Volume 4, Issue 1, January 2014 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

By Modifying BEB Algorithm an Optimized MAC 802.11 Protocols for Wireless Network

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Abstract— in wireless ad-hoc network, backoff is traditionally based on the IEEE binary exponential backoff algorithm. As wireless ad-hoc network is usually used in the critical situation, its efficiency and performance is significant. Since MAC is the fundamental layer the design of an efficient and high performance underlying MAC protocol is significant for the overall performance of the ad-hoc network. In the IEEE 802.11standard the network nodes uses Binary Exponential backoff (BEB) is a randomized protocol for regulating transmission on multiple access broadcast channel. BEB is a method in which on each collision on the shared channel, nodes sending collided packets need to backoff for a random period of time, which is uniformly selected from Contention Window (CW), and it is doubled after each collision and immediately reduces to a minimum value after each successful transmission. The problem with original MAC protocol is its static behaviour means at each collision its waiting time increases exponentially and at each successful transmission its waiting time decreases one slot a time. Since the MAC with BEB scheme suffers from low throughput and poor fairness under various network condition, it is not a good choice for ad-hoc network. In this paper we propose an modified algorithm that is adaptive in nature and changes with time. In our proposed we modify the existing backoff algorithm and proposes an enhanced adaptive MAC protocol for wireless LAN and compare the performance of enhanced 802.11 MAC protocol with conventional 802.11 MAC protocol on different parameters.

Keywords— Mobile Ad-hoc Network (MANET), Binary Exponential Back-off (BEB), 802.11 Medium Access Control (MAC),

I. INTRODUCTION

Since their emergence, wireless network have became increasingly popular in the computing industry. This is particularly true within the past decade, which has seen wireless network being widely adopted to enable mobility. Over the development process of computer networks, two main variations have been introduced infrastructure or infrastructure less. Recently significant number of researchers have move towards studying Mobile Ad-hoc Network (MANET). Interest in MANETs, due to many new characteristics provided by this type of network. First MANET is easily deployed allowing a plug-and-communicate method of networking. Secondly MANET [1] is infrastructure less, eliminating the need for an infrastructure reducing the cost of establishing the network. Moreover such networks can be useful in disaster recovery where there is not enough time and resources to install and configure an infrastructure. Thirdly, MANETs also no need of central management [1].

Nodes forming an ad-hoc network are required to have the ability to double up as a client, a server and a router simultaneously. Moreover, these nodes also have the capability to connect to and automatically configure to start transmission data over the network. As a result of having the characteristics mentioned so far....protocol used for ad-hoc network generally function in a distributed manner [2]. The generally Distributed Coordinating function is used for synchronous, contention based, distributed access to the channel [3]. It is impractical to expect a MANET is to be fully connected, where a node can directly communicate to every other node in the network. Typically nodes are obliged to use a multi-hop path for transmission, and a packet may pass through multiple nodes before being delivered to its intended destination. The wireless medium used by MANETs has a number of problems bandwidth sharing, signal fading, noise, interference etc. with such a public medium, a well organized and effective Medium Access Control (MAC) is indispensable to organize sharing the scarce bandwidth resource [1]. Based on the features mentioned, the design of the Medium Access Control protocol is a significant factor affecting the performance of MANETs. Many researchers have proposed the mechanism of channel sensing and packet sensing to avoid collision. The sensing mechanisms typically rely on the transmitter and receiver performing a handshake prior to the transmission of the data packet [4]. More specifically, the Medium Access Collision Avoidance (MACA) method proposed by Karn [5] implements the handshake via a pair of Request-To-Send (RTS) and Clear-To-Send (CTS) messages. When a node has data to send it first send RTS to the destination. The receiver responds with CTS packet [4]. On receipt of the CTS, sender sends its Queued data packet. All other nodes overhearing the CTS message will defer from sending out any packet until the predicted transmission period indicated in the CTS packet, is passed. Any node that overhears the RTS signal but not CTS is allowed to send out packets in a certain time period is either the RTS/CTS handshake is not completed or it is out of range of the receiver.

As part of an efficient MAC protocol, a backoff algorithm is used to avoid collisions when many nodes try to access the medium [2]. Only one of the nodes is granted access to the channel, while other contending nodes are suspended into a backoff state for some period.

