Performance Enhancements in IEEE 802.11 DCF MANET through Variation of SIFS Values in Distance Vector Routing Environment

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Abstract—**This paper describes and investigates the performance enhancement techniques used in IEEE 802.11g MANET in AODV and DSDV routing environment. Through variation of Short Interframe Space (SIFS) values, a better scheme to enhance the wireless network performance can be achieved. This is important especially to assign high priority network nodes that carry time sensitive data to reach the intended receiver in a timely manner. Using NS-2, network simulations are done and the findings are presented. It is showed that nodes using the variated SIFS values can achieve higher throughput compared to nodes using the default SIFS values.**

Keywords-component; IEEE 802.11; wireless; DIFS; SIFS, AODV, DSDV, NS-2

I. INTRODUCTION

In recent years, wireless LAN (WLAN) has become the main alternative for users to gain Internet access. This is due to the advantages of being unwired. Users can reach the Internet anytime and anywhere. One of the main factors is the price drop of wireless network devices [1] in the market, which leads to the mass usage of wireless networks at the level of end users.

As WLAN became more popular, more users are planning to shift from wired to wireless networks. According to a survey published in [2], it is projected that WLAN revolution will take over the wired network. The strong and growing demand for WLANs in both consumer markets such as residential networks [3] and industrial markets such as retail, education, health care and wireless hot-spots in hotels, airports, and restaurants [1] has been documented repeatedly in business, industry and education [2].

As users shift towards WLAN, so does the network applications. This includes time sensitive applications such as video and voice streaming that requires Constant Bit Rate (CBR). This has become a critical issue because WLAN was not designed to carry real-time and multimedia traffic. The highly congested WLAN are demanding for better enhancement of performance that requires fast yet reliable transmission.

In this research, the proposed technique involves modifying the SIFS through variation of values. This is done by fine tuning the SIFS values. Several values of SIFS will be tested to identify the most optimum value to achieve the best throughput for better performance in both distance vector routing environment, Adhoc On-Demands Distance Vector (AODV) and Destination Sequenced Distance Vector (DSDV).

The remainder of this paper is organized as follows. Firstly, this paper will discuss on the IEEE 802.11 channel coordination function before focusing on the Distributed Coordination Function (DCF). Then, a review on several MANET routing are discussed. Other proposed techniques from previous research on **DIFS** and **SIFS** are presented before outlining the author's proposed techniques. Finally, a brief description of simulation scenarios using NS-2 and findings are given.

II. CHANNEL COORDINATION FUNCTION

WLAN uses the free 2.4GHz radio frequency (RF) as the medium to transfer data and share information. Since radio frequency is half-duplex by nature, it is impossible for two mobile stations (MS) to send and receive data at the same time. A MS must either listen or transfer data at a time to avoid data collision. Therefore, there must be a rule for the MSs involved to take turns to use the radio frequency. The method for the MSs to take turns is called **coordination function**.

There are two types of coordination functions which are the **Point Coordination Function (PCF)** and **Distributed Coordination Function (DCF)**. Since this paper focuses on **DCF**, the following section will discuss more on the **DCF** access method.

A. Distributed Coordination Function

In **DCF**, the technique to use the RF channel is distributed to each of the mobile station (MS). The MS themselves determine whether they have the opportunity to transmit data. It is a contention-based method where MS have to compete with each other to use the RF. In the contention basis, any MS can attempt to transmit data at any time it wanted to, if the channel is sensed to be idle.

However, problem occurs when two or more MS start to transmit data at the same time, where a collision will happen. In order to avoid collision, DCF implements a mechanism called **Carrier Sense Multiple Access with Colllision Avoidance (CSMA/CA)** which is primarily adopted by wired LAN's **Carrier Sense Multiple Access with Collision Detection (CSMA/CD)** to avoid collision.

Figure 1. below illustrates on how DCF mechanism avoids collision.

