

A Delay Based Routing Algorithm For Ad hoc Wireless Networks

Anuj Kumar Chauhan¹, Sohan Garg²

1. Department of IT, RKGIT Ghaziabad (U.P.)
2. Department of MCA, RKGIT Ghaziabad (U.P.)

Abstract: In this paper, we present a delay based routing algorithm for ad hoc wireless networks. In an ad hoc environment there is no wired infrastructure and the mobile hosts work as a router to maintain the status about the connectivity. A mobile ad hoc network is an autonomous collection of mobile users (nodes) that communicates over relatively bandwidth-constrained wireless links. Each node is equipped with wireless receivers and transmitters using antennas that may be omnidirectional, highly directional, or possibly steerable. Due to nodal mobility, the network topology may change rapidly and unpredictably over time. The network is decentralized, where network organization and message delivery must be executed by the nodes themselves, i.e., routing functionally will be incorporated into mobile nodes. The design of the network protocols for mobile ad hoc network is a complex issue. These networks need efficient distributed algorithm to determine network organization (connectivity), link scheduling, and routing. But, the existing routing algorithms designed for ad hoc wireless networks have slow response, excessive overhead and become unsuitable under the above considerations. The full approach, for referring the internal state of the network relies on Round Trip Time (RTT) measurements only. We consider the RTT mean and RTT variance as fuzzy input variables and delay as a fuzzy output variable. Under such condition the performance of the proposed algorithm is tested. It is shown that under these conditions the algorithm gives better results. The proposed routing algorithm is simulated in MATLAB 6.5.

Keywords: Ad hoc wireless networks, routing, fuzzy logic, RTT, topology

Introduction:

Traditionally, ad hoc networks are considered useful in situations where the necessary infrastructure for centralized administration may not be economically practical or physically possible. Well-known examples of these situations are communication networks established at battlefields or disaster areas. The absence of the need for a base station contributes positively to the ease of an ad hoc network. In an ad hoc wireless network where wired infrastructures are not feasible, mobility and bandwidth are two key elements presenting research challenges. Mobility causes the life time of a connection between two hosts to vary greatly; and limited bandwidth makes a network to be easily congested by control signaling. Routing schemes developed for wired networks seldom consider restrictions of this type. We consider some factors which affect the routing performance of ad hoc wireless networks. These factors include signal power, mobility, bandwidth, distance, topological changes, congestion etc. These factors are subject to frequent and very difficult to model. The DBF [1] (Distributed Bellmanford) or LS (Link State) [2] have been proposed in the past for both wire line and wireless networks. The advantage of DBF is its simplicity and computational efficiency due to its distributed characteristics. However, the slow convergence and the tendency of creating loops make DBF not suitable for a wireless network with high mobility, large distance and change of topology. To address the limitations of DBF and topology broadcast in mobile wireless network, a number of efforts have been made in the recent past. One such effort is the DSDV [3]. In this protocol, each mobile host, which is a specialized router that periodically advertises its view of the interconnection topology with other mobile hosts within the network to maintain up-to-date information about the status of the network. Unfortunately, in DSDV a node has to wait until it receives the next update message originated by the destination in order to update its distance-table entry for that destination. Recently, a number of distributed shortest-path algorithms have been proposed [4,5,6,7] that utilize information regarding the length and second to-last hop (predecessor) of the shortest path to each destination to eliminate the counting to infinity problem of DBF. We call this type of algorithm as path-finding algorithms. According to these algorithms, each node maintains the shortest path spanning tree reported by its neighbors. Path-finding algorithms are an attractive approach for wireless networks, because they eliminate counting-to-infinity problem. However, these algorithms can still incur temporary loops in the paths specified by the predecessor before they converge; without proper precautions, this can lead to slow convergence or incur substantial processing if a node is required to update its entire routing table for each input event. To address these problems several routing algorithms have been proposed such as Gifni-Bertsekas (GB) algorithm [8], the light weight mobile routing (LMR) protocol [9], the wireless routing protocol [WRP], and dynamic source routing (DSR)[10]. However, these algorithms do not satisfy the requirements of ad hoc wireless network completely. In this paper, we propose a new routing protocol for ad hoc wireless networks which addresses some of the problems with existing approaches. The objective of our design is to keep the routing overhead low while contributing to high overall throughput. In our proposed

