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Comparative Study of Fuzzy Logic Mobility Based FLM-AODV Routing Protocol and AODV in MANETs

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Abstract

In mobile ad hoc wireless networks (MANETs), traditional protocol like AODV performs well for low mobility of nodes but not for high node mobility. So, it becomes important to consider mobility factor during the path selection procedure of routing protocol. Here, a fuzzy logic mobility based protocol (FLM-AODV) that considers the mobility factor is proposed. Due to the consideration of mobility factor, the proposed protocol has better performance than the traditional AODV. The experiment results show that the proposed protocol has advantages of improved average end-to-end delay and packet delivery ratio (PDR) over existing AODV protocol.

Keywords: *Mobile ad hoc routing, wireless networks, fuzzy logic system*

1. Introduction

Mobile ad hoc networks possess different characteristics like infrastructure less, dynamic topology, mobility etc [1]. These characteristics attract both academia and researcher to design the routing protocol for real-time applications of MANETs like battlefield communication, war rooms, multimedia, conference meeting etc [2]. These routing protocols [3-5] based on their updating routing table, are classified into three categories: 1) Table driven: routing table updation periodically; 2) On demand: routing table updation on demand; 3) Hybrid: a mixture of above mentioned first and second.

With advancement in the portable devices like laptops, smart phones etc., the designing of routing protocol is getting more challenging in comparison to earlier times. In MANETs, each node acts as a router and they communicate with each other either through a direct connection or through intermediate nodes. The nodes can move from one place to another. If the mobility is low, then traditional routing protocols like on demand AODV perform well. However, they only used hop count metric to select the route. For high mobility, the number of broken links gets increased. Due to this link breakage, the mobility metrics become an important parameter to be considered while taking the routing decisions.

In this paper, along with hop count parameter, a new fuzzy logic based mobility metric is also taken into consideration to improve the performance of AODV protocol optimization for PDR and end to end delay. This protocol in short named as FLM-AODV. With the objective of less link breakage, a fuzzy logic based system is incorporated into traditional routing protocol 'AODV'. These mobile nodes can be used to perform the different network operations like forwarding the packets, routing the packets and service discovery. In diverse environment, applications of MANETs own various types of network topologies and multiple characteristics [6]. Since the mobility of nodes are highly dependent on the type of applications and in the environment in which the network exists. Henceforth, it plays an important role in the performance of routing protocols [7]. Therefore, the parameters of protocol to be configured with a mechanism that works dynamically in different network situations and moreover these dynamical configurations must be adaptable to the variations in network topology. Therefore, Mobility parameter is also considered along with the hop count while taking routing decision to select a path in this protocol. The simulation results of the proposed protocol prove the improved performance of FLM-AODV over traditional AODV.

The structure of this paper is ordered as follows: Section 1 describe the introduction of AODV routing protocol. Section 2 describe the existing related research work. The fuzzy logic

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system based proposed method is described in Section 3. Section 4 presents the simulation results of the proposed method, while conclusions are drawn in Section 5.

2. Related Work

In the presence of mobile nodes, it is very difficult to provide the hard Quality of service (QoS). When the nodes are mobile in nature, the topology keeps on varying. Munjal et al., [8] discussed the need for autoconfiguration of protocols in MANET. However, Mobility affects the link breakage and overall performance. Therefore, the mobility of nodes should be taken in account while taking the route decision. It increases the route stability and improves the performance. Marwaha et al., [9] used fuzzy logic based routing algorithm to select the best route based on minimum output value given by fuzzy logic. The input parameters were residual node energy, signal strength and node queue length. Their results proved the superiority of their proposed algorithm over the conventional AODV routing protocol. Arora et al., [10] has improved packet delivery ratio and throughput of various routing protocol based on knowledge base algorithm. In this algorithm, the selected path is said to have the highest mean value of the header number. Sakthivel et al., [11] enhance the lifetime of nodes and improve the network performance by considering energy factor in MPR selection in OLSR routing protocol Song and fang [12] improved the traditional DSR algorithm performance by the using of fuzzy logic system into their proposed method. The parameters that affect the routing decision of their proposed protocol are the bandwidth that is available for link, strength of the signal and Buffer Occupancy Ratio. Xu et al., [13] proposed stable link routing algorithm that considers node movement in specific amount of time. They also considered energy for providing energy awareness of the link. Their approach has resulted into improved performance than the traditional. Michele et. al [14] improved the path by applying fuzzy logic to its method and obtained an increase in the network lifetime. Torshiz et al., [15] enhances the network performance by considering the parameters bandwidth and hop count while selecting the route path. It also improves the network life time by keeping the almost same power dissipation rate of all nodes. To improve the 3D video quality in wireless system M. Alreshoodi et al., [16] selected QOS parameter from both layers i.e. application and physical for its fuzzy logic system. To improve the traffic Management for internet J. Liu and O. Yang [17] proposed traffic management scheme that uses fuzzy logic system based IntelRate controller. They verified the effectiveness and superiority of the intelrate controller over existing explicit traffic control protocols. Fuqaha et al. [18] developed an algorithm for channel estimation and channel selection by using fuzzy based techniques. They reported significant improvement in the communication infrastructure and connection bit error rates.

