Analytical Approach to Estimate the occurrence of bottleneck node in multi hop communication Network

Y. Srinivasa Rao*, Dr. Mohammed Ali Hussain#

*Research Scholar, Dept. of CS, Dravidian University, Kuppam, Andhra Pradesh, India.

#Professor, Dept. of ECM, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P, India .

Abstract- Designing optimistic medium access control protocol for MANET under real time traffic is greatest stimulating job due to its characteristics such as mobility, heterogeneity and constrained resources. Network load adaption is one of eminent substantial issue in efficient MAC protocol designing. In literature number of MAC protocols designed for MANET by addressing the issue of load balancing, while developing the efficient routing protocols to get efficient results regarding packet delivery and resource conservation. However these protocols did not consider the problem of bottleneck intermediate node in multi hop communication medium. The key difficulty with bottleneck Wireless communication [1]consist of two types of communication models i.e. wireless infrastructure based model and wireless infrastructure less model. In wireless infrastructure model consist of central coordinator between communication entities. But, in wireless infrastructure less model communication in happen without central coordinator. Here communicating nodes communicate directly if they are present in the radio range of one another, otherwise they need to take the help of intermediate nodes for communication. Thus, wireless infrastructure less network from multi hop communication model. Thus the nodes need to submit their resources for communication. Example of this types of network is Mobile ad hoc network, MANET in short [2]. If the available resources are constrained or limited then the performance of communication degrades. MANET acts as a peer to peer communication model as nodes in a network need to behave as a router to forward the packets of other nodes and as well as host to transmit its own packets. Selecting neighbor node and forward the packets based on its resources or packet handling capacity is a challenging task i.e. designing appropriate optimistic MAC protocol is challenging task in MANET, as nodes in a network has constrainedresources such as battery, buffer and processing capacity and communication range.

Due to theses limited resources, MANET gains an attraction towards the researchers to develop various efficient MAC protocols to establish efficient communication between communication entities. The IEEE 802.11 [3] specify the two methods for channel access. First method is distributed coordination function (DCF), which is contention based approach for channel access and second method is point coordination function (PCF), which is contagion free approach intermediate node is packet loss due to congestion in node buffer. In this paper we design a probabilistic model to estimate the occurrence of bottleneck node in multi hop communication network. This estimation is used in MAC protocol to reduce the packet loss during the communication and Send the packets to those intermediate nodes which are capable of handling the traffic without loss.

Keywords- MANETs, Bottleneck node, Poison random Process & Energy.

I. INTRODUCTION

for channel access. Distributed coordination function work based on the principle of Carrier Sense multiple Access/Collision Avoidance (CSMA/CA), which is default approach for accessing channel in wireless networks. It is prove equal opportunity or priority to all the nodes to access the medium. For instance, any node want to participate in communication, then it check the medium for its status whether it is engage in other communication or it is free. If it finds the medium as free, then node needs to wait for some predefined interval of time i.e., DIFS (distributed coordination function inter frame space). Again it check whether the medium is free or busy, if it is free then it start the communication. If it finds that medium is not free then node wait for the wait for random interval of time and sense the medium again.

The another mechanism of IEEE 802.11 to access the channel is Point coordination function, which access the medium through centralized method by controlling and coordinating the channel access mechanism with the help of polls other nodes and permit them to access the contention fre channel. Both, point coordination function (PCF) and Distributed coordination function (DCF) [4] used to access the contention free channel and are used for inter frame spacing cordiantion and controlling.

Later IEEE 802.11 e [5] is developed to provide QoS communication by developing EDCA [] mechanism, which is the enhancement of existing 802.11 distributed coordination function (DCF) by enabling the distributed channel access. It is the method of enabling the service differentiation to the various traffic patterns. IEEE 802.11 e EDCF is shown in figure 1. Enhanced DCF categorized the incoming traffic towards the node into four sub categories i.e., access sub category for best effort, voice, video and background traffics. EDCA defines different channel access settings to different sub categories incoming traffics, so that every incoming traffic has its own priority to access the channel. Parameters setting of EDCA are CWmax(),CWmin(),AIFS (), and retry-limit. Every sub access subcategory has buffer space, queue and behave as a self-sufficient back-off entity.

