and making efficient use of network resources. And to be more effective in routing decision considering upon multiple constraints in terms of end-to-end delay, packet delivery ratio and throughput.

The remainder of this paper is organized as follows: In Section II we briefly describe the AODV routing protocol and mention some problems in adapting the protocol in mobile ad- hoc networks. Section III describes Design of Fuzzy-based Multiple metrics Routing. Section IV briefly discusses about our proposed routing scheme and section V draws conclusions and future work.

2. Related study and problem statements

AODV builds routes using a route request / route reply query cycle. When a source node desires a route to a destination for which it does not already have a route, it broadcasts a route request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables. In addition to the source node's IP address, current sequence number, and broadcast ID, the RREQ also contains the most recent sequence number for the destination of which the source node is aware. 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. Nodes keep track of the RREQ's source IP address and broadcast ID [8]. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it. As the RREP propagates back to the source, nodes set up forward pointers to the destination. Once the source node receives the RREP, it may begin to forward data packets to the destination. If the source later receives a RREP containing a greater sequence number or contains the same sequence number with a smaller hop count, it may update its routing information for that destination and begin using the better route.

When a route is not available for the destination, a route request packet (RREQ) is flooded throughout the network. The RREQ contains the following fields [2],[5],[6]:

source address	request ID	source sequence No.	destination address	destination sequence No.	hop count

Figure 1. RREQ message format

source address	destination address	destination sequence No.	hop count	life-time

Figure 2. RREP message format

If a node is the destination, or has a valid route to the destination, it unicasts a route reply message (RREP) back to the source. This message has the above format.

To the best of our knowledge, current conventional AODV routing protocol choose an optimal path via a least hop-count between a source and destination without considering the correlations of the different selection parameters. However, there are lots of uncertain and varying conditions in MANET, and the topology of MANET is affected by many correlated parameters .Thus, consideration of only one or two parameters is not reasonable for determining an optimal path.

3. Design of fuzzy-based multiple metric routing

In this section, we analyze the following three important parameters: the number of intermediate hops in a route, bandwidth and mobile speed and explain why they are suitable to act as input parameter for our Fuzzy Inference System. The procedure of fuzzy Inference System is described in detail. Finally, we give a description about our multiple constraints routing protocol based fuzzy Inference System.

3.1. Multiple selection parameters

The number of intermediate hops. is one of the most popular selection parameters for finding a routing path. It allows the routing protocols to find the routes having the shortest distance. To some degree, the shortest distance in network means the least end-to-end delay between the source and the destination. And if the data packets flow through the smallest number of intermediate hops, they will have fewer chances for path failures, which results in higher reliability and longer life span of a given path.

Mobile Speed: Speed of a node can also affect the stability of networks. The faster the mobile speed is, the more easily the node will move out of each other’s transmission range and the more possible the link failure is. If the link being used fails, route rediscover will starts, and network delay will increase. At the same time, packet loss will be more possible.

Bandwidth: Affects the network delay. If bandwidth resource is insufficient, queuing delay will increase and congestion may appear. If some packets are discarded due to congestion, which results in even heavy delay.

3.2. Implementation of Fuzzy Inference Engine

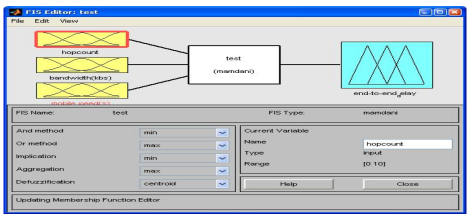

Figure. 3 Generalized fuzzy system

Three major processes are designed in fuzzy logic system (FLS).They are fuzzification, fuzzy inference and defuzzification .