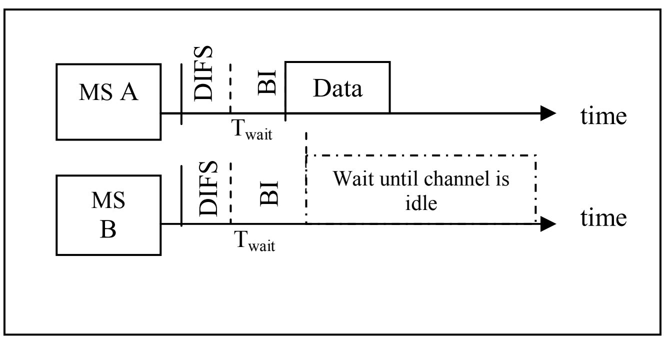

Figure 1. The operation of DCF mechanism

Instead of having the two MS, MS A and MS B responsible for the collision to wait a random amount of time (as in CSMA/CD), **CSMA/CA** has all the clients to wait for a random amount of time, $\mathbf{T_{wait}}$, which consists of **DCF Interframe Space (DIFS)** and **backoff interval (BI)** before attempting to do transmission, as shown in (1). **BI** is a uniform random value, sampled exponentially from [0, CW] where CW is the Contention Window with a maximum value of 1023 time slots.

$$\mathbf{T_{wait}} = \mathbf{DIFS} + \mathrm{BI} \quad (1)$$

Note that the value of **DIFS** is the same for each station. BI value is taken randomly to avoid collision. Meanwhile, **DIFS** is derived from an equation as in (2) below:

$$\mathbf{DIFS} = 2\ (\mathrm{SlotTime}) + \mathbf{SIFS} \quad (2)$$

In this paper, modifications are done by changing the values of SIFS. Through the equation, it can be seen that changing the SIFS values will also change the DIFS values directly.

III. MANET ROUTING PROTOCOLS

Routing is the process of selecting paths in a network along which to send data or physical traffic. Mobile Ad-hoc Network (MANET) itself has different methods of defining routings which can be divided into two main categories. These categories are Table Driven routing protocols and Source Initiated on Demand routing protocols [4]. These two categories are described as in the following paragraphs.

Table Driven routing protocol is also known as proactive protocols. In the MANET topology, each node using table driven routing protocols will maintain a routing table. The routing table will be updated periodically, transmitted throughout the network to maintain consistency. Therefore, a routing table will always be in a stand-by mode where route has already existed prior to traffic. Therefore transmission occurs without delay. Otherwise, traffic packets should wait in queue while the nodes construct the routing information corresponding to its destination. However, this routing is not suitable for a highly dynamic network topology where the nodes are always mobile and the number of nodes involved in the topology is always changing. This scenario requires a significant amount of resource to keep track of the changes in order to keep routing information up to date and reliable. Some of the examples of this proactive routing protocol are Destination Sequenced Distance Vector (DSDV), Wireless Routing Protocol (WRP), Global State Routing (GSR) and Clusterhead Gateway Switch Routing (CGSR).

Contrary to Table Driven routing, the Source Initiated on Demand (also known as reactive) protocols only initiates a route process discovery on demand, hence its name. Routes will be discovered only when a nodes wants to send packets to its desired destination. For this purpose, a node initiates a route discovery process through the network. This process is completed once the route is established or all possible routes had been discovered. Then, it is maintained by a route maintenance process until the destination becomes inaccessible along every routing path options or until the path is no longer needed. Some examples of the Source Initiated on Demand routing protocols are Ad-Hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Temporally Ordered Routing Algorithm (TORA).

In this study, we will look into the two distance vector routings, which are AODV and DSDV.

IV. RELATED WORKS

In 1994, Request for Recommendations (RFC) 1633 [5] proposed a technique to support QoS using Intserv. However, it is rejected by Deng and Cheng in a research done [6] as it leads to a major drawback. In Intserv, a certain allocation of the bandwidth is reserved for the usage of high priority traffic. However when the source is reserved but unused, it is simply wasted. Therefore, it is not practical to be implemented in networks, including in WLANs.

