ISSN:0975-9646

An Adaptive MAC 802.11 Protocol for MANET Using Exponential Algorithm

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***Abstract*—A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. They have undergone rapid growth in the past several years because of their application in military and rescue services, disaster recovery operations, mobile conferencing and many other applications. The Media Access Control (MAC) data communication protocol sub-layer provides addressing and channel access mechanisms that make it possible for network nodes to access common wireless channel through Distributed Coordination Function (DCF). The major problem with available wireless network is collision and slow collision resolution when the number of station increases. When the nodes are competing for channel access, only single node got channel access. Whenever node access channel the outcome occurs in two cases either successful transmission or collision. The problem with original MAC protocol is its static behaviour. It means at each collision it's waiting time increases exponentially and at each successful transmission its waiting time decreases one slot at a time. Due to this static behaviour of existing 802.11 MAC protocol we proposed our modified algorithm that is Adaptive in nature and changes with time. In our proposed work we will modify the existing Back-off algorithm and proposed an enhanced adaptive MAC protocol for wireless LAN and compare the performance of enhanced adaptive 802.11 MAC with conventional 802.11 MAC protocol on different parameters.**

***Keywords*—Mobile Ad-Hoc network, Wireless Network, MAC 802.11, Distributed Coordinated Function, Binary Exponential Back-off (BEB) Algorithm.**

I. INTRODUCTION

Mobile Ad-hoc network are self-configuring infrastructure less network of mobile devices connected by wireless. Since the network is decentralized, where all network activity including discovering the topology, delivering messages must be executed by the nodes themselves. As MANET network are infrastructure less there exist no dedicated routers. Instead, all mobile nodes act as a router and also responsible for discovering and maintaining routes. Furthermore without centralized administration, MANETs can be called autonomous. MANETs suffer from temporary link failures and route changes. The IEEE project 802 standard recommend an international standard for Wireless Local Area Network (WLANs) and provides detailed medium access control (MAC) and physical (PHY) layer specification for WLANs. WLAN can operate in two modes namely infrastructure based and infrastructure-less mode or ad-hoc mode.

a) **Infrastructure**: Wireless mobile networks have traditionally been based on the cellular concept and relied on good infrastructure support, in which mobile devices communicate with access points like base stations connected to the fixed network infrastructure. Typical examples of this kind of wireless network are GSM, UMTS, WLL, WLAN, etc. [1].

b) **Infrastructure less**: The mobile wireless network is commonly known as a mobile ad hoc network (MANET). A MANET is a collection of wireless nodes that can dynamically form a network to exchange information without using any pre-existing fixed network infrastructure [1]. Wireless ad hoc network themselves are an independent, wide area of research and application, instead of being only just a complement of the cellular system.

In WLANs, nodes transmit packet in unsynchronized fashion. The protocol employed in the MAC layer responsible for coordinating access to the shared channel while minimizing conflicts. In the 802.11 protocol, the fundamental mechanism to access the channel is called Distributed Coordinating Function (DCF). This is a random access scheme, based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol. Retransmission of collided packet is managed according to Binary Exponential Back-off rules. The following section describes the common Media Access Control Layer used by the 802.11 family of standards. The 802.11 family uses a MAC layer known as CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). Note: classic Ethernet uses CSMA/CD (Collision Detection). CSMA/CA is like all Ethernet protocols, peer-to-peer.

In CSMA/CA a Wireless node that wants to transmit performs the following sequences [3]:

1) Listen on the desired channel.
2) If channel is idle it sends a packet.
3) If channel is busy node waits until transmission stops then a further **CONTENTION** period. (The contention period is a random period after every transmission on every node and statistically allows every node equal access to the media. To allow TX to RX turn around the contention time is **slotted** 50 micro sec for FH and 20 micro sec for DS systems).
4) If the channel is still idle at the end of the **CONTENTION** period the node transmits it packet otherwise it repeat process defined in 3 above until it gets a free channel.

Key:

1) D = DCF Inter Frame Space (DIFS).
2) S = Short Inter Frame Space (SIFS).
3) CW = Contention Window.
4) MPDU = MAC Protocol Data Unit.