The inputs into our FLS are:1) the number of intermediate hops, 2)bandwidth, 3)mobile speed, as we analyzed before, reflect the network status and the nodes ability to reliably deliver network packets. These three parameters are updated in RREQ packets as the route discovery progresses. Finally, when the RREQ packet arrives at the destination node, it inputs the three parameters of the route to the FLS, and produces an output value which represents the delay of the route, and returns this value through the RREPs.The step involved in the calculation of delay value of a route are elaborated as following:

fuzzification of Inputs and Outputs: The three input variables to be fuzzified are the number of intermediate nodes, bandwidth, and mobile speed.On the existing knowledge of MANET, the terms “Low”, “Medium”, “High” are used to describe the bandwidth.The terms used to describe the number of intermediate hops are “Short”, “Medium”, and “Long”. “Slow”, “Medium”, “Fast”are terms for representing the mobile speed.For the output variable, end-to-end delay using the term “Very Low”, Low”, “Medium”, “High” and “Very High”.Triangular memembership functions are used for representing these variables.

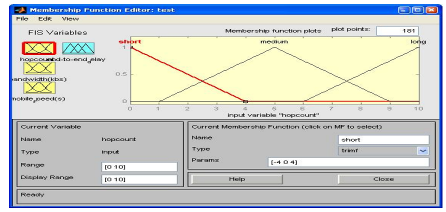

Figure. 4 Membership function for hop count

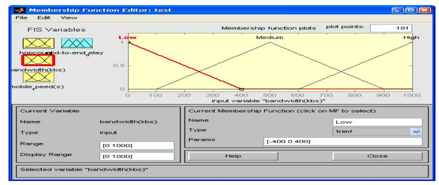

Figure. 5 Membership function for bandwidth

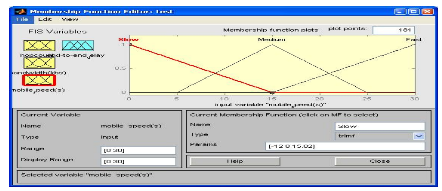

Figure. 6 Membership function for mobile speed

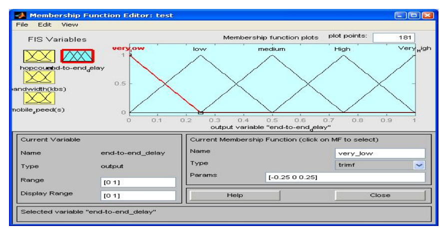

Figure. 7 Membership function for end-to-end delay

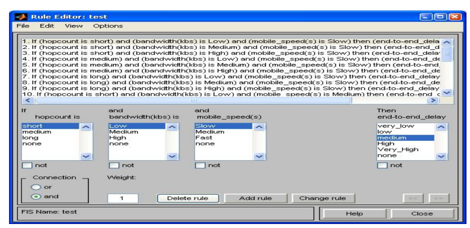

Figure. 8 Fuzzy rule base

Knowledge Base Rule Structure: The fuzzy rules have IF-THEN structure. The inputs are then combined using the AND operator. The following is an example of rules which describes the input output mapping.

If (Mobile Speed is “Slow”) AND (Hop Count is “Short”) AND (Bandwidth is “High”) Then End-to-End Delay is “Very Low”.

Defuzzification: Defuzzification refers to the way a crisp value is extracted from a fuzzy set as a representation value. There are many kinds of defuzzifiers, Here we take the centroid of area strategy for defuzzification.

$$Z_{coz} = \frac{\int_z \mu_A(Z) z dz}{\int \mu_A(Z) dz}$$

$\mu_A(Z)$ = The aggregated output of the Membership Function

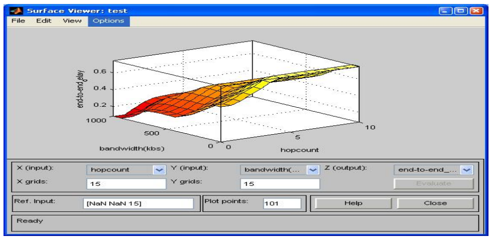

Figure. 9 Surface viewer test

4. Proposed routing scheme

Our proposed communication scheme performs a route discovery process similar to the AODV. In AODV, if a source node is going to communicate with a destination node, the source node broadcasts RREQ messages first and a path is established by the RREP reply to RREQ arrive first. Every node in MNAET acts as both a terminal and a router. Each node can become a destination for data traffic, thus, FLS is embedded in every mobile node. Such FLS in a given destination node produces the end-to-end delay value between the source node requiring route discovery and destination node.