Following the drawback of Intserv, Deng and Cheng [6] proposed a method to support two priorities in WLAN by variation the CW values. These two priorities are high priority traffic and low priority traffic. In contention, high priority stations will wait for a shorter period amount of time, PIFS compared to low priority traffic which will wait a longer period of time, DIFS before attempting data transmission. Using simscript simulator, different priorities of traffic which includes video (high priority), voice (high priority) and data (low priority) with a ratio of 1:1:2 are simulated. Results showed that high priority traffic has an improvement in performance especially in heavy load conditions. In low load conditions, low priority traffic has the required bandwidth. Although voice and video traffic showed improvements in terms of access delay and packet loss, data traffic suffers access delay and higher packet loss compared to the legacy DCF.

On the other hand, Xiaohui [7] suggests the Modified DCF (M-DCF) scheme, which uses different values of CWmin and CWmax for service differentiation. Simulations of ad-hoc wireless LAN with 10 data stations and between 10 and 35 voice stations were performed. Voice service had CWmin of 7 and CWmax of 127 while data service had CWmin of 15 and CWmax of 255. The outcome illustrates that M-DCF decreases the total packet dropping probability and the dropping probability of voice packets as well as reduces the contention delay of both voice and data packets compared with DCF.

Another work done by Barry [8] and Veres [9] recommend using different values of CWmin and CWmax for different priorities, in which higher priority has lower CWmin and CWmax values than those of lower priority. Simulations of high priority traffic with CWmin between [8, 32] and CWmax = 64, and low priority traffic with CWmin between [32, 128 and CWmax = 1024] were performed. The outcomes show that the high priority and low priority traffic undergo different delay.

Benveniste [10] recommends Urgency Arbitration Time (UAT) to differentiate services, which is the time a station has to wait before a transmission attempt following a period when the medium is busy. Benveniste also introduces AIFS and Backoff Counter Update Time (BCUT) but both are actually DIFS and SlotTime. Higher priority traffic is assigned shorter AIFS and BCUT values compared to the low priorities. The AIFS value for high priority is the same as PCF Interframe Space (PIFS) and a minimum backoff time of 1 in order to prevent conflict with medium access by centralized protocol PCF. A simulation was carried out where AIFS (high_prio) = PIFS, AIFS (low_prio) = DIFS, CW (high_prio) = [1, 32] and CW (low_prio) = [0, 31]. Results showed that the delay and jitter of high-priority traffic are decreased and under moderate load condition, the performance of low priority traffic is also improved compared to DCF.

Meanwhile, a lot of researches were also carried out to study the performance of different routing protocols. Noorani [11] examines the performance of AODV and DSR routing protocols under the TCP VEGAS traffic under NS-2 simulations. The results indicate that AODV has a better performance in terms of throughput and end to end delay. However, AODV also suffers from heavy packet drop.

Nada [12] examines the operations, problems and challenges faced by both IPv4 and IPv6. In simulating the scenarios, the routing protocol was not mentioned. It is purely on investigating the performance between two different addressing schemes.

Chin et al. [13] investigates the experience of implementing two distance vector MANET routing protocols, AODV and DSDV through testbeds. Several issues on investigating MANET protocols were highlighted which are handling unreliable links, minimizing the dependency on topology specific parameters, mechanisms for handoff and reducing packet loss during handoff and incorporating neighbor discovery and filtering into a neighbor selection sub-layer.

V. PROPOSED SCHEME

DIFS (which consists of SIFS and BI) is the duration for a mobile MS that wants to transmit data has to wait after sensing the channel is idle. The technique proposed to support better performance in this experiment is that MS are assigned shorter **SIFS**. Since SIFS directly affects DIFS, this means a configured MS that uses shorter SIFS will have a shorter waiting time, which allows the MS to transmit ahead of other MS. While this MS will always have a shorter waiting time, it means this MS is most likely to have the opportunity to always being first to transmit data after the channel is sensed idle compared to other MS. This scheme can further be depicted in Figure 2. below.