routing algorithm RTT data are used to detect wireless links in the communication path. Generally speaking, a RTT is the interval between the sending of a packet and receiving its acknowledgement. It includes both the network delays, such as router-queue delay and link propagation delay as well as host-processing delay, such as the time that takes the sender and receiver to process the packet and the acknowledgement. Normally, the propagation delay is a significant contributor to the round trip time.

Fuzzy Logic:

Fuzzy Logic was introduced by L.A.Zadeh in 1960s as a mean to model the uncertainty of natural language, and has been widely used for supporting intelligent systems. Fuzzy set is a superset of conventional or Boolean logic that has been extended to handle the concept of partial truth. A Fuzzy Logic system basically contains the three elements which are following:

1. Fuzzifier
2. Interface method (fuzzy rules and Reasoning)
3. Defuzzifier

1. Fuzzifier: A fuzzifier is responsible for mapping any crisp value into proper values in fuzzy logic space. This work is done by using transactions from false to true (0 to 1). Mathematically, a membership function associates each element $\mu_X(x)$ in the universe of discourse U with a number in the interval [0, 1] as shown in (1):

$$(1) \quad \mu_X : U \rightarrow [0,1]$$

Therefore, a fuzzifier maps crisp data $x \in U$ into a fuzzy set $X \in U$, and $\mu_X(x)$ gives the degree of membership in the range [0, 1]. Where 1 denotes full membership and 0 denotes no membership. So fuzzy sets are indeed an extension of the classical sets in which only full membership or no membership exist. Fuzzy sets on the other hand, allow partial membership.

Fuzzy Rules and Fuzzy Reasoning: Fuzzy system performs reasoning on the input data by following a predefined inference method. The amount of rules depends on both the number of inputs and membership functions associated to each input. The general form of a fuzzy rule is following:

If(x_1 is F_1) and(x_2 is F_2) and (x_3 is F_3)and (x_n is F_n) then (y is G).

Where F_i and G are the fuzzy sets associated with the input and output fuzzy variable x_i and y , respectively where $i= 1, 2, 3, \dots, n$.

Defuzzifier: Once the input data have been numerically processed by fuzzy reasoning then they are converted back to the crisp values. This task to convert data into the crisp data is done by defuzzifier or we can say that the defuzzifier combines together mathematically the result of each rule into a single crisp value. Several methods are used to doing so.

Proposed Routing Algorithm: The proposed routing algorithm consists the following points:

Fuzzy Input Variables: Input variables for the proposed routing algorithms are defined as the RTT mean t in equation (2) and RTT variance α_t in equation (3) being $i=1,2,3,4, \dots, n$ are the max samples. Since the maximum value of RTT is always limited by either the timeout timer or the fast retransmit mechanism. Equation (2) and (3) imply the fuzzy input variable t (RTT mean) and α_t (RTT variance) from 0 to T_{max} where T_{max} is the maximum sample. A Fuzzifier has to map the crisp values t and α_t into the fuzzy draft.

$$(2) \quad t = (1/n) \sum_{i=1}^n t_i$$

$$(3) \quad \alpha_t = (1/n) \sum_{i=1}^n (t_i - t)^2$$

The figure 1 and figure 2 shows the RTT mean and RTT variance respectively. The RTT mean has been divided into three fuzzy sets small (from 0 to 0.4) medium (from 0.2 to 0.8) and large (from 0.6 to 1.0) and the sets small (from 0 to 0.4) medium (from 0.2 to 0.8) and large (from 0.6 to 1.0) have been used for another fuzzy input variable RTT variance.

