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A Fuzzy Based Adaptive Congestion Control Gateway Discovery Algorithm for MANET

Ravi Sharma
Department of Computer Science and Engineering,
M.M.M. University of Technology,
Gorakhpur, UP (273010), India
ravi.cs.0904@gmail.com

Rakesh Kumar
Department of Computer Science and Engineering,
M.M.M. University of Technology,
Gorakhpur, UP (273010), India
rkiitr@gmail.com

***Abstract*— Integration of MANET with the Internet allows mobile users from the MANET domain to access wired resources. A lot of work in the research community is undergoing nowadays as this integration helps in sharing important data during earthquake, military operation etc. The connection of ad hoc networks to the Internet is typically established via gateways to extend its coverage area. The gateway is responsible for broadcasting routing information. The routing information contains configuration parameters which create routes to the Internet from MANET nodes by means of Modified Router Advertisement (MRA) packets. Many of the authors given the control mechanism for interval emission of MRA packets but it is still not optimal. So in order to dynamically adjust the T value, in this work, we compute optimum frequency (T value) for interval emission of MRA packets by the Internet gateway and congestion control mechanism for broadcasting or forwarding of MRA packets at an intermediate mobile node in the MANET. we present input parameters which is supported by fuzzy control system and congestion control approach for MRA packets at intermediate nodes supported by randomize mechanism. The work of congestion control is implemented using network simulator (ns-2) and dynamic adjustment of T value is computed on MATLAB using fuzzy inference control system. The adaptive protocol shows enhancement in terms of packet delivery ratio, throughput and decreases end-to-end delay, overhead communication to the existing solution.**

Keywords*— *MANET, Internet, MRA, Internet Gateway Selection, Fuzzy Control System, Congestion Control, MATLAB, NS2 .

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) [1-2] is a group of mobile that formed without the help of the centralized administration, so it is infrastructure less network. In MANET mobile nodes are establish the communication between them directly or indirectly with help packet passing. Since this network creates anywhere, anytime and self-organizing in nature. The demand of this network for personal as well as commercial use is increasing day by because of its nature like easy to establish, no infrastructure cost, place independent etc [3].

In near future, the Internet access forms going to be changed because of mobile nodes and its mobility features, so that computation form also going to be changed. Wireless technology provides quick Internet access without deploying the infrastructure over the multiple wireless networks. A MANET generally considered as stand-alone network and mobiles are communicated to each other, to fulfill the requirement of mobile nodes in its network. The stand-alone feature of MANET limits its services and applications, so for extending its requirement need to provide the Internet [4] connectivity. The MANET-INTERNET integration needs global connectivity [5] approach that provides the access to much popular application chats, mail, file transfer, video conferencing, etc. Integration approach extends the coverage area of MANET as well Internet.

Integration of mobile nodes in a MANET becomes active research for researches in the different organization. To connecting with the Internet there is need of one mobile node in MANET that has two interfaces, one interface communicates with mobile nodes in MANET and second interface of mobile node communicate with outside the MANET. The multihop [6-7] communication required to communicate with the mobile node outside of its proactive area.

The proactive area of Internet Gateway in which it emits the MRA [8-9] packets to its neighbor nodes, so that intermediate update its route to Internet Gateway to forward or broadcast the packets to its destination. In this works, we are provided the fuzzy control inference system [10] to calculate the optimal interval emission (T value) for the Internet Gateway to whether broadcast MRA packet or no and this approach simulated using MATLAB Mamdani inference control system. The other proposal provided to control MRA packets at intermediate nodes, whether broadcast/forward MRA packets to its neighbors and it is simulated using ns2 [11-12].

The paper is structured as follows. Section II presents related work of adaptive protocol and congestion control protocol for the Internet Gateway discovery in MANET. Section III presents proposed work of optimal T value calculation and MRA packets need to forward/broadcast at intermediate nodes. Section IV presents simulation and results analysis using ns2. Section V presents conclusion and future scope of this work.

II. Related Work

A. Adaptive Gateway discovery approach

In Zhang et al. [13], the dynamic adjustment of the advertisement interval emission is based on movement degree. The movement degree calculated as the ratio of a number of GW_SOL packets to the number of registered gateway during the last interval of GWADV. The movement degree(MD) compute as if threshold value is less than to MD value then the Internet Gateway decrease its advertisement periodicity or otherwise it increase its advertisement periodicity.