5) A = ACK

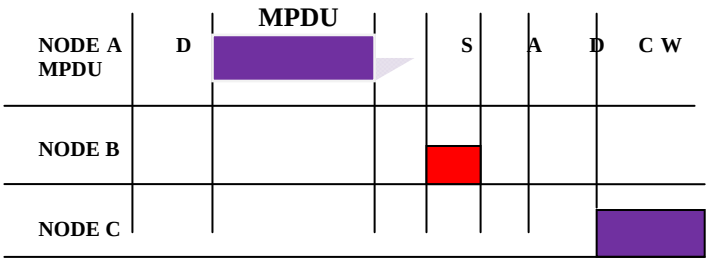

Figure 1

802.11 also offer a polling mode known as PCF (Point Coordination Function) which is fairly classic polling scheme.

II. MAC IN MANET

1) Medium Access Control Protocols for Ad-Hoc Wireless Networks.

Nodes in the wireless network share a common broadcast radio channel. Since the radio spectrum is limited, the bandwidth available for communication in such networks is also limited. Access to this shared medium should be controlled in such manner that all nodes receive a fair share of the available bandwidth, and the bandwidth is utilized efficiently [4] [5].

2) Classifications of MAC protocols

MAC protocol for ad-hoc network can be classified into several categories based on various criteria such as initiation approach, time synchronization, and reservation approach. Ad-Hoc network MAC protocol [4] [5] can be classified into three basic types:

a) Contention based protocols.
b) Contention based protocol with reservation mechanism.
c) Contention based protocol with scheduling mechanism.

A. Contention Based Protocol:

These protocols follow a contention based channel access policy. A node does not make any resource reservation priori. Whenever it receives a packet to be transmitted, it contends with other nodes for access to the shared channel. They are further divided in two types:

a) Sender initiated protocols; packet transmissions are initiated by sender node.
b) Receiver initiated protocols; the receiver node initiates the contention resolution protocol.

B. Contention Based Protocol with Reservation Scheme:

Ad-Hoc wireless networks sometimes may need to support real time traffic, which requires QoS guarantees to be provided. In order to support such traffic, certain protocols have mechanism for reserving bandwidth in priori. Such protocols can guarantee QoS to time sensitive traffic sessions. These are further divided into two types:

a) Synchronous protocols; these system require time synchronization among all the nodes in the network.
b) Asynchronous protocols; they do not require any global synchronization among the nodes.

C. Contention Based Protocols with Scheduling Mechanisms:

These protocols focus on packet scheduling at nodes, and also scheduling nodes for access to the channel. Node scheduling is done in a manner so that all nodes are treated fairly. Scheduling based schemes are also used for enforcing priorities among flows whose packets are queued at nodes. Some scheduling schemes also take into consideration battery characteristics, such as remaining battery power, while scheduling nodes for access to the channel.

III. MAC SUB-LAYER ARCHITECTURE

The basic medium access method of the IEEE 802.11 MAC protocol is the carrier sense multiple access with collision avoidance (CSMA/CA) [6]. Figure 2 illustrates the MAC architecture indicating the Distributed Coordination Function (DCF) and Point Coordination Function (PCF) as two component of its architecture.

A DCF is used in both independent and infrastructure networks; whereas, a PCF is an optional access method and used only in infrastructure network configuration.

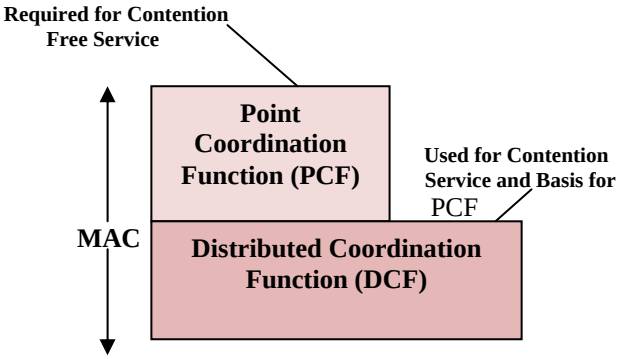

Figure 2 MAC Sub layer Architecture

1) Distributed Coordination Function

A DCF is the basic medium access method using CSMA/CA and a random back off time following a busy condition [6]. Since a wireless station cannot hear its own transmission, it cannot detect the collision [7]; therefore, the CSMA/CA algorithm is used. A positive acknowledgement is also needed for each transmitted frame. If an acknowledgement is not received, a retransmission takes place [2] [11].