II. BINARY EXPONENTIAL BACKOFF ALGORITHM

In IEEE 802.11 standard MAC protocol, the Binary Exponential Backoff algorithm is used [6]. In this algorithm, when a node over the network has a packet to send, it first senses the channel using a carrier sensing technique. If the channel is found to be idle and not being used by any other node, then node is granted access to start transmission. Otherwise node wait for inter-frame space and the back-off mechanism is invoked. A random backoff time is chosen in the range [**0, CW-1**]. A uniform random distribution is used here, where **CW** is the current Contention Window size. The following equation is used to calculate the backoff time (**BOT**):

BOT= (rand () MOD CW) * aSlotTime .....(i)

The backoff procedure is performed then, by putting the node on a waiting period of length BOT. Using carrier sense mechanism, the activity of the medium is sensed at every time slot. If the medium is found to be idle then the backoff period is decremented by one slot time

Backoff time (BOT) new = (BOT)old- aSlotTime ....(ii).

If the medium is busy during the backoff, then backoff timer is suspended. That is, backoff period is counted in terms of idle time slots. Whenever medium is found idle longer than the inter-frame space, backoff is resumed. When the backoff period is finished with a **BOT** value of zero, a transmission should take place. If the node succeeds to send a packet and receive an acknowledgement for that packet, then the **CW** for this node is reset to the minimum, which is equal to 31 in this case of BEB.

BEB has a number of disadvantages [2], one major disadvantage is the problem of fairness. BEB tends to have a preference for most recent contention winner and new contending node over other nodes when allocating channel access. Determining backoff period is accomplished by choosing a random backoff value from Contention Window (**CW**) which has a smaller size for new contending nodes and contention winners. This behaviour causes what is known as "channel capture effect" in the network. Another problem of BEB is stability. BEB has been designed to be stable for large number of nodes [1]. However number of studies has shown that BEB could suffer from instability [1].

III. RELATED WORK

The Binary Exponential Back-off is a randomized protocol for regulating transmission on a multiple access broadcast channel. The BEB algorithm is used by IEEE802.11 Medium Access Channel (MAC). BEB uses a uniform random distribution to choose the back-off value that often leads to reducing the effect of window size increment. There are lots of papers discussing new back-off mechanisms such as:

Fibonacci Backoff Algorithm for Mobile ad-hoc Network [7]: described new FIBO algorithm to improve conventional BEB. The back-off algorithm called Fibonacci Back-off algorithm was proposed to reduce the differences among successive contention window sizes. Results from simulation experiments revealed that Fibonacci Increment Back-off algorithm achieves a higher throughput than the Binary Exponential Back-off used in MANETs.

A Media Access Protocol for Wireless LAN [4]: Proposed Multiplicative Increase and a Linear Decrease (MILD) Back-off algorithm. This algorithm aims to solve the unfairness problem by reducing the probability of successful users to access the channel. In this algorithm the contention window size is incremented by a factor multiplication when a transmission failure occurs. Results of simulation revealed that this Back-off algorithm gives better performance in MANET.

On Back-off Mechanism for Wireless Mobile Ad-hoc Network [8]: S. Manasser introduces about some **Back**-off mechanism for wireless Mobile ad-hoc network, focused on presenting and illustrating the performance of the two proposed algorithm called Pessimistic Linear Exponential and Optimistic Linear Exponential. Experimental results demonstrate that PLEB improves the network throughput and reduce packet delay for large number of nodes and large network size with low mobility speed. On the other hand, OLEB has the same experimental results at high traffic rates.

Enhancement of IEEE 802.11 Distributed Coordination Function with exponential increase exponential decrease Back-off algorithm [9]: in this paper author enhanced the IEEE 802.11 distributed coordination function with an exponential increase and exponential decrease back-off algorithm whereas they also studied the effects of increasing and decreasing the waiting time intervals using exponential Back-off algorithm. Results representing the exponential increase algorithm have good results using the coordinating function.

Design of MAC protocols with Fast Collision Resolution for Wireless Local Area Network [10]: they proposed a fast collision resolution (FCR) algorithm has the following characteristics: 1) uses much smaller initial contention window size as compared to the IEEE 802.11 MAC.2) uses much larger contention window size as compared to the IEEE 802.11 MAC.3) increase the contention window size when a node is in both a collision state or in deferring state.4) reduces the back-off timer exponentially fast when a prefixed number of consecutive idle slots has been detected.5) assigns the maximum successive packet transmission limit to achieve good fairness performances.