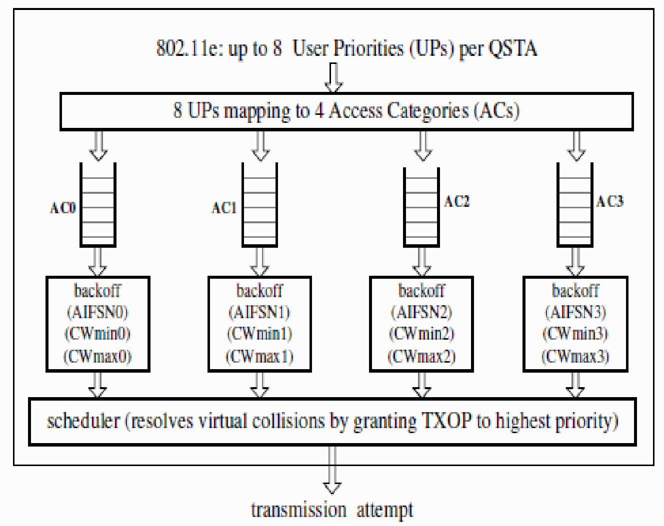

Fig.1: for IEEE 802.11e EDCA

These MAC protocol only consider about the sending node status but not intermediate node status. If node receives heavy traffic because of present in route to forward the traffic of multiple nodes, and node receive the traffic more than its handling capacity then node drops the packet due to buffer overflow. Thus this paper design a probabilistic model to analyze the status of an intermediate node to become bottleneck to drop the packets due to buffer overflow. This mechanism computes the average queue length and average waiting time of the current packet of an intermediate node, and it is useful for controlling packets of an intermediate node and hence improve the communication performance.

II. ANALYTICAL APPROACH TO ESTIMATE THE OCCURRENCE OF BOTTLENECK

We consider the multi-hop MANET [6] composed of mobile devises with heterogeneity in their resources and are disseminated in wireless communication area. Nodes in a network have constrained resources with respect to battery, buffer and computation capability. Source node directly communicate with destination node if it is present in its radio range. Multi hop communication is happen when source and destination are not present in a radio range of one another, and they need to be relay on an intermediate node.Here an intermediate node need to acts as a router, and apply its resources to achievesuccessful communication. If the route selection metric is based on energy aware or residual energy or node satisfies threshold level of energy, then an intermediate node become bottleneck to forward the packets from multiple sources. For heterogeneous mobile nodes over a large geographical area, Poisson point distribution is a best approximation [7].

To enable communication among the multi-hop communication entities, we enable source and destination with an intermediate node needs to be active for communication. Here source start transmitting packets to destination through intermediate nodes. Packets get drop from an intermediate node, if the incoming packets towards it greater than its buffer capacity [9]. Without loss of generality, we are considering the constrained mobile devises with below attributes:

(i) An intermediate node must be an active intermediate node to forward the packets. Active intermediate node is a node is ready to forward the packets of source node.
(ii) Every intermediate node has sufficient resources to forward the packets
(iii) Let an intermediate node has finite buffer and can store the N_p number of packets, buffer further divided into inline out line buffer. Arriving packet first store in inline buffer and according to its diction it is forwarded to next node by storing inside outline buffer
(iv) In ideal condition an intermediate node process $'n'$ number of packets from its buffer$(1 < n \leq N_p)$within a given time interval. In a particular interval of time let $'t'$ node can process $'\alpha'$ number of packets from its buffer.
(v) Queue develop at node buffer if packet arrived at node more than $'\alpha'$ in particular time interval $'t'$ and if the queue size is more than the buffer capacity then the packets get dropped from an intermediate node.
(vi) TO evaluate the probability of packet drop from an intermediate node due to buffer overflow, we consider the following methodology

Packets arrived at node buffer randomly, if coming packets are more than the value of $'\alpha'$ in particular time interval $'t'$ then queue is formed, and this formation of queue is also random. We considering the multi hop MANET scenario, in which multiple sources are trying to forward the packet through an intermediate node in particular time interval $'t'$. From poison random process, we compute the mean queue formation of buffer due to arriving packets from multiple sources in small interval of time $'\Delta t'$ is computed by following equation(1).

$$Mean\ queue\ formation = \frac{\text{Queue formation}}{Number\ of\ packets} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Above equation (1) is validated by below considerations

1. Probability of creation of queue size at an intermediate node due to one packet in particular small time interval $'\Delta t'$ is independent of other packet's queue creation with another time interval. If there is no queue formation in a particular time interval $'\Delta t'$ then it is computed as $'1 - queu\ due\ to\ one\ packet\ at\ time\ interval\ '\Delta t'$ '
2. Now, exact queue $'q'$ formation by incoming packets let $'P_n'$ at buffer in time interval $'t'$, is computed as

$$P(q) = \frac{(\vartheta t)^q e^{-\vartheta t}}{q!} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Buffer formation is depends on incoming packets in particular amount of time with multiple sources and packet departure process of an intermediate node. If the queue size of node is reached the capacity of node buffer, then next incoming packet get drop from an intermediate node. Thus we need to compute the probability of number of packets present in the node buffer is calculated by below equation (3) .