2) Point Coordination Function

A PCF offers a guarantee of access to the medium for stations in a BSS [6]. This is beneficial for time-bound application traffic, such as voice or video.

IV. BINARY EXPONENTIAL BACK OFF ALGORITHM

Binary Exponential Back-off is a randomized protocol for regulating transmission on a multiple access broadcast channel. The Binary Exponential Back-off algorithm (BEB)

is used by IEEE 802.11 Medium Access Control (MAC). BEB uses a uniform random distribution to choose the back-off value that often leads to reducing the effect of window size increment.

V. RELATED WORK

The back-off procedure shall be invoked for a STA to transfer a frame when finding the medium busy as indicated by either the physical or virtual carrier-sense mechanism (figure 3) [12]. The back-off procedure shall also be invoked when a transmitting STA infers a failed transmission.

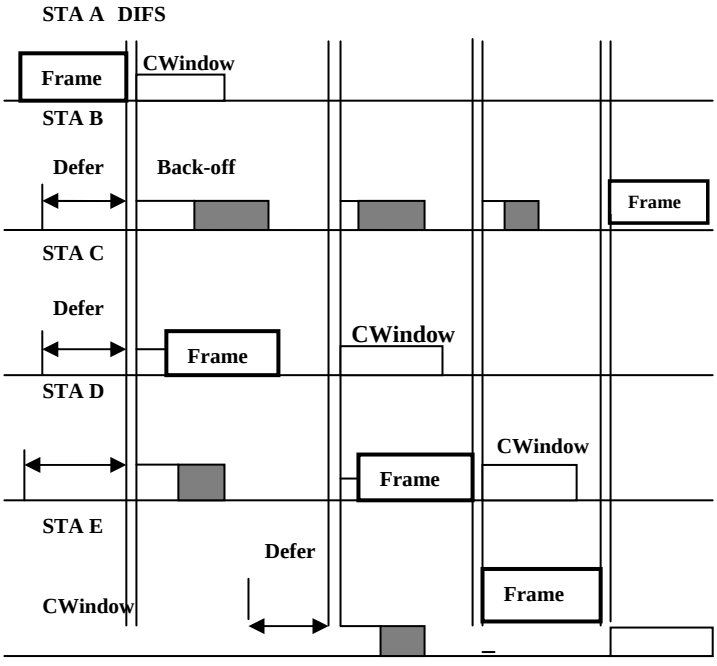

Figure 3: Back-off Procedure

To begin the back-off procedure, the STA shall set its back-off timer to a random back-off time. All back-off slots occur following a DIFS period during which the medium is determined to be idle for the duration of the DIFS period, or following an EIFS period during which the medium is determined to be idle for the duration of the EIFS period following detection of a frame that was not received correctly. A STA performing the back-off procedure shall use the carrier sense mechanism to determine whether there is activity during each back-off slot. If no medium activity is indicated for the duration of a particular back-off slot, then the back-off procedure shall decrement its back-off time by Slot Time. If the medium is determined to be busy at any time during a back-off slot, then the back-off procedure is suspended; that is, the back-off timer shall not decrement for that slot. The medium shall be determined to be idle for the duration of a DIFS period or EIFS, before the back-off procedure is allowed to resume. Transmission shall commence whenever the back-off timer reaches zero. A back-off procedure shall be performed immediately after the end of every transmission. In the case of successful acknowledged transmissions, this back-off procedure shall begin at the end of the received ACK frame. In the case of unsuccessful transmissions requiring acknowledgement, this back-off procedure shall begin at the end of the ACK timeout interval. If the transmission is successful, the CW value reverts to a $\mathbf{CW_{min}}$ before the random back-off interval is chosen, and the STA short retry count and/or STA long retry count are updated. This assures that transmitted frames from a STA are always separated by at least one back-off interval. The effect of this procedure is that when multiple STAs are deferring and go into random back-off, then the STA selecting the smallest back-off time using the random function will win the contention. DCF adopts an exponential back-off scheme. At each packet transmission, the back-off time is uniformly chosen in the range (0, W-1). The value 'W' is called contention window, and depends on the number of transmission failed for the packet. At the first transmission attempt, is set equal to a value $\mathbf{CW_{min}}$, called minimum contention window. After each unsuccessful transmission, 'W' is doubled, up to a maximum value $\mathbf{CW_{max} = 2^m * CW_{min.}}$ The value and reported in the final version of the standard are summarized in Table 1[8] [9] [10].