3. Fuzzy Systems

The principle steps that are followed to consist the Fuzzy inference system are [5, 9, 15]:

1) Input and output linguistic variables selection:

Metrics that affect the routing decision and input for the fuzzy logic system are mobility and hop count. The three linguistic variables that used for the designed fuzzy inference system towards input side are: low, Medium, and High. Towards the output side five linguistic variables are used these are: very low, low, medium, high, and very high, here each variable is having value between 0 to 1.

2) Fuzzification:

This process converts these crisp values in to fuzzy value using rule base where all the rules are defined.

3) Inference engine:

The inference engine in this fuzzy system provides output based on system rule base as defined next.

4) System rule base:

Rule base is the combination of rules that are based upon hop count and mobility of nodes. Each rule is in the form of if then. Here rule base can have maximum here 3×3 rules.

5) Defuzzification:

Finally, with the use of defuzzification process the fuzzified values are converted back to crisp values that can be used in real time systems.

These principle steps of fuzzy inference system are shown in Figure 1.

Table1. Rule Base for FLM-AODV

	Mobility		
Hop count	Low	Medium	High
Low	Very Low	Low	Medium
Medium	Low	Medium	High
High	Medium	High	Very High

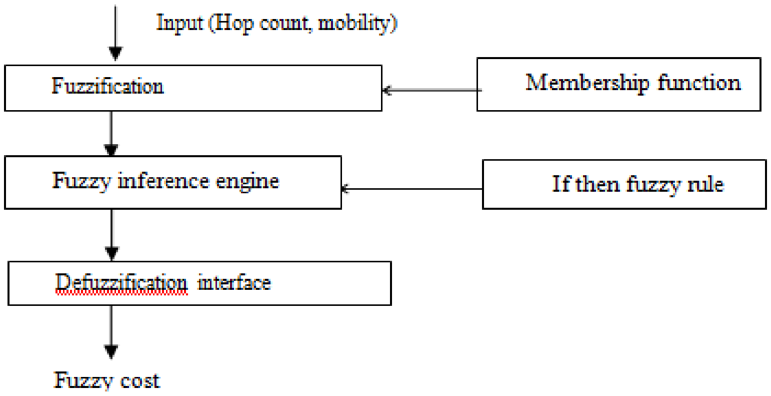

Figure 1. Fuzzy Logic Inference System

3.1. Fuzzy logic Mobility based-AODV (FLM-AODV)

In AODV protocol, a node willing to communicate broadcasts a RREQ packet in the network to find out the path up to the destination node. The transmitting node would be either source node or intermediate node or destination node. The transmitted RREQ packet contains the fuzzy input parameters i.e. hop count and mobility. The input parameters passed by the RREQ packet are processed by the fuzzy logic system to calculate the output fuzzy cost. This output fuzzy cost participates in the path selection process. If the value of current fuzzy cost is smaller than the stored fuzzy cost, then it replaces the stored fuzzy cost while updating the node routing table. This process repeats several times before the packet transmitted by the source node reaches the destination node. On reaching the destination node, the packet selects the path and updates the reverse route entry. The stepwise algorithm for above discussed method is presented in Figure 2.

4. Simulation Results

To measure the effectiveness of the proposed FLM-AODV protocol, the simulation environment is set up. For performance comparison, the fuzzy logic system is integrated into the route selection process of MANETs traditional AODV routing protocol. Due to the availability of network simulator NS2.35, it is used to simulate the proposed FLM-AODV. The simulation parameters considered for FLM-AODV are listed in Table 2. In this simulation scenario, the number of chosen nodes in the networks are 50 and are placed within a 700m X 700m area. The node transmission range is set to 250 m. The movement of nodes takes place according to random waypoint model with node and their speed varies from 0 to 20 m/s.

The CBR traffic pattern, which generates UDP packets from the available nodes, is considered in the simulation. The UDP packet size is 512 bytes. In addition, the MATLAB is used to simulate fuzzy cost by processing the input parameters received from NS2. The output results from MATLAB are routed to NS2 to optimize the routing decision.