$$\left(\frac{packet\ arrival\ rate}{\beta packet\ departure\ rate}\right)^n \left(1 + \left(\frac{packet\ arrival\ rate}{packet\ departure\ rate}\right)\right) \ldots(3)$$

Where,

$n = number\ of\ packets$

If the packet wait inside the queue more than it life time, and still packets are arrived by an source node then packets get dropped by the node. Packet waiting time is computed by following equation (4)

$$\left(\frac{packet\ arrival\ rate}{packet\ departure\ rate}\right) * \left(e^{-(packet\ arrival\ rate - packet\ departure\ rate)*t}\right) \ldots\ldots\ldots\ldots(4)$$

III. PERFORMANCE RESULTS

To estimate the neighbor node buffer status, we consider the multi hop communication model in MANET with variable number of nodes dissimilated in radio communication region of 1000x1000 sq units. We assume that the node can store up to packets in its node buffer for communication after that incoming packets to node will drop from buffer. A packet life time is considered as 200ms. The variable packet arrival and departure times are considered. Performance results are shown in figure 1,2,3 and 4.

1. Queue size at node buffer due to variable average number of packets arrived towards it
2. The average packets departure intervals are considered as 0.02s and 0.0166 s.
3. Consider the two intermediate nodes with different packet arrivals and departures, as shown in figure 1

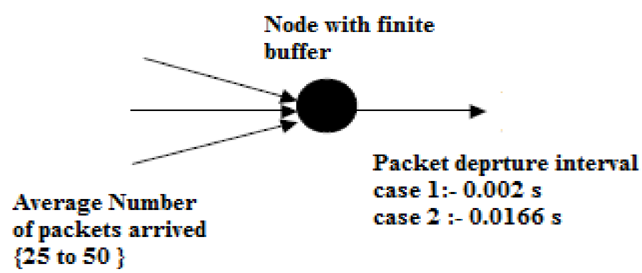

Fig.2: Variable arrival and departure pattern at two intermediate nodes

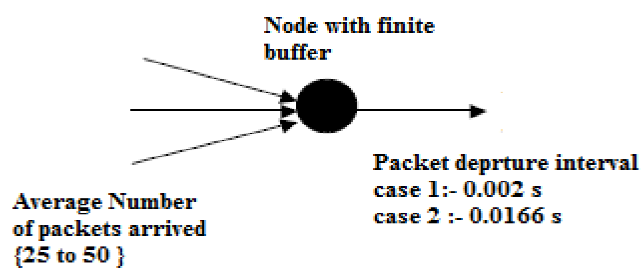

Fig.3: Variable arrival and departure pattern at two intermediate nodes

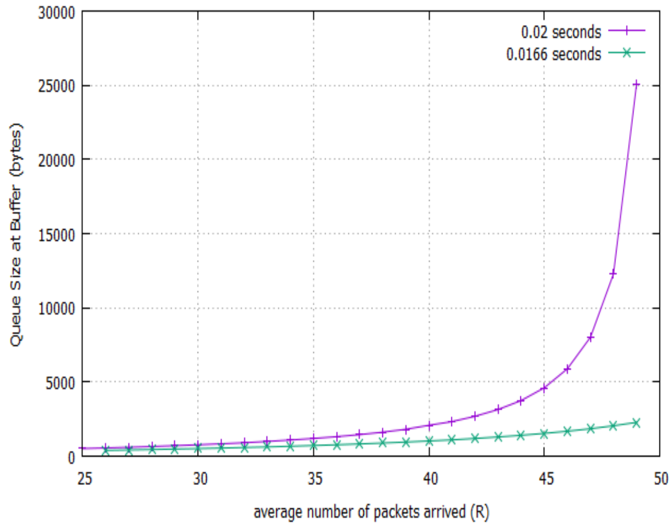

Fig.4: Queue size of buffer different packet arrivals

In above figure 2, packets drop by node two at packet arrival rate reach more than 45. However packet drops due to expire of TTL [8] occur earlier than the arrival rate reach more than 45, which is shown in figure 3.