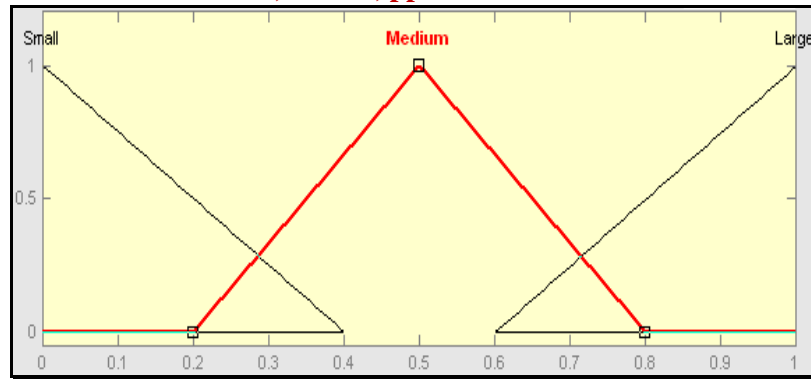


Figure 1: Input Variable RTT Mean

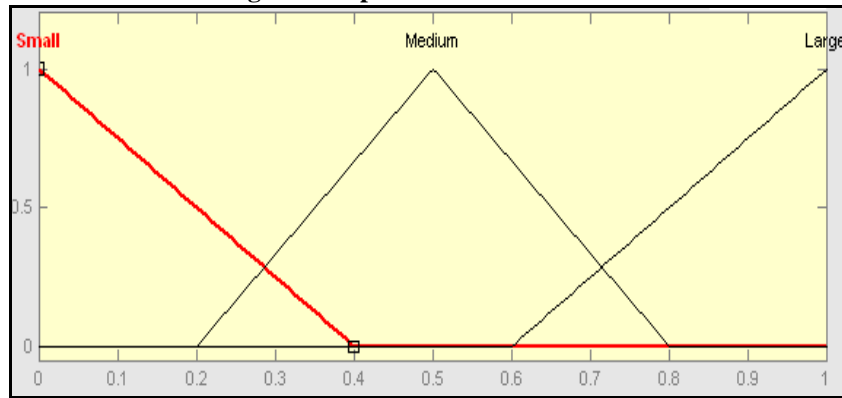


Figure 2: Input Variable RTT Variance

Fuzzy Output Variable: We have only one fuzzy output which is delay and this fuzzy output variable has been divided into three singleton fuzzy sets poor(from 0 to 0.4), average (from 0.2 to 0.8) and excellent (from 0.6 to 1.0) as shown in figure 3.

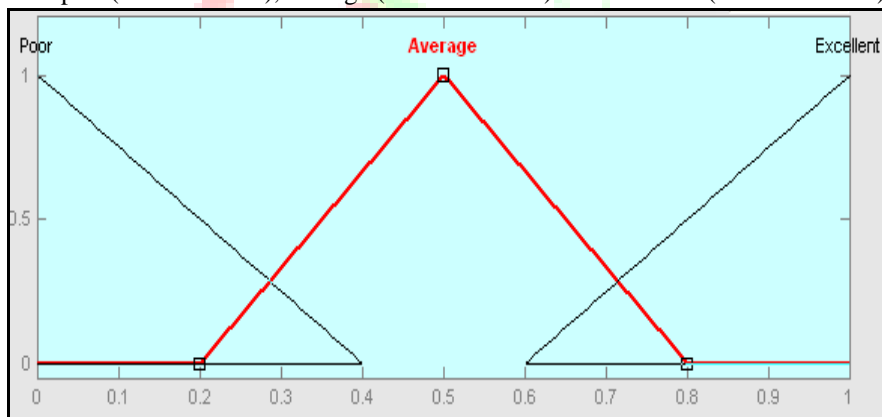


Figure 3: Output Variable Delay

Fuzzy Rule Base: The collection of the fuzzy rules that are expressed as fuzzy condition statements forms the rule base of a fuzzy logic. The rule base provides the various delay based routes for different ranges based on the RTT mean and RTT variance. This proposed approach is generic and should be easily modified to fit with different routing metrics. The Centroid of area method is used as defuzzification methods to produce the non fuzzy set. The fuzzy rules are given below:

- (If RTT mean is Small) and (RTT variance is Small) then Delay is Excellent.
- (If RTT mean is Small) and (RTT variance is Medium) then Delay is Excellent.
- (If RTT mean is Small) and (RTT variance is Large) then Delay is Excellent.
- (If RTT mean is Medium) and (RTT variance is Small) then Delay is Poor.
- (If RTT mean is Medium) and (RTT variance is Medium) then Delay is Average.
- (If RTT mean is Medium) and (RTT variance is Large) then Delay is Excellent.

- (If RTT mean is Large) and (RTT variance is Small) then Delay is Poor.
- (If RTT mean is Large) and (RTT variance is Medium) then Delay is Poor.
- (If RTT mean is Large) and (RTT variance is Large) then Delay is Poor.

Delay

RTT Mean / RTT Var.	Small	Medium	Large
Small	Excellent	Excellent	Excellent
Medium	Poor	Average	Excellent
Large	Poor	Poor	Poor

Table 1: Fuzzy Inference Rules

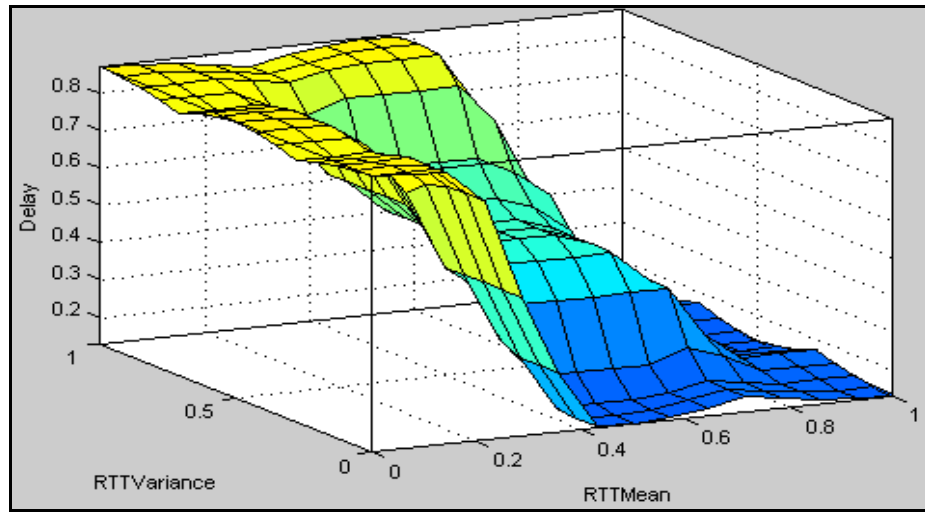


Figure 5: Delay O/P with respect to RTT Mean and RTT Variance

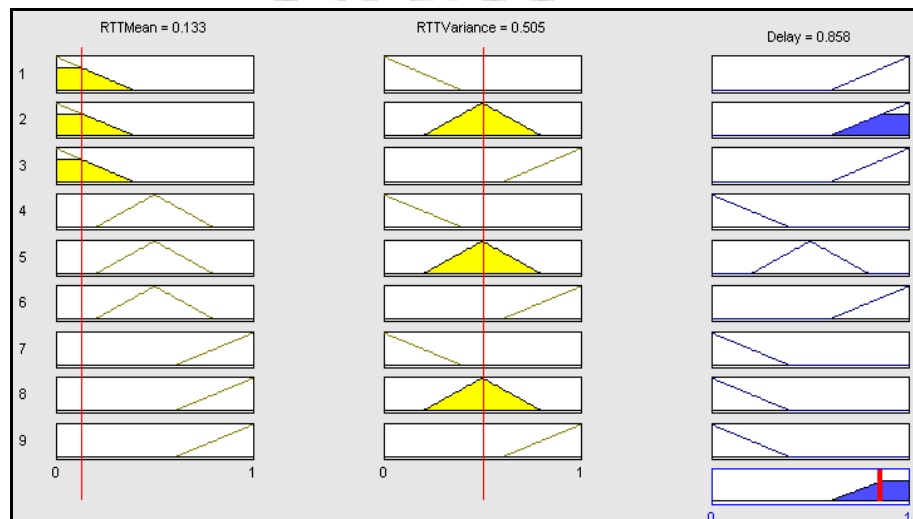


Figure 6: Delay with small RTT Mean and medium RTT Variance

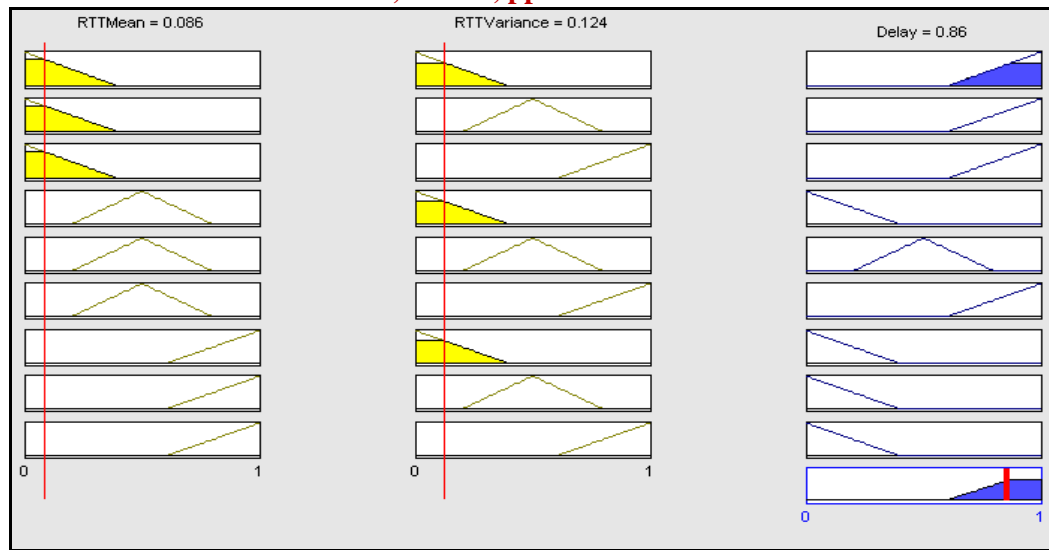


Figure 6: Delay with small RTT Mean and small RTT Variance

Experimental Results: The fuzzy rule base is represented as a 3D-decision surface, presented in figure 5 and MATLAB has been used for the same. Inputs to the proposed routing algorithm are on the horizontal axes and the output is on the vertical axis. The decision surface illustrate that when both RTT mean and RTT variance are small then delay is excellent but, as RTT mean increases up to large with small RTT variance the delay becomes poor. Against it, when RTT mean is small and RTT variance increases up to the large the delay is gain excellent. In the decision surface it is also clear that when RTT mean is small and RTT variance is large then delay is excellent but as we increase the RTT mean up to medium and put RTT variance large then delay is again excellent but as RTT mean reaches at large the delay becomes poor.

Conclusions: We have studied several existing routing algorithms for ad hoc wireless networks and found that no single routing algorithm is the solution for the same. The fuzzy metric approach improves the performance compared with the other approach used traditionally in the routing technique. The proposed approach offers the improvement schemes with its features such as it yields loop free routes, helps in multi path routing, gives the faster response at low overheads and the overall evaluation is positive in the sense that we applied an intelligent algorithm for inferring statistically the internal state of the network, and the outcome was surprisingly accurate. The results of the proposed routing algorithm confirm that the protocol presents a considerable reduction of routing overhead, whereas the overall performance is competitive with other protocols. Optimization extensions on the basic operation of the protocol are also proposed to improve load balancing, bandwidth utilization, and enhance the quality of the routes used.