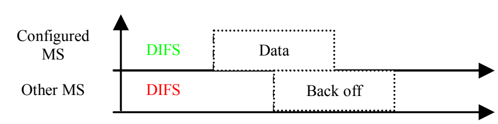

Figure 2. Configured MS and Other (Normal) MS transmission on proposed scheme

In order to test the outcomes of the proposed scheme, a simulation using NS-2 was carried out which will be described in the next section.

VI. NETWORK SIMULATION SETUP

Simulation is done using NS-2 version 2.34 [14]. NS-2 is an opensource simulation tool that uses C++ as its library while network simulation scenario is configured using Tool Command Language (TCL). Network environment is configured to conform the IEEE 802.11g scenario. In the next paragraphs, several assumptions and configurations are discussed. Both AODV and DSDV routings will apply these configurations.

Several assumptions were made in order to evaluate the wireless network performance. Each MS will have only one type of configuration (using the default IEEE 802.11g default configuration or using the proposed scheme configuration) and transfer only one type of data. 16 MSs are used where eight of them are senders and the rest are receivers. The receivers will receive data from one sender only. There will be eight pairs of sender-receiver, and thus eight network flow. Each network flow will be tagged, namely **fid1 to fid8.** From the eight flows, only **fid1** will be represented by the configured MS and will be analyzed.

In order to see the difference in terms of improvement or degradation of the proposed scheme, the simulations findings are compared with the default IEEE 802.11g findings. Therefore, the default IEEE 802.11g network was also simulated as the controlled experiment. Several values of **SIFS** will be used. TABLE I. below shows the different values of **SIFS** tested on the simulations.

TABLE I. THE DIFFERENT VALUES OF **SIFS** USED IN THE SIMULATIONS

Experiment	SIFS (µs)
Default 802.11g	10
Scenario 1, fid1	8
Scenario 2, fid1	6
Scenario 3, fid1	4

Each of the experiment is then put into test by simulating the scenarios to conform to the default (as the benchmark) and proposed parameters.

VII. RESULTS AND FINDINGS

Each event on the network simulation (packet sent, received, forwarded, dropped) will be recorded into a raw log file called the tracefile. In order to extract information to determine the throughput of the network performance, several scripts, written in the AWK language is used. Then, shell scripts are used to automate the AWK script to read and extract the tracefile.

Extracted information is isolated in a different textfile before being imported into a statistical tool. SPSS is used to analyze the information statistically. The mean value of the throughput is examined to determine the performance of the throughput. This is because the mean value of the throughput will reflect the overall throughput performance of the selected network flow. TABLE II. below shows the results of the simulations of using different values of **SIFS** on AODV environment.

TABLE II. MEAN THROUGHPUT RESULTS OF SIMULATIONS IN AODV

Results of **fid 1**		
Experiment	SIFS (µs)	Mean Throughput (kbps)
IEEE 802.11	10	3977.81
Scenario 1 fid1	8	4343.77
Scenario 2 fid1	6	0.70423
Scenario 3 fid1	4	0.70426

From the table above, it is already expected that using shorter SIFS will increase the mean throughput of the configured MS. It is shown in **Scenario 1 fid1** that using shorter SIFS (8µs) increased the mean throughput compared to using longer DIFS (28µs). It is an improvement of 9.2% of throughput which is an increase from 3977.81 kbps to 4343.77 kbps.

Meanwhile TABLE III. below shows the results of the simulations of using different values of **SIFS** on DSDV environment.

TABLE III. MEAN THROUGHPUT RESULTS OF SIMULATIONS IN DSDV

Results of **fid 1**		
Experiment	SIFS (µs)	Mean Throughput (kbps)
IEEE 802.11	10	3875.92
Scenario 1 fid1	8	4210.31
Scenario 2 fid1	6	123.989
Scenario 3 fid1	4	121.178

Similar to AODV, DSDV showed signs of improvements in using shorter SIFS values. Using 8 µs of SIFS resulted on an increase of throughput. From the above table, an increase of 8.63% of throughput was shown, rising from 3875.92 kbps to 4210.31 kbps.