Enhancing the Performance of Ad-hoc Network using New Adaptively Varying Back-off Technique [11]: As wireless ad-hoc network is usually used in the critical situations, its efficiency and performance is significant. Since MAC is the fundamental layer, the design of an efficient and high performance underlying MAC protocol is significant for the overall performance of the ad-hoc network. In this paper, they proposed a back-off algorithm called New Adaptively Varying Back-off (NAVB) to enhance the performance of ad-hoc network, they analysed the four different proposals namely BEB, MILD, MIMD and AETF in this paper. As ad-hoc network is commonly applied in emergency situations and nodes are battery driven MILD and AETF are not suitable for ad-hoc network because of their above mentioned inherent drawbacks. Therefore they have compared the performance of NAVB with other two algorithms. The simulation results show that NAVB outperforms the BEB and MIMD.

A Survey of MAC Protocol for MANET [12]: in this paper, survey of the Medium Access Control (MAC) approaches for wireless mobile ad-hoc networks is presented. In general, as MAC level throughput increases, the energy efficiency also increases due to decrease in the number of frame retransmission. However, the approach using directional antennas results in more power consumption. But the use of power efficient MAC protocol increases the overall efficiency of a MANET by saving per node energy consumption. Persistence in transmission increases the maximum throughput, but the throughput stability may decreases.

IV. PROBLEM STATEMENT

In ad-hoc wireless network we used MAC protocol to enhance the performance of existing network and for better results. Distributed Coordinating Function is powerful protocol of MAC for best performance. The role of back-off algorithm is crucial in ad-hoc network for performance. The back-off procedure is executed when nodes want to access the channel while back-off timer value depends on the random number so it is very difficult to predict the back-off duration accurately, then the channel used the Binary Exponential Back-off algorithm for transmission. In case of any sending data if ACK and CST not received it means collision is occur and after collision all involving nodes increases their contention window twice. If there is no collision or successful transmission its waiting time decreases by one slot a time. After analysis of existing protocol there are number of improvements are identified. Performance of network depends upon many factors like channel, transmission medium, number of stations, the behaviour of Medium Access Control mechanism and size of contention window. In our proposed work we modify the back-off procedure and working of channel access mechanism when collision occurs.

V. PROPOSED METHODOLOGY

The problem with original MAC 802.11 protocol is it static behaviour, means at each collision its waiting time increases exponentially and at each successful transmission or free channel detection waiting time decreases one slot a time. Due to its static nature we propose a new algorithm that is Adaptive in nature and changes with time.

Original BEB Algorithm

```
Condition 1:

If (channel is busy)
   {
      Wait for channel idle
      }
   Else if
         {
           Transfer data
If (collision)
{
 Called back-off and increase the back-off time exponentially
 }
}

Condition 2:

If (idle slot is detected or successful transmission)
      {
         Contention window reduces one slot a time.
  }
```

Our proposed algorithm is based on two criteria's:

1) When collision occur waiting time increases slowly as compared to increases exponentially in original algorithm.
2) When free channel detection or successful transmission waiting time decreases exponentially as compared to decreases 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
  }
}
Condition 2:
If (idle slot is detected or successful transmission)
{
   Proposed algorithm decreases waiting slot exponentially as compared to original algorithm one slot a time
}
```

In our proposed work we defined different scenarios over existing protocol are as:

***1. Fibonacci Based Increment*:** in this method we proposed a new back-off procedure in which the channel allocation method is different. In this method the channel is allocated as per new Fibonacci back-off means whenever collision is occur at channel the contention method allocated channel as per Fibonacci based mathematical function. The Fibonacci function behaves as a mathematical Fibonacci function in which contention window size increment in a predefined manner which is not in actual BEB.

E.g. in case of 3 collisions the back-off time is:

Original BEB $2^3 = 8 = (0,1,2,3,4,5,6,7)$

Fibonacci BEB f (3) = (0, 1, 1, 2,)

Means, here we can see that the waiting time increase slowly as compared to actual BEB where waiting time increases slowly.

Fibonacci BEB Algorithm

Step 1: when node wants to send data
Step 2: node sense channel. If it is free it simply sends data.
Step 3: if (ACK == yes) then packet received successfully (repeat process 1)
Step 4: if (ACK == no) means acknowledgment not received then new BEB (Fibonacci) back-off is called to calculate the waiting slot time.
Step 5: if (n=number of collision < 16) then discard packet
Else
WT = Fibonacci (n)
End if
Step 6: wait till WT = 0 and then send packet again
If (collision) then
Go to step 5
Else
Go to step 1
Step 7: end

2. Logarithmic Based Decrement: in this approach we proposed a new plan in which we will work over channel when it is continuously idle. In existing BEB method at each collision the back-off time increases double and at each successful transmission waiting time is decremented by one slot a time. In our proposed work we will work over back-off decreasing time slots or free channel. When channel continuously detected free we will decrease the waiting time by the log function.

E.g. the logarithmic BEB is worked when we detected continuously idle slot i.e. in our case it is 5, if we detect continuously 5 idle slots then we call Logarithmic back-off.

Original BEB: each time WT (waiting time) decreases by one slot at each successful transmission even if we detect free channel continuously like if WT = 512 means node has to wait 512 slot time.

Logarithmic BEB: if (idle slot ==5)
Then
Log_2 (WT) = New (WT)
End if

E.g. $\log_2 (512) = 9$

WT = 9

So here we can see that waiting time decreases fast rather one slot a time in actual BEB.

Logarithmic BEB Algorithm