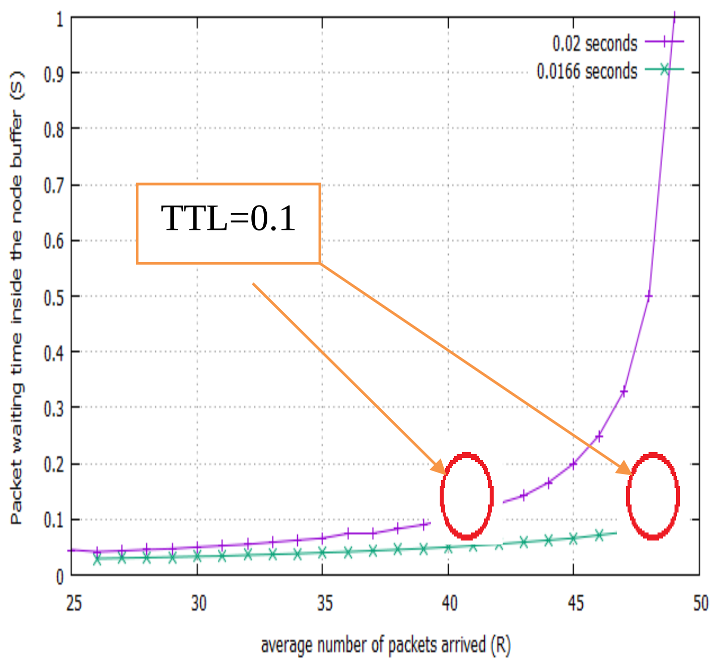

Fig.5: Packet waiting time inside the buffer at different packet arrivals

Performance results clearly indicate that MANET needs an efficient medium access control protocol [10] to extend the network performance by reducing the packet loss by an intermediate node.

IV. CONCLUSION

This paper develops a probabilistic model to evaluate the packet drop due to buffer overflow from an intermediate node in different traffic conditions. This model is useful for MAC protocols decide whether it needs to transmit packet to its intended destination or not through particular intermediate node. The packet loss estimation, average waiting time in the buffer and queue length in buffer is used to control the traffic towards the input buffer and to decide the node to take part of route or not.

V. REFERENCES

[1]. Tse, David, and PramodViswanath. *Fundamentals of wireless communication*. Cambridge university press, 2005.

[2]. Roy, RadhikaRanjan. *Handbook of mobile ad hoc networks for mobility models*. Springer Science & Business Media, 2010.

[3]. Gossain, Hrishikesh, NageshNandiraju, Kumar Anand, and Dharma P. Agrawal. "Supporting MAC layer multicast in IEEE 802.11 based MANETs: Issues and solutions." In *Local Computer Networks, 2004. 29th Annual IEEE International Conference on*, pp. 172-179. IEEE, 2004.

[4]. Bianchi, Giuseppe. "Performance analysis of the IEEE 802.11 distributed coordination function." *IEEE Journal on selected areas in communications* 18, no. 3 (2000): 535-547.

[5]. Choi, Sunghyun, Javier Del Prado, and Stefan Mangold. "IEEE 802.11 e contention-based channel access (EDCF) performance evaluation." In *Communications, 2003. ICC'03. IEEE International Conference on*, vol. 2, pp. 1151-1156. IEEE, 2003.

[6]. Broch, Josh, David A. Maltz, David B. Johnson, Yih-Chun Hu, and JorjetaJetcheva. "A performance comparison of multi-hop wireless ad hoc network routing protocols." In *Proceedings of the 4th annual ACM/IEEE international conference on Mobile computing and networking*, pp. 85-97. ACM, 1998.

[7]. Mohammad, Arshad Ahmad Khan, Ali Mirza, and SrikanthVemuru. "Analytical Model for Evaluating the Bottleneck Node in MANETs." *Indian Journal of Science and Technology* 9, no. 31 (2016).

[8]. Mohammad, Arshad Ahmad Khan, Ali MirzaMahmood, and SrikanthVemuru. "Energy-Aware Reliable Routing by Considering Current Residual Condition of Nodes in MANETs." In *Soft Computing in Data Analytics*, pp. 441-452. Springer, Singapore, 2019.

[9]. Lee, S-J., and Mario Gerla. "Dynamic load-aware routing in ad hoc networks." In *Communications, 2001. ICC 2001. IEEE International Conference on*, vol. 10, pp. 3206-3210. IEEE, 2001.

[10]. Rao, Y. Srinivasa, and Mohammed Ali Hussain. "Dynamic MAC Protocol to Enhancing the Quality of Real Time Traffic in MANET Using Network Load Adaptation." (2018): 1612-1617.