References

- [1] A. James Freebersyser, B. Leiner, "A DoD perspective on mobile ad hoc networks", in: Charles E. Perkin (Ed.), *Ad hoc Networking*, Addison Wesley Reading, May 2001, pp.29-51.
- [2] J. Macker and S. Corson, "Mobile Ad hoc Networks (MANET)", *IETF WG Charter*, <http://www.ietf.org/html.charters/manetCarter.html>, 1997.
- [3] IEEE Computer Society LAN MAN Standards Committee, "Wireless LAN medium access control (MAC) and physical layer (PHY) specifications", *IEEE Std. 802.11*, 1997, pp. 11-97.
- [4] A. Adya, P. Bahl, J. Padhye, A. Wolman, and L. Zhou. "A Multi -radio unification protocol for IEEE 802.11 wireless networks". In *IEEE International conference on broadband networks*, (BroadNets), 2004.
- [5] C. Perkins, "Ad hoc Networking," Chapter 4, Addison-Wesley, December 2000.
- [6] C. Siva Ram Murthy and B.S. Manoj, "Ad hoc Wireless Networks Architecture and Protocols", Prentice Hall, 2004.
- [7] D.B. Johnson, D. A. Maltz and Y.C. Hu., " The dynamic source routing protocol for mobile ad hoc networks (DSR)," IETF Mobile Ad hoc Networks Working Group, Internet Draft, 16 Apr. 2003.
- [8] K. Wu and J. Harms, "QoS support in mobile ad hoc networks", 2001, pp. 329-342.
- [9] H.J. Zimmerman, "Fuzzy Set Theory and its Applications", 2nd ed. Boston: Kluwer 1991.
- [10] M. Ismail, "Routing Protocols for Ad Hoc Wireless Networks", M.Sc. (ISS) Project, Carleton University, Ontario, Canada, August 2001.
- [11] Souheila BOUMAN. Jalel BEN Othman, "Data security in ad hoc networks using multipath routing", Personal, indoor and Mobile Radio Communications, PIMRC 2003. 14th IEEE Proceedings on Vol. 2, June 2005, pp. 7-10.

Vol. 1, Issue 2, pp. 142-147

- [12] Sushant Jain, "Energy aware communication in ad hoc networks", Technical Report UW-CSE, June 2003, pp. 27-43.
- [13] Anand Prabhu Subramaniam, A.J.Anto, Janani Vasudevan and P. Narayanasamy, "Multipath power sensitive routing protocol for mobile ad hoc networks", WONS 2004, Madonna di Campiglio, Italy, January 2004.
- [14] M. Elizabeth, R. Belding, "Routing approaches in mobile ad hoc networks", www.interscience.wiley.com/cgi-bin/summary/109720221/summary?cretry=1&sretry, 2004.
- [15] I. Stojmenovic, "Position based routing in ad hoc networks", *IEEE Communications Magazine*, July 2002, pp. 128-134.
- [16] Mahesh K., S.R. Marina, "On-demand multipath distance vector routing in ad hoc networks", 9th International Conference on 11-14 Nov. 2001.
- [17] Shafinaz Buruhanudeen, "Overview of ad hoc routing protocols", University of Bradford, UK, Nov. 2002, pp. 59-506.
- [18] L. Cheng and I. Marsic, "Fuzzy reasoning for wireless awareness", *International Journal of wireless information Networks*, Vol. 8, Issue 1, Jan.2001, pp. 15-26.
- [19] P. Gupta and P.R. Kumar, "The capacity of wireless networks," *IEEE Transaction on Information Theory*, Vol. 46. No. 2, March 2000, pp. 388-404.
- [20] V. Wong and V. Leung, "Location management for next generation personal communication networks", *IEEE Network*, Vol. 14, no. 5, 2000, pp. 14-20.
- [21] Z. Ye, S. Kishnamurthy, and S. Tripathi, "A framework for reliable routing in mobile ad hoc network", *Proceedings of IEEE INFOCOM*, 2003, pp. 1-12.