In Bin et al. [14], the complete adaptive approach is proposed, in which periodic emission of advertisement packet at large interval of time and periodicity is adaptive when mobility detected in the network. It used maximal source coverage work to dynamic adjustment of time to live (TTL) value. At fixed amount of time regular mobility degree (RMD) calculated. The threshold is taken to make a decision whether the advertisement periodicity change or not.

In Boukerche et al. [15], the proposed approach used to calculating the Modified Router Solicitation (MRS) packets generated by each mobile node in MANET i.e. called MRSCOUNT or TMRS. This work based on MRSCOUNT used to make the decision, how many MRS going to receive in next TMRS.

In Yuste et al. [16], the proposed work based on fuzzy control inference system, which controls the interval emission of MRA in its proactive zone. Outside the proactive zone the mobile nodes generate MRS packets. The numbers of inputs parameters are taken to adjustment of interval emission of advertisement packets are Number of received MRS (NMRS), Link Changes (LC) and TTL changes (TTLC). The threshold value 0.5 is used to compare the outcome of fuzzy control inference system. If it exceeds the threshold value then MRA packet broadcast else not.

B. Congestion control Gateway discovery approach

In Hamidian et al. [17], the proposed a mechanism for Internet connectivity for mobile ad-hoc networks by doing alternation into AODV routing protocol. The methods used to provide the Internet connectivity are the reactive, proactive and hybrid approach. In this approach the Internet Gateway selection approach based on number physical hops metric between Internet Gateways and the mobile node.

In Khan et al. [18], the proposed a calculating load along the path and provide the mechanism to route update at each mobile node as the request are processed that reduce the path along the path to transverse from the source node to destination node. This concept increases the network throughput, reduce the routing overhead and help to select less congested path from the network.

In Yuste et al. [19-20], the proposed an adaptive gateway discovery for MANET by taking account these parameters are network load, the node density and node mobility for selection the optimal value of T (interval emission). This approach reduces the congestion on to the network. In type-2 approach, fuzzy control system installed in mobile nodes to calculate the stability factor and fuzzy output is compared with min 0.3 and max 0.8 threshold value to make the decision whether MN forward packets or discard it.

III. Proposed Work

In this work, we determine the optimal value of interval emission (T value) of MRA packets by the Internet gateway in its proactive area, so that each mobile node gets route update for traversing packets. Congestion control mechanism is also proposed for the network so that mobile nodes broadcast or forward the MRA packets to its neighbors or purge it.

A. Adaptive Adjustment of T value

Adaptive adjustment of interval emission (T value) of MRA packet by the gateway to its neighbor mobile nodes. This adaptive mechanism base on some inputs parameters are path request factor, a number of active links and signal ratio factor, so that these parameters are used to decision making of next T value for broadcasting the MRA packets to its near mobile nodes to get update its route for traversing its data packets over the network. This decision making of next T value is designed using MATLAB fuzzy control mechanism for given network parameter as the input to it.

1) Fuzzy Inference Control System: Fuzzy inference control system consist of 4 phases through that input parameters have to pass, they are:

- Fuzzification
- Inference
- Composition
- Defuzzification

2) Adaptive System Input Parameters: The input parameters for calculating optimal value of interval emission (T value) of MRA packets by Internet Gateway are as follows:

a) Path Request Factor(PRF): Source nodes in MANET generate RREQ packet when they are a reactive area for accessing the Internet Gateway and this factor is defined in (1).

$$PRF = NMRS / (NMRS + NSource) \qquad (1)$$

where, NMRS is a number of Modified Router Solicitation (MRS) by source mobile nodes in MANET, for the request to establishing the route to the Internet Gateway and NSource is the number of source nodes in MANET willing to get the service from the Internet.

b) Number of Active Link (NAL): This factor calculated by comparing the active link at the previous stage and current stage that also state the stability factor for the system and this factor is defined in (2).

$$NAL=NAL/\,(NAL+NSource) \tag{2}$$

c) Signal Ratio Factor(SRF): Signal packets used to communicate between nodes over the network to establish the connection between a source node to a destination with the context of error packets over the network that leads to the inefficient system and this is defined in (3).

$$SRF=1-(EP/\,(EP+S)) \tag{3}$$

where, EP is Error packet and SP is Signal Packet over network, while establishing the communication between nodes in MANET.