Algorithm:-

1. Identify following parameters:

N* = *number of nodes;

S_n* = *Source node; (The node willing to communicate by establishing a connection)

D_n* = *Destination node; (The node where the packet sent by S_n will be received)

I_n* = *Intermediate node; (The node, which will perform both operations i.e. reception and transmission simultaneously)

2. Initiation of RREQ packet; (from S_n to all its neighboring node with QoS values)

3. Extraction of mobility at I_n; (by using packet information)

4. Computation of fuzzycost value for every rule in rule base; (Process carried by fuzzy logic)

5. Computation of precise fuzzycost value, fcost $_{new}$; (defuzzification process)

6.
```
If (In==Sn)
{
        fcost_old=fcost_new;fcost_final= fcost_new;
}
Elseif(In==Dn)
{
        if (fcost_new << fcost_old)
        {
                fcost_old=fcost_new;
                fcost_final=fcost_old;
         (Computation of total fuzzy cost and transmission of RREP through the route with fcost_final from Dn
         to the Sn)
         (on receiving RREP packet Sn establishes path connection to the destination node.)
                        exit;
        }
        Else
        {
                fcost_final=fcost_old;
                        exit;
        }
  }
  Else
  {
                if (fcost_new << fcost_old)
        {
                fcost_old=fcost_new; (RREQ packet is forwarded from In to In+1)
                goto step7;
        }
        Else
        {
          fcost_old=fcost_old; (RREQ packet is discarded)
          goto step 7;
        }
  }
```

7.
```
If (In+1==Dn)
{
        fcost_final=fcost_old;
        (Computation of total fuzzy cost and transmission of RREP through the route with fcost_final from Dn
        to the Sn)
        (on receiving RREP packet Sn establishes path connection to the destination node.)
                        exit;
}
  Else
  {
```

Figure 2. FLM-AODV Algorithm

Table 2. Simulation Parameters

Environment Variable	Values
Routing Protocol	AODV
Simulation area	700*700
Number of nodes	50
Packet size	512
Mobility Model	Random way point
Simulation time	50,100,150,200,250 seconds
Node speed	0-20 m/s
Traffic type	CBR

The evaluation and comparison of two protocols is carried out in terms of following three performance parameters:

1. Packet delivery ratio (PDR): It is the ratio obtained of number of data packet received at the destination node to the total number of data packet transmitted by the source node. Figure 3 demonstrates the variation of PDR with respect to simulation time for in a simulation environment of 50 nodes. It is observed that FLM-AODV has higher packet delivery ratio than the traditional AODV. This increase in PDR is due to more stable of the selected path.

2. End to End Delay: It is the average time taken by the data packet to travel between from source to destination node. From Figure 4, it is observed that the average end-to-end delay of FLM-AODV is lesser than that of traditional AODV.

3. Normalize Routing Load (NRL): It is the ratio of number of control packets and total number of data packets transmitted in the network. Figure 5 displays that the NRL of FLM-AODV is lesser than that of original AODV. The reasons for the less value of NRL is the generation of less number of control packets due to less number of broken links and lower delivery time.