When a source needs to start a communication with a node, first, it checks its own routing cache. If it cannot find any available route path entries, it sends route discovery (RREQ) packets to its neighbors. It starts a timer for the route selection time window as soon as it sends this RREQ .This is the time till which it will receive the route replies sent back from the destination node. At each node on the path the routing constraints are gathered and stored in RREQ.

When the RREQ packets arrive at the destination node, it sends back a Route Reply packet (RREP) to the source node, through that given route with end-to-end delay value in a new field (End-to-End delay).The End-to-End delay field is set as a default value of -1 when a source node broadcasts a RREQ message for a route discovery process.

The source node accepts all RREP packets which arrive within the time frame. It then compares the value of end-to-end delay available in its routing table. If the current route has a least delay value, then this route replaces the one present in the routing table, else this RREP is simply dropped. After that the following packets will be sent along the new route which is selected based on renewed data and makes sure that data packets are always the route with the lowest delay.

Bandwidth	End-to-end delay

Figure. 10 New added field to the head of RREQ & RREP

5. Conclusion and future work

Our proposed system considers QoS requirements for real time application. It takes the different network state parameters as the constraint conditions. Accounting for the uncertainty of route information in ad-hoc network, fuzzy logic system is adopted. Benefiting from all these optimizations, the improved protocol can be better performance than conventional AODV protocol. We will analyze the performance of our proposed scheme with single metric ad hoc-on-demand reactive AODV routing algorithm on NS-2 simulator is our future work.

6. References

[1]M. A. Rajan, M. G. Chandra, L. C. Reddy and P. Hiremath, “Concepts of Graph Theory Relevant to Ad-hoc Networks”. *International Journal of Computers, Communications & Control*, Vol. 3, No.Suppl, pp. 465-469, 2008.

[2]C. Perkins, E. Belding-Royer and S. Das, “Ad Hoc On-Demand Distance Vector (AODV) Routing”. IETF RFC 3561, July 2003.

[3]S. Chen and K. Nahrstedt, “Distributed Quality of Service routing in Ad hoc networks”. *IEEE Journal on Selected Areas in Communication,* Vol. 17, No. 8, pp. 1488-1504, 1999.

[4] R. Sivakumar, P. Sinha and V. Bharghavan, CEDAR: “Core Extraction Distributed Ad hoc Routing”. IEEE Journal on Selected Areas in Communication, Vol. 17, No. 8, pp. 1454-1465, 1999.

[5] C. Y. Chang, C. T. Chang, T. S. Chen and H. R. Chang, “Hierarchical management protocol for constructing a QoS communication path in wireless Ad Hoc networks”. Information Sciences, Vol. 177, No. 13, pp. 2621-2641, 2007.

[6] B. L. Sun and L. Y. Li, “A QoS Multicast Routing Optimization Algorithms Based on Genetic Algo-rithm” Journal of Communications and Networks, Vol. 8, No. 1, pp. 116-122, 2006.

[7] B. L. Sun, L. Y. Li, Q. Yang and Y. Xiang, “An Entropy-Based Stability QoS Multicast Routing Protocol in Ad Hoc Network, Lecture Notes in Computer Science, Vol. 3947, Springer-Verlag, pp. 217-226, 2006. Fuzzy

Controller Based QoS Routing Algorithm with a Multiclass Scheme for MANET 437
[8]B. L. Sun, S. C. Pi, C. Gui, et al, Multiple Constraints QoS Multicast Routing Optimization Algo-rithm in MANET based on GA. Progress in Natural Science, Vol. 18, No. 3, pp. 331-336, 2008.

[9]B. L. Sun, H. LI, Y. Zeng and Q. Q. QIN, Fuzzy QoS Controllers in Mobile Ad Hoc Networks using Genetic Algorithms. Journal of Computational Information Systems, Vol. 3, No. 6, pp. 2255-2260, 2007.