3) Algorithm for Adaptive Adjustment of T value

Step 1: Identify the inputs as path request factor, the number of active links and signal ratio factor in fuzzy inference control system.
Step 2:Identify the output as T optimal value in fuzzy inference control system.
Step 3:Construct the fuzzy partition with the help of membership function for each input and output.
Here, we have consider input parameters range as low (0,0.5), moderate (0,0.5,1), high (0.5,1) and output parameter range as very low (0,.25), low (0,0.25,0.5), moderate (0.25,0.5,0.75), high (0.5,0.75,1), very high (0.75,1).
Step 4:Construct the knowledge-based for decision-making logic for the system as is given in Table I.
Step 5:Combination mechanism applies here as max method to convert several fuzzy conclusion into a single conclusion.
Step 6: Defuzzification mechanism applies here as centroid method to convert the fuzzy value into crisp value i.e., the T optimal value.

TABLE I. INFERENCE RULES

Optimal T Value	Input Parameters		
	PRF	***NAL***	***SRF***
VH	L	L	L
M	L	L	M
H	L	L	H
M	L	M	L
M	L	M	M
L	L	M	H
L	L	H	L
L	L	H	M
VL	L	H	H
M	M	L	L
M	M	L	M
L	M	L	H
M	M	M	L
M	M	M	M
L	M	M	H
L	M	H	L
L	M	H	M
VL	M	H	H
L	H	L	L
L	H	L	M
VL	H	L	H
L	H	M	L
L	H	M	M
VL	H	M	H
VL	H	H	L
VL	H	H	M
VL	H	H	H

B. Congestion Control Mechanism

Congestion control mechanism work is extended the AODV+ protocol with a purge factor that will be calculated using randomize method into the system. During the gateway advertisement packet broadcasting to near mobile nodes, then intermediate mobile nodes make the decision to either broadcast or forward the advertisement packet to its neighbors or purge it. Before forwarding advertisement packet, every mobile node calculates the purge factor which is a method of the number of hops counts traversed by the advertisement packet. The randomize purge factor is calculated between 0 to 1 and mobile node generates random values between 0 to 1. If the generated random value is higher than the calculated purge factor, then the mobile node forwards the advertisement packet to its outgoing mobile nodes. Otherwise, the advertisement packet is purged. The broadcasting advertisement packets by the gateway, results in multiple advertisement packets via the neighbor's node. Hence it results in increase overhead communication, an end to end delay and a decrease in packet delivery ratio, throughput, and other performance factors. A major percentage of these packets are redundant, when flooding concept are used to broadcasting advertisement packets. The single advertisement packet is enough to update its route from source to destination. Hence in this proposed work for AODV+ protocol used to minimize the redundant advertisement packets, or purge as much as possible of these redundant advertisement packets. The AODV+ purge policy is traditional and its value lesser compare to the higher value of advertisement packet hops count. As advertisement packets at mobile nodes near to gateway, the chance of survival of advertisement packets is higher.

In this work, the purging of redundant advertisement packets eliminates a percentage of advertisement packets that never reach to others nodes in the network, resulting in a decrease of network congestion. Hence, packet delivery ratio, throughput is should be higher and an end to end delivery, overhead communication packets is should be lesser than compare to AODV+ protocol. The following algorithm shows the workflow, that how the intermediate mobile nodes carry out the decision-making task by generating purge factor and compare to a random generating value between 0 to 1.

1) Randomize Purge Factor: The system calculates random number by using rand() method for setting threshold in the system. The random number is used in this system to compare the calculated purge factor using AODV+ advertisement header field i.e, hop count. The random numbers is compared with purge factor, whether to broadcast/forward MRA packets by intermediate mobile to its neighbors or purge it.

2) Algorithm for Congestion Control:

Step 1: Calculate random number using rand() method and normalize it.

