Accountability of WMNs using BEB Algorithm

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Abstract- Wireless mesh networks (WMNs) has the ability of dynamic self-organization, self-configuration and self-healing. These features facilitate quick deployment, easy maintenance, low cost and high scalability. These also provide cost effective solutions for internet facilities which has led to their popularity. There is an access of shared medium by all the existing nodes in the network. It may lead to collisions when multiple nodes access the medium simultaneously, thereby increasing the congestion in network. The Binary Exponential Back-off Algorithm will control the shared medium access and helps to reduce collisions and congestion in the network.

Keywords: Binary Exponential Back-off, Contention Window, DIFS, IEEE 802.11, SIFS, Wireless Mesh Network.

I. INTRODUCTION

Wireless mesh network (WMN) is a collection of nodes connected in a wireless fashion and communicating through mesh topology. It is a self-organized and self-configured network. It consists of two types of nodes, Mesh Clients, which are the wireless devices like mobile phones, laptops etc. and Mesh Routers, which are responsible for forwarding the traffic within the network or among other connected networks [13].

Mesh routers serve as the backbone in these networks. Some mesh routers have the extended functionality of gateways/bridges, which enhances their capability of connecting with other networks. They have minimum mobility and support multi-hop routing. Sometimes, mesh clients can also act as routers in the network. The range within which the radio nodes communicate as a single network is termed as Mesh cloud [13].Wireless mesh networking is also a type of ad-hoc networking but with enhanced capabilities like more reliability, more robust, easy network maintenance, inter-operability with other type of networks, service area coverage etc [1].

Wireless mesh networks can be Decentralized, in which there is no central controller in the network to monitor and control the communication or Centralized, in which there is a central controlling node in the network to monitor the communications [13].These networks offer a great extent of redundancy and are thereby, very reliable networks. Whenever any node in the network fails, it doesn't affect the other communicating nodes because each node is connected to multiple nodes, thereby, making it easier to build up an alternate route to the destination. Since these networks support multi-hop routing, they help to carry out communications at very large distances through intermediary nodes, which perform routing/packet forwarding.

WMN is a promising wireless technology for a wide variety of applications like broadband home networking, community and neighborhood networking, enterprise networking etc and is gaining a wide popularity because it needs minimal upfront investments. Another advantage of WMNs is that these can be deployed incrementally, one node at a time, as needed [2].

II.IEEE 802.11 STANDARDS

The original IEEE 802.11 standard was first published in 1997 with an aim to define Medium Access Control (MAC) layer and Physical (PHY) layer specifications for wireless connectivity for fixed, portable and moving stations within local area. It also describes wireless LAN architecture, including functions and services required by compliant IEEE 802.11 devices to operate within different possible types of Wireless LAN configurations defined in the standard. Further, this standard was modified and extended to support new features and functionalities of security, QoS (Quality of Service), better data transmission rates etc [4].

The additional IEEE 802.11 Standards are as listed below:

*a) IEEE 802.11 a***:** This standard was released in 1999. It provides a new physical layer specification in 5GHz band to enable faster data transmission rates. The MAC layer specification is same as in the original standard. The new PHY layer specification uses Orthogonal Frequency Division Multiplexing (OFDM) system. It provides a wireless LAN with data payload communication capacity of 6, 9, 12, 18, 24, 36, 48, 54 Mbps. This standard defines 12 different channels for the operation of OFDM PHY [4].

b) IEEE 802.11 b: This standard, approved in September 1999, is a natural extension to the original standard. It serves the purpose of higher data transmission rates using the same 2.4 GHz ISM band. It provides 5.5 and 11 Mbps payload data rates in addition to 1 Mbps and 2Mbps data rates of the original standard. Additionally, mechanisms have also been defined that allow discovery and negotiation of a common transmission scheme between the two devices [4].

c) IEEE 802.11g: This standard was approved in June 2003 and it also operates in 2.4 GHz ISM band. It provides for increased data rates up to 54Mbps. An extended rate PHY (ERP) has been defined to achieve this increase [4].

2.1. Comparison of various IEEE 802.11 standards

The comparison of various IEEE standards [5] is as shown in table 1 below:

Table 1: Comparison of IEEE 802.11 standards

Parameter/ Standard	**Bandwidth (MHz)**	**Frequency (GHz)**	**Data rate (Mbps)**	**No. of radio channels**
IEEE 802.11 (June 1997)	22	2.4	1,2	13
IEEE 802.11a (Sept 1999)	20	5	6,9,12,18,24.36.48.54	12
IEEE802.11b (Sept 1999)	22	2.4	1,2,5.5,11	13
IEEE 802.11g (June 2003)	20	2.4	6,9,12,18,24,36,48,54 Additional 22 ,33	13

III. PROBLEM DEFINITION

Wireless mesh networks are based on IEEE 802.11 standard and consist of multiple nodes and access points working in a shared medium. The resources in a shared medium are fixed and common for all stations communicating in the network. Therefore, there is a wide possibility that multiple stations may try to access the resources and the medium simultaneously which leads to collisions in the network. This type of situation increases time delays and prevents other stations to access the medium further until the collisions are resolved. Thus the performance of the network degrades. So there is need for a mechanism for an efficient access to the shared medium in order to minimise collisions.