```
Step 1: check number of idle slots.
Step 2: if (idle slot >= 5) then check node WT
                If (WT! = 0) then
              New WT = log2 (WT)
            End if
                Else
                  New WT = WT-1.
             End if
Step 3: end
```

3. Fibonacci Based Increment and Logarithmic Based Decrement: in this approach we used the combination of both method as discussed above, means slow increment and fast decrement. In this we proposed a new algorithm i.e. FiLog in which Fibonacci function used for increment and Logarithmic function used for decrement. Whenever collision occurs at channel we call Fibonacci algorithm to calculate waiting time for next transmission and then send packets as per new Fibonacci BEB WT. Second thing we continuously monitor the idle slots if we detect more than five idle slots we decrease the waiting time by log function which decreases WT fast.

FiLog Algorithm

```
Step 1: if (channel == free)
              If (WT==0) then go to send
             End if
         Else (CIS >=5)
                  Calculate new WT
                New WT = log2 (WT)
       Send:  if (WT=0) send and wait for ACK
              If (ACK == ok)
            Then (exit)
           Else
                Calculate new waiting time
                 New WT = Fibo (n)
             End if
End if
Step 2: End
```

Fibonacci and exponential whereas Fibonacci used for increment and Exponential used for decrement. The purpose of this method is that at each collision contention window increases in Fibonacci manner, and at every successful transmission waiting time decreases exponentially, as compared to 1 slot a time.

FiExpo Algorithm