PHY	Slot Time	CW_{min}	CW_{max}
FHSS	50 µsec	16	1024
DSSS	20 µsec	32	1024
IR	8 µsec	64	1024

Table 1

Slot Time, Minimum and Maximum Contention Window Values for three PHY specified by 802.11: Frequency Hopping Spread Spectrum (FHSS), Direct Sequence Spread Spectrum (DSSS) and Infrared (IR)

The back-off time counter is decremented as long as the channel is sensed idle, "frozen" when a transmission is detected on the channel, and reactivated when the channel is sensed idle again for more than a DIFS. The station transmits when the back-off timer reaches zero.

VI. PROPOSED WORK

In wireless communication environment, when the channel is shared among the number of nodes. It is difficult to decide to whom the channel is allocated because every node having equal possibility to send and receive. So to decide the priority of all the nodes in the wireless LAN we use a Back-off. Traditionally based on IEEE Binary Exponential Algorithm (BEB), the probability of collision is very high when the network in complex and dance or traffic is high and low when low traffic is there. The existing back-off is poor back-off and needs improvements for enhancing the performance and reduces collisions. To improve the performance of existing protocol we analyse the limitations and then study all the parameters that affects the performance of original protocol. The major factor that affects the performance of Ad-Hoc MAC 802.11 protocol is:

1) Transmission failure due to collision resolution.
2) Number of idle slot due to back-off at each transmission slot.

The problem with original MAC protocol is its static behaviour. Means at each collision it's waiting time increases exponentially and at each successful transmission or at each idle slot its waiting time decreases one slot a time.

Due to its static nature we will modify existing algorithm and proposed a new algorithm. Our proposed algorithm is based on two scenarios:

1) When collision occur the contention window increases slowly as compared to increases exponentially.
2) When idle slot is detected our proposed algorithm reduces the collision window size exponentially. Rather than reduce one slot at a time.

Original Algorithm:

```
Condition 1:
        If (Channel is busy)
          {
            Wait for channel idle
           }
         Else if
           {
              Transfer data
                If (collision)
                {
          Called back-off and increases the back- off
time exponentially
                  }
              }
Condition 2:

        If idle slot is detected and successful
transmission
        {
          Contention window reduces one slot a time
          }
```

Proposed Algorithm:

```
Condition 1:
            If (Channel is busy)
            {
            Wait for Channel idle
              }
Else if
        {
          Transfer data
           If (collision)
           {
       Called back-off and increase the waiting time
 By some event time scheduler which is other random
function like Fibonacci function, logarithmic function and
Markov model for random distribution
            }
        }
 Condition 2:
            If (idle slot is detected or successful
transmission)
            {
                Proposed algorithm decreases waiting
slot exponentially as compared to original algorithm one
slot at a time
              }
```

VII. Simulation Environment

Simulation is the fundamental tool in the development of MANET protocol, because the difficulty to deploy and debug them in real network. The simulation eases the analysing and the verification of the protocols mainly in large scale systems. It offers flexible testing and with different topologies, mobility patterns, several physical and link layer protocols. To test the new protocol Network Simulator (NS2) will be used. Simulator will be run for conventional 802.11 MAC and will be run for enhanced 802.11MAC protocol under the same environment to see the performance differences against different various parameters. The performance matrices will be tested are:

1) Average end-to-end delay
2) Throughput
3) Average jitter
4) Total packet loss ratio.

VIII. Conclusion

In this paper, we analyzed the existing IEEE MAC 802.11 protocol is less efficient and not adaptive in continuously load verging condition. To solve the entire problem we will propose a new "An improved adaptive Medium Access Control protocol for wireless LAN". In our proposed we will modify the existing Binary Exponential Back-off Algorithm (BEB).

1) Our proposed algorithm is adaptive in nature means change its behaviour according to load variations.
2) At every collision waiting time increases exponentially means contention window increases two times as present size, but in our proposed it increases some other defined manner so that the contention window size increases slowly.
3) At each successful transmission or free channel detection the waiting time reduces exponentially as compared to one slot at a time by computing the medium occupancy ratio for instance, can be also of some interest concerning the energy consumption.

Different parameters for back-off factors will be tested and compare against the existing 802.11 MAC protocol which can give better performance. Simulation for the new protocol will be tested on Network Simulator (NS2).

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