Secondly, in most approaches successful transmissions are marked by acknowledgement packets sent by the receiver to the sender within some specified time interval. The collisions in the network increase time delays and congest the network due to which acknowledgement timeout occurs for other communicating stations. In such time out situations the sender assumes that the packet has been either dropped or lost in the network, even though either the packet or its acknowledgement is struggling somewhere in the mid-way to reach the receiver/ sender respectively. So such packet and acknowledgement delays cause the sender to retransmit the packets again and again till it receives the acknowledgement. These re-transmitted packets also increase the network traffic and congestion. Therefore there is a need to have some limit for re-transmission.

In order to overcome the above problems of shared medium, a binary exponential back-off algorithm has been adopted by IEEE 802.11.

F. Cali et. al. [3] had proposed for using p-persistent MAC protocol, in which a station can transmit with probability p and refrain from transmitting with probability 1-p. The value of p was to be calculated at runtime and was to be updated after each successful transmission. The problem associated with this approach was complexity for computing the value of p and determining the state of network.

Maninder Kaur et. al [8] had given a mathematical solution to avoid congestion and analyse snoop behaviour in wired cum wireless network. A snoop protocol had been considered as a solution for problems faced by TCP in wireless networks. Snoop Protocol introduces a snoop agent at base stations which monitors packet flow, maintains a packet cache and thus recovers lost packets locally.

P. Chatzimisios, et. al.[10] and J. A. Moura et. al. [6] have suggested an exponential decrease in the CW value, assuming a fixed scale for decrease. The network conditions were not taken into consideration for this. This was considered as better approach to reset CW value slowly on a successful transmission as it would deal better with the remaining congestion in network. The other stations would wait for some extra time before accessing the medium as compared to the standard algorithm, thus reducing chances of unexpected collisions.

Maali Albalt et. al. had suggested a history based back-off algorithm in which the size of contention window was adjusted by taking into account the history of past trials for transmission [7]. Practically, maintaining history of previous trials in an extra variable and keeping it updated creates an extra overhead in the network.

Tahiry Razafindralambo [12] et. al. have proposed a simple back-off algorithm that relies only on local information, as successful transmissions and collisions under- gone by each station without taking advantage of the carrier sensing mechanism nor the packets that can be decoded. When the number of stations is not known, it is difficult for the protocol to have an optimal behavior.

3.1. Binary Exponential Back-off (BEB) Algorithm

According to this algorithm, the waiting time of a station is increased exponentially if the medium is found busy. Alternately, it is set to minimum if a successful transmission takes place [7].

Each station senses the medium for the time interval consisting of DCF (Distributed coordination function) Inter Frame Space (DIFS) and current value of Back- off timer.

DIFS [7] is calculated as:

$$DIFS=SIFS + (2*SlotTime) \qquad (1)$$

where SIFS (Short Inter Frame Space) is the time interval between data frame sent and the acknowledgement received.

Back- off timer [7] is randomly picked in the range of current contention window of the station i.e. [0, CW-1].

If the station remains idle for an interval equal to DIFS, it can start its transmission procedure.

There are two control packets used before the actual transmission:

a) RTS(Request to Send)
b) CTS(Clear to Send)

The station that needs to transmit sends RTS packet to the destined station and waits for the response, i.e., CTS packet from the receiver. DCF mechanism [7] is summarised as in Figure 1. After receiving the CTS packet, the sender actually transmits the data and waits for an acknowledgement. A positive acknowledgement is received in case of successful transmission and CW (Contention window) value is set to minimum [7], i.e,

$$CWnew=CWmin \qquad (2)$$

On the other hand, if the acknowledgement is not received within time period of AckTimeOut, it implies that collision has occurred. Then, re-transmission procedure is followed if the re-transmission limit is not reached. The re-transmission limit is as given below [7]:

a) 7 for short frames
b) 4 for long frames

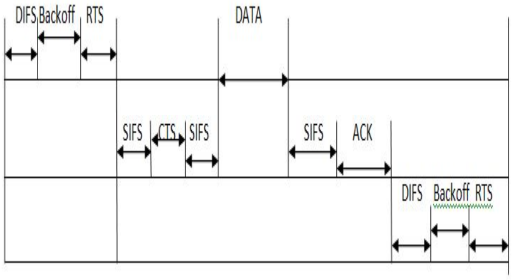

Figure 1 DCF operation

If the re-transmission limit is reached, the frame is dropped. If not, then CW value is increased exponentially.

$$CWnew=min\,[2*CWold,\ CWmax] \qquad (3)$$

If the station is sensed to be busy during DIFS interval, then it has to wait till the back-off interval. Therefore, Binary exponential back-off algorithm [9] can be summed up as in Figure 2.