```
Step 1: if (channel== free)
              If (WT=0) then go to send
             End if
    Else (CIS>=5)
               Calculate new WT
                New WT = WT/2
Send:  if (WT=0) then send and wait for ACK
          If (ACK==ok)
       Then (exit)
     Else
                Calculate new waiting time
                 New WT = Fibo (n)
       End if
        End if
Step 2: End
```

VI. SIMULATION TOOL

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 analyzing and the verification of the protocols mainly in large scale system. It offers flexible testing with different topologies, mobility pattern, several physical and link layer protocols. To

test the new protocol Network Simulator 2 (NS2) will be used. NS2 is an open-source event-driven simulator designed specifically for research in computer communication networks. Simulator will be run for original protocols and then will be run for proposed protocols under the same environment to see the performances differences.

Table 1: Simulator Parameters

Type	Values
Channel	Channel/wireless channel
Radio Propagation Model	Propagation/tworayground
Network Interface	Physical/Wirelessphy
MAC	MAC 802_11
Interface queue	Queue/drop tail/priqueue
Antenna	Antenna/Omni antenna
Link Layer	LL
Interface Queue Length	50
Routing Protocol	AODV
Simulation Time	100s
Number of Mobile Nodes	10

VII. SIMULATION RESULTS

Below given comparisons graphs shows the results of our proposed protocols, in Figure 1 graph showing the results of proposed Fibonacci , Logarithmic, FiLog and FiExpo MAC Protocols against Packet loss which gives better results as compared to original MAC protocol whereas in Figure 2 graph showing the results of Proposed Protocols against packet received which also gives better performance compared to actual MAC.