Step 2:Calculate purge factor= (1/(Hop_count_of_ advertisement_packet + 1)).

Step 3:Calculate value between 0 and 1 as a random number.

Step 4:If (random_number > purge_factor) then broadcast / forward advertisement packet.

IV. SIMULATION AND RESULT ANALYSIS

Our work consists of two parts:

- In the first part, we calculate optimal value interval emission of MRA packets by Internet Gateway with the given input parameters which is implemented in MATLAB using fuzzy inference control system.
- In the second part, we provide congestion control mechanism at intermediate nodes in MANET, whether to broadcast MRA packets to its neighbors or purge it i.e., simulated on network simulator (ns 2).

Let’s discuss simulation and analysis with inputs values and output value:

A. Calculation of Optimal T value on MATLAB Fuzzy Inference System

The application based calculation of optimal interval value (T value) on MATLAB fuzzy inference control system as shown in a systematic way:

Step 1: Construction of Input and Output parameters using triangular membership as shown in Fig. 1 and Fig. 2.

Step 2: Construction of Output parameters using triangular membership as shown in Fig. 2.

Step 3: Construction of knowledge based on MATLAB rule editor shown in Fig. 3.

Step 4: Calculation of optimal T value using combination and defuzzification mechanism for input parameters as shown in Fig. 4.