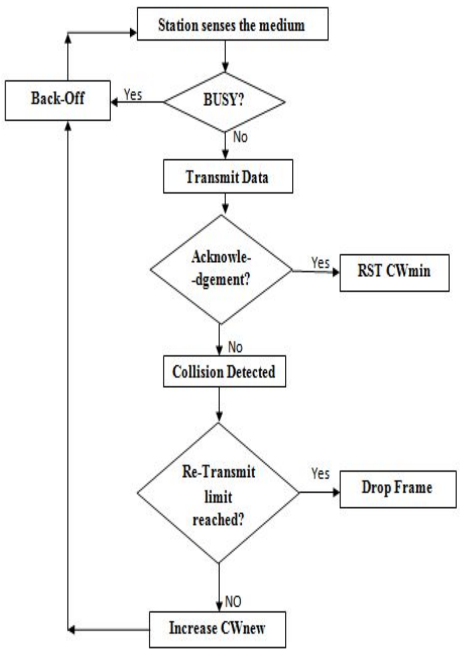

Figure 2 Binary Exponential Back-off Algorithm

IV. PERFORMANCE EVALUATION

The experiment for evaluating the performance of a wireless mesh network has been conducted using OPNET Simulator. A hybrid wireless mesh network has been considered with routers that form the backbone of the mesh and IEEE 802.11 wireless LAN stations. The Binary Exponential Back-off algorithm has been implemented to analyze the overall throughput and the delay in the network by carrying out simulations as discussed further.

4.1. Throughput

Network throughput is rate of successful message delivery over a communication channel. It is usually measured in bits per second [11]. From the results as shown in Figure 3 below, it is clear that network throughput is up to 7800 bits per second approximately when the simulation is run for about a minute and the average throughput during this time interval is 4000 bits per second approximately.

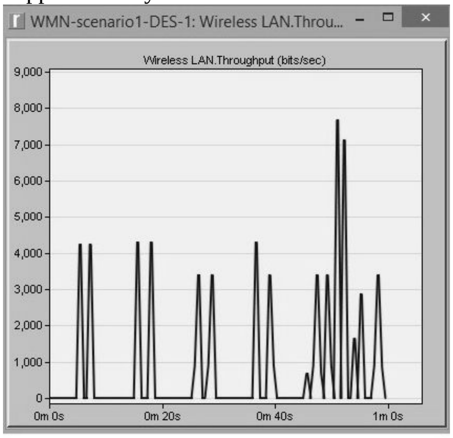

Figure 3 Throughput of the Network

4.2. Delay

Delay specifies how long it takes for bits of data to travel across the network from one node to another node [11].It represents the end to end delay of all the packets received by the wireless LAN MACs of all the WLAN nodes in the network and forwarded to the higher layer. The delay observed in the conducted experiment is as depicted in the Figure 4. The minimum delay of 0.00014s has been observed twice in the time interval of 40s-1. A maximum delay of 0.00082s has been observed just once in complete simulation period.

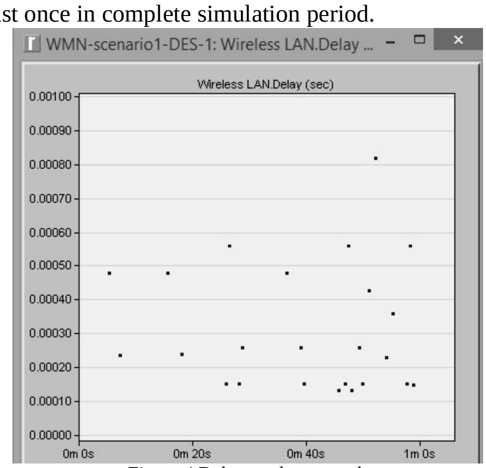

Figure 4 Delay on the network

V. CONCLUSION

The BEB algorithm has helped to control the shared medium access by multiple nodes in the proposed wireless mesh network. As shown in the simulation results above, a good network throughput is achieved and the delay has been controlled in the network. Further, the performance of BEB algorithm can be improved by devising alternates for setting up contention window size, rather than setting it to a minimum value on successful transmission.

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