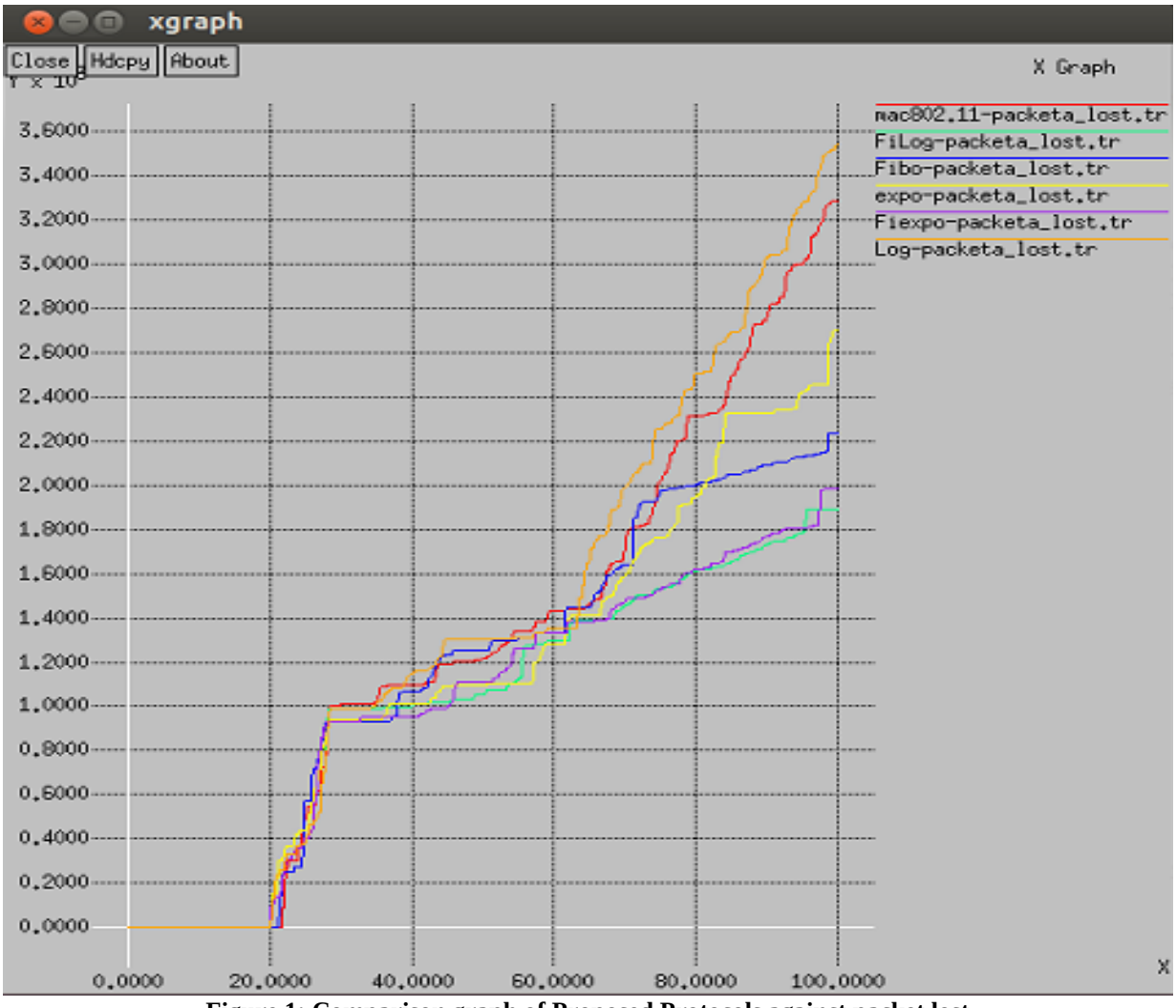

Figure 1: Comparison graph of Proposed Protocols against packet lost

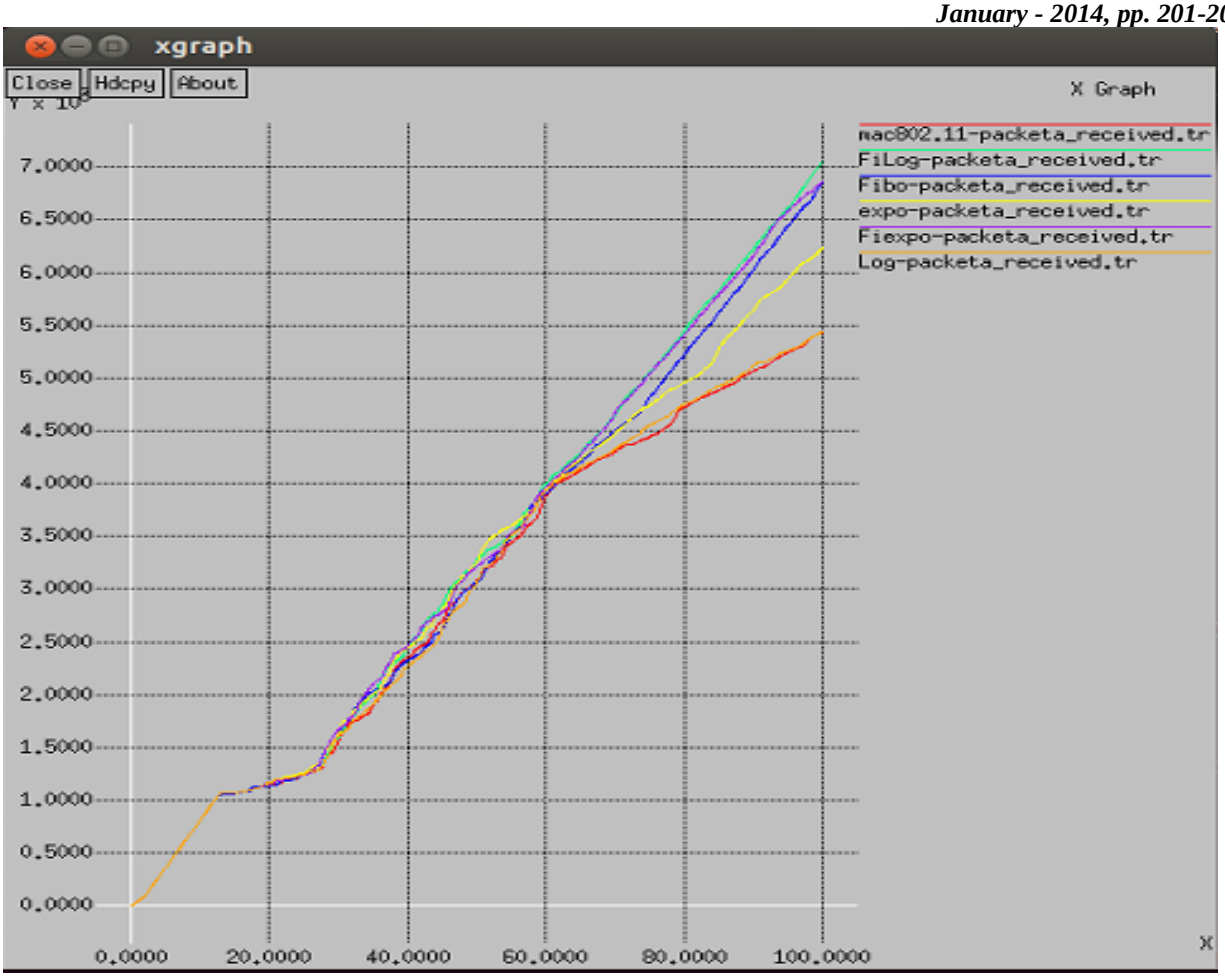

Figure 2: Comparison graph of Proposed Protocols against packet received

As per our results, we can see that our proposed algorithm gives better performance rather conventional MAC 802.11 protocol (Where red line shows MAC 802.11, green line shows FiLog, blue line shows Fibonacci, yellow line shows exponential, magenta line shows FiExpo and orange line shows Logarithmic Protocols).

VIII. CONCLUSION AND FUTURE WORK

In this research we analysed the IEEE 802.11 is less efficient and not adaptive in continuously load verging conditions. To solve the entire problem we proposed a new "An Adaptive Medium Access Control Protocol for wireless LAN" in our proposed we modified the Binary Exponential Back-off algorithm.

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

As in future if the loads were unpredicted or there are less number of competitive nodes we can use our proposed work for the better efficiency and results. As far as future work is concerned we can use different randomization function to change the behaviour of the waiting and can improve the performance of the network, we can also use the Markov model and data mining algorithms to prepare the test that directed the network load and behave dynamically as per load and need.

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