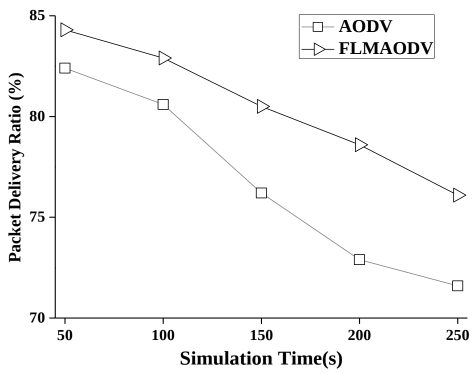

Figure 3. Packet Delivery Ratio vs Simulation time

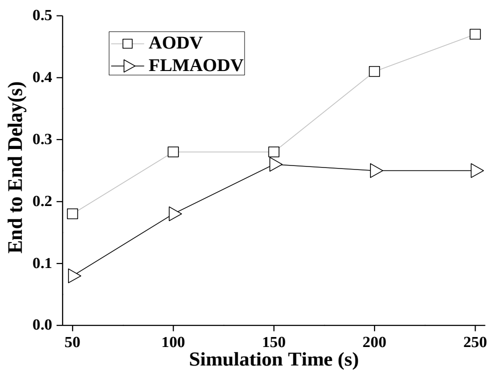

Figure 4. Delay vs Simulation time

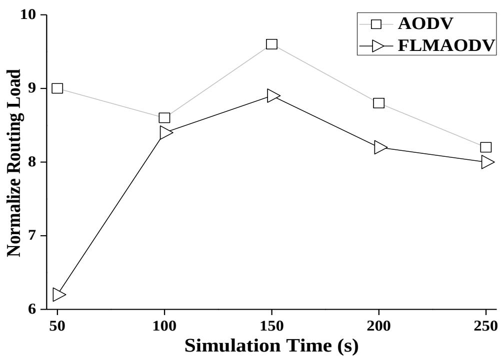

Figure 5. Normalize routing Load vs Simulation time

5. Conclusion

The proposed FLM-AODV routing protocol is presented and its performance is evaluated in this paper. It can select the communication path having more stability than that of traditional AODV. The proposed protocol is simulated by using NS2.35 and MATLAB simulator. The results of the MATLAB simulation i.e. metrics hope count and mobility of nodes are used in the calculation of dynamic fuzzy cost. The comparison of the proposed protocol's simulated performance with that of well-known AODV signified the advantages of the proposed protocol in terms of packet delivery ratio, end to end delay and normalized routing load.

References

[1] CSR Murthy, BS Manoj. Ad Hoc Wireless Networks: Architecture and Protocols. Pearson Ltd. 2004.
[2] Asha G Mahadevan. An Adaptive Cross-Layer Architecture to Optimize QOS Provisioning in MANET. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2017; 6(1): 16-25.
[3] V Sharma, B Alam: Unicaste Routing Protocols in Mobile Ad Hoc Networks: A Survey. *International Journal of Computer Application.* 2012; 51: 148-153.
[4] JM leo Manickam, S Shanmugavel. *Fuzzy based trusted Ad Hoc On-demand distance vector routing protocol for MANET*. Proceedings of 3rd International Conference on Wireless and Mobile Computing, Networking, and communications. 2007.
[5] TJ Ross. Fuzzy logic with Engineering Application. New York: McGraw Hills, Inc. 1995.
[6] R Desai, BP Patil. Prioritized Sweeping Reinforcement Learning Based Routing for MANETs. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2017; 5(2): 383-390.
[7] G Singal, V Laxmi, MS Gaur, S Todi, V Rao, M Tripathi, R Kushwaha. Multi-constraints link stable multicast routing protocol in MANETs. *Elsevier journal of Ad hoc Networks*. 2017; 63: 115-128.
[8] A Munjal, N Singh. Review of stateful address auto configuration protocols in MANETs. *Elsevier journal of Ad hoc Networks*. 2015; 33: 257-368.
[9] S Marwaha, D Srinivasan, CK Tham, A Vasilakos. *Evolutionary fuzzy multi-objective routing for wireless mobile Ad Hoc networks*. Proceedings of International Conference on Evolutionary Computation, CEC 2004 Congress 2. 2004: 1964-1971.
[10] SK Arora, H Monga. Performance evaluation of MANET on the basis of Knowledge Base Algorithm. *Elsevier journal International Journal Optik – international journal for Light and Electron Optics*. 2016; 127(18): 7283-7291.
[11] M Sakthivela, G Palanisamy. Enhancement of accuracy metrics for energy levels in MANETs. *Elsevier journal of Computers & Electrical Engineering*. 2015; 48: 100-108.
[12] W Song, X Fang. *Multi-metric QoS Routing based on Fuzzy Theory in Wireless mesh network*. IET International Conference on Wireless, Mobile and Multimedia Networks. 2006: 1-4.
[13] B Xu, Y Li. A novel link stability and energy aware routing with tradeoff strategy in mobile ad hoc networks. *International Journal of Communication*. 2014; 9(9): 706-713.
[14] MN Lima, Helber WD Silva, ALD Santos, G Pujolle. *Survival Multipath routing for MANETs*. Proceedings of IEEE Conference on Network Operation and Management symposium. 2006: 425-432.
[15] MN Torshiz, H Amintoosi, A Movaghar. *A Fuzzy Energy-based extension to AODV routing*. International Symposium on Telecommunications. 2008: 371-375.
[16] M Alreshoodi, E Danish, J Woods, A Fernando, C De Alwis. Prediction of Perceptual Quality for Mobile Video Using Fuzzy Inference System. *IEEE Transactions on Consumer Electronics*. 2015; 61(4): 546-554.
[17] J Liu, OWW Yang. Using Fuzzy Logic Control to Provide Intelligent Traffic Management Service for High-Speed Networks. *IEEE Transactions on Network and Service Management*. 2013; 10(2): 148-161.
[18] AA Fuqaha, B Khan, A Rayes, M Guizani, O Awwad, GB Brahim. Opportunistic Channel Selection Strategy for Better QoS in Cooperative Networks with Cognitive Radio Capabilities. *IEEE Journal on Selected Areas In Communications*. 2008; 26(1): 156-167.