However, it is interesting to note that using SIFS shorter than 8µs leads to a question. This applies for both AODV and DSDV environment. Initially, using shorter SIFS will lead to shorter waiting time and higher throughput. This is true in the Scenario 1 fid1. However, it is a different case in **Scenario 2 fid1** and **Scenario 3 fid1** where throughput dropped dramatically. This was not expected and is totally opposed to the initial assumption. After several further analyses, this phenomenon can be described as below.

In IEEE 802.11, **SIFS** is also being used during the transmissions of TCP packets where ACK packets are involved. This can be shown as in Figure 3. below.

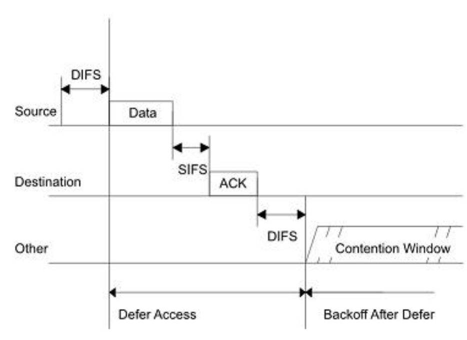

Figure 3. The usage of **SIFS** in TCP packet transmission

From the figure above, the source MS has transmitted data to the destination MS. In TCP transmission, each packet sent by the sender will be replied by the receiver to notify the sender that the packet has already arrived. The notification is called the ACK packet. In IEEE 802.11, the receiver has to wait an **SIFS** period of time before transmitting the ACK to avoid collision. With regard to the experiment done in this research, changing the value of the **SIFS** has not only affected the **DIFS** but also the waiting time of the receiver to send the ACK to the sender which explains the very low number of successful transmissions.

The **SIFS** behavior of being the waiting time for ACK packets leads to low successful transmission. Initially, the sender sends the packet to the receiver. After the sender sends the packet, it then waits for **SIFS** and listen for any ACK. However since the **SIFS** is too short, the sender only listens for the ACK for a very short time where the ACK could not arrive before the **SIFS** times out. The sender then suspects packet collision or packet drop. When the channel is idle, the sender retransmits the packet and the cycle continues where the ACK cannot arrive before **SIFS** times out. The looping process can be depicted as in Figure 4. below.

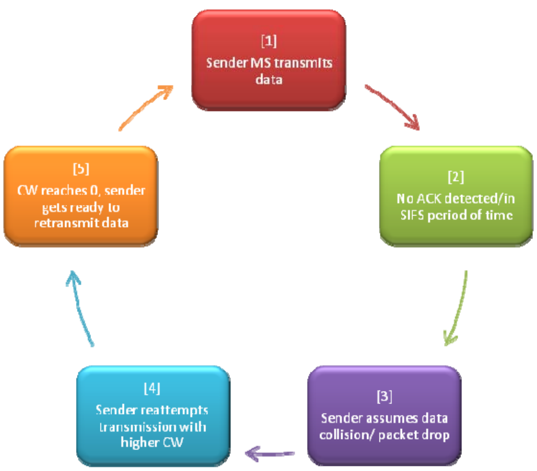

Figure 4. Scenario on low number of successful transmission in shorter value of **SIFS**

Therefore with regard to this research, the best **SIFS** value to support better performance done in the NS-2 simulation is **8µs.**

VIII. CONCLUSION

This paper primarily focuses on the study to enhance the performance of wireless LAN through modifications of SIFS values. Tests are done exhaustively in order to unearth the best SIFS value to be implemented in the IEEE 802.11g. Although IEEE 802.11e (IEEE 802.11 amendment to support QoS) and IEEE 802.11n (IEEE 802.11 amendment to support better performance using Multiple Input Multiple Output - MIMO) introduced by IEEE are gaining breakthrough in the market, it requires end to end upgrades in terms of hardware and software. This requires a very high cost to be implemented in the near future.

The configurations and simulations done is this paper involves modifying the SIFS to get better performance in terms of throughput. From the findings and result of the experiments, it is proved that the new provision technique proposed for the IEEE 802.11g ad-hoc network in this paper has the ability to enhance the throughput of network flow thus improving the IEEE 802.11 for better performance.

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