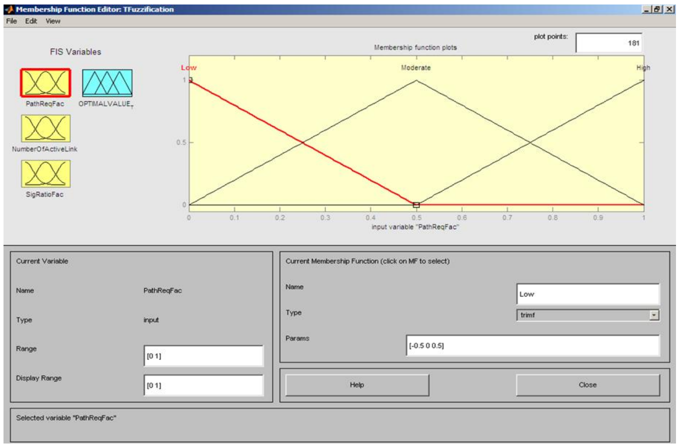

Fig. 1. Input membership function editor

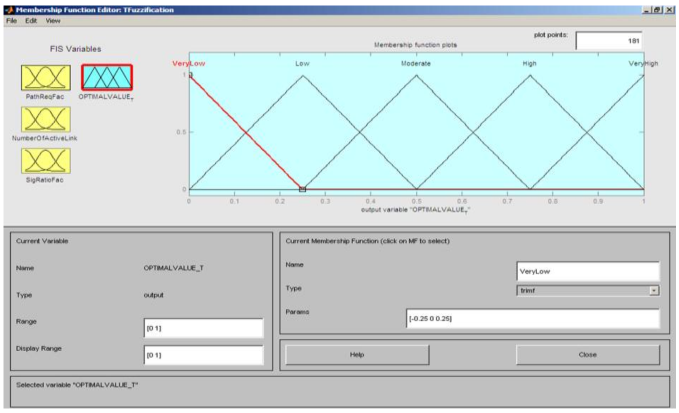

Fig. 2. Output membership function editor

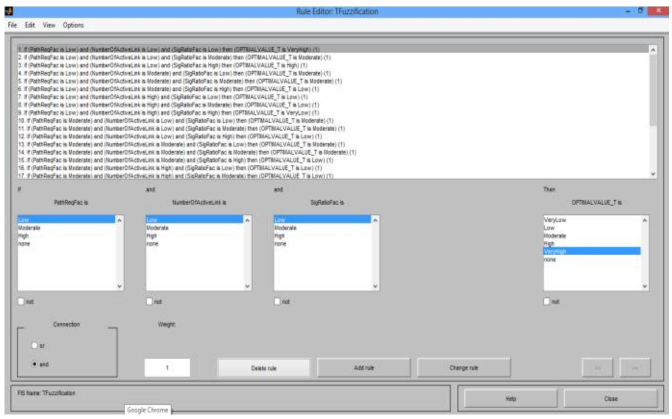

Fig. 3. Fuzzy system rules editor

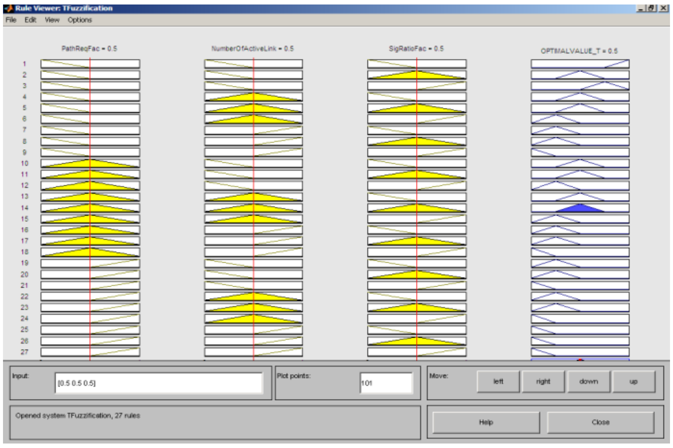

Fig. 4. Fuzzy system rule viewer

B. *Implementation of Congestion Control Mechanism using NS2*

In this work congestion control mechanism given for AODV+ routing protocol, that makes a decision at an intermediate node in MANET, whether MRA packets needs to broadcast or forward to its neighbors or purge it. The congestion control mechanism that is implemented on ns2 using extending AODV+ protocol i.e., MAODV+.

1) Simulation Scenario: The inputs are taken into the system to construct system scenario, a traffic model and others inputs parameters are represented in Table II.

TABLE II. SIMULATION PARAMETERS

Parameter	Value
Simulator	Ns-2 (ver. 2.34)
Simulation Time	10s to 50s
Number of Mobile nodes	25
Number of Wired nodes	2
Number of Internet Gateway	4
Routing Protocol	MAODV+
Traffic Agent	CBR
Mobility Model	Random Waypoint
Mobility Speed	10-20 m/s
Terrain area	830m × 608 m
Transmission Range	250 meter

2) Comparison Criteria: Performance of AODV+ and MAODV+ protocols are evaluated for congestion control mechanism at intermediate nodes in MANET, after the extensive simulation of these protocols on NS2 by the varying simulation input parameter from 10 to 50s.

a) Average Packet Delivery Ratio: Average packet delivery ratio of MAODV+ is better in term of AODV+ result. We observed the data by varying the input simulation parameter that initially the result of MODV+ is better than the AODV+, but after varying input simulation time parameter from 10s to 50s the difference between these protocols going to decreasing i.e., shown in Fig. 5.

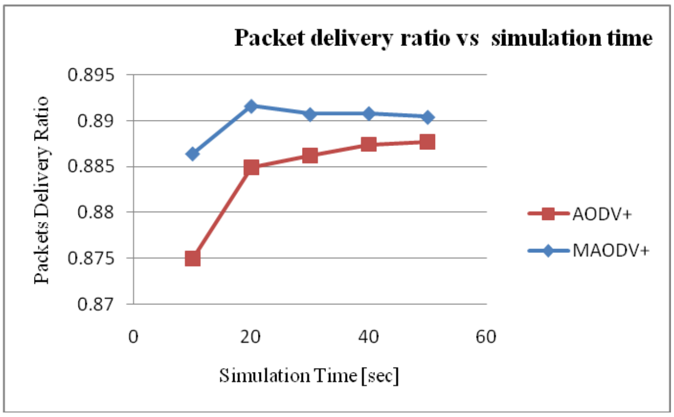

Fig. 5. Average packet delivery vs simulation time

b) Average End to End Delay: The Average end to end delay of MAODV+ is better in term of AODV+ result. We observed the data by varying the input simulation parameter that initially the result of MODV+ is much better than the AODV+ at 10s, but after 20s simulation time the difference between these protocols become less i.e., shown in Fig. 6.

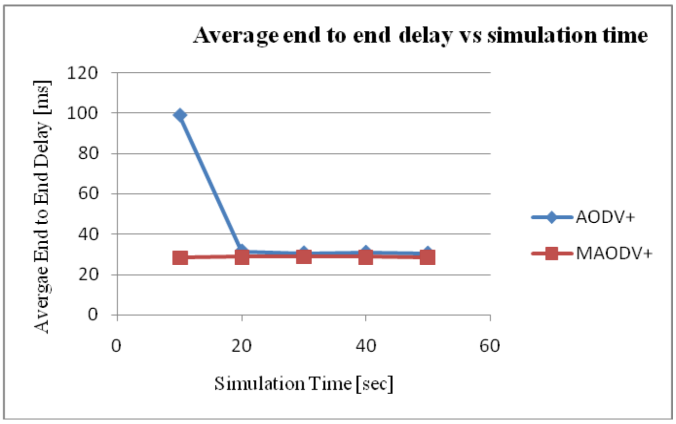

Fig. 6. Average end to end delay vs simulation time

c) Average Throughput: The average throughput of MAODV+ is better in term of AODV+ result. We observed the data by varying the input simulation parameter that the result of MODV+ is better than the AODV+, but with a small difference between them i.e., shown in Fig. 7.

d) Communication Overhead: The communication overhead of MAODV+ is better in term of AODV+ result. We observed the data by varying the input simulation parameter that initially the result of MODV+ is better than the AODV+, but after varying input simulation time parameter from 10s to 50s the difference between these protocols going to increasing i.e., shown in Fig. 8.

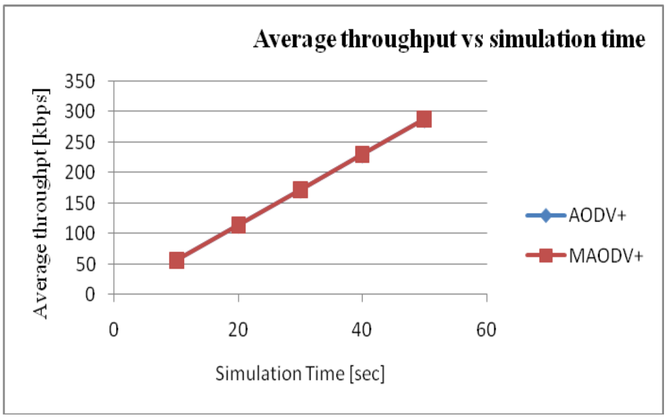

Fig. 7. Average throughput vs simulation time

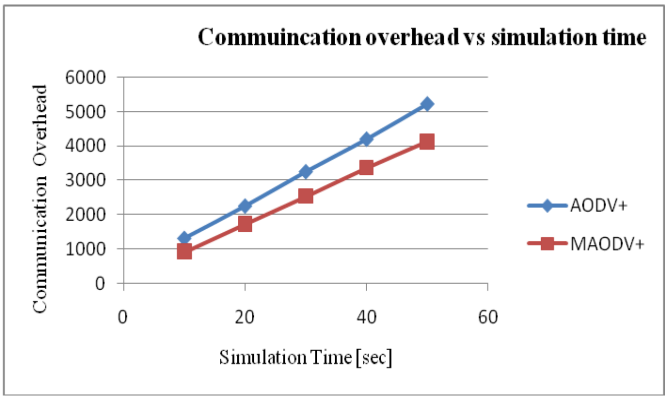

Fig. 8. Communication overhead vs simulation time

V. CONCLUSION AND FUTURE WORKS

The proposed work provides different parameters for computing the optimal value of interval emission (T value) of MRA packets by Internet Gateway to its neighbouring mobile nodes in MANET and the modified congestion control mechanism decides that MRA packets at intermediate mobile nodes would get broadcast/forward to neighbours or else purge it, which in turn increase the throughput and packet delivery ratio as well as decrease communication overhead and end to end delay for this network.

Further in near future this proposed works need to be carried out to compute optimal value of interval emission (T value) of MRA packets using MATLAB fuzzy inference control system need to incorporate into NS 2 to be simulated for obtaining the expected result for MANET-INTERNET integration and the modified congestion control mechanism at intermediate nodes for broadcasting/forwarding of MRA packets to increase the network performance needs further investigation to get better results.

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