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REVERSE DIRECTION TRANSMISSION USING SINGLE DATA FRAME AND MULTI DATA FRAMES TO IMPROVE THE PERFORMANCE OF MAC LAYER BASED ON IEEE 802.11N

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ABSTRACT: *Reverse direction transmission and block ACK are effective ways to improve the performance of MAC layer that reduces the overhead and increases the system throughput. As high as 600 Mbps of physical data rate is achieved in IEEE 802.11n where high data rate of the current MAC layer leads to a high performance overhead and low performance throughput. Further,designing the MAC layer is still ongoing to achieve high performance throughput. In this paper, we examine the performance enhancement of the proposed 802.11n MAC layer in terms of reverse direction transmission using a single data frame and multi data frames. We implemented these schemes in the NS2 simulator to show the results for TCP traffic and compared them with the literature.*

KEYWORDS: Reverse direction transmission, single data frame, Multi data frames, MAC layer, IEEE 802.11n.

1.0 INTRODUCTION

In the last few years, there has been an explosive growth in IEEE802.11 WLAN [1]. Recently, Wireless local area networks (WLANs) are becoming more well-known and their importance has been increasingly realized. There has been also a widespread acceptance of the IEEE 802.11 WLANs as a matching technology to high-speed IEEE802.3 (Ethernet) for portable and mobile devices. Such great achievement of this technology is attributed to its effectiveness in pursuing the increase in the data transmission rates while maintaining a relatively low price. The specified features of IEEE 802.11, 802.11b, and 802.11a/g can provide up to 2 Mb/s, 11 Mb/s, and 54 Mb/s data rates. Furthermore, the IEEE 802.11Working Group is adopting the IEEE 802.11n, which is a modified version of higher throughput and higher speed improvement. While the primary aim of IEEE 802.11a/.11b/.11g/.11e/.11n is to provide higher speed data rates, which are accompanied with diverse physical layer (PHY) specifications [2], distributed coordination function (DCF) is the particular CSMA/CA mechanisms applied in the 802.11 MAC. In the DCF inter-frame space (DIFS), a clear channel assessment (CCA) is initially performed when a transmission is intended to be performed in a station. During the inactive mode of the medium, assumption that the station takes the ownership of the medium is made, and a frame exchange sequence is initiated. The station will wait for the inactivity mode of the medium when it senses that it is engaged, defers for DIFS, and is followed by random back-off duration. The station makes assumption to take ownership and initiates a frame exchange sequence during the event when inactivity remains for DIFS deferral as well as the back-off duration. The goal of IEEE 802.11n is to provide a higher throughput rather than higher data rates, along with PHY and improvements of medium access control (MAC) [3]. In IEEE802.11b [4], it is stated that specification of the physical layer standard for WLANs in 2.4 GHz radio band is available and it supports three channels with the maximum rate of 11 Mbps per channel. Similarly, specification of the physical layer standard for WLANs also exists in theIEEE802.11a. However, it has a limited radio band in 5GHz, which implies that 802.11a does not have compatibility with 802.11b/g. Moreover, it involves eight channels and the maximum physical layer rate is around 54 Mbps per channel. In IEEE802.11g, there is a defined new physical layer standard for WLANs in the 2.4 GHz radio band. It also includes three available channels in 802.11g, which have a maximum rate of 54 Mbps per channel. Thus, the 802.11g standard can support the modulation of OFDM (orthogonal frequency division multiplexing). However, for its backward compatibility with 802.11b, it can support the modulation of CCK (complementary code keying). Thus, the emergence of IEEE802.11n technology has significantly supported the multimedia applications, such as the DVD and HDTV 9.8Mbps and 20Mbps respectively. IEEE 802.11e is a MAC layer version that extends from the 802.11 standard for Quality of Service (QoS) provision. Unfortunately, the current 802.11 MAC does not possess any effective service differentiation capability because it treats all upper layer traffic in the same fashion. Wireless LANs based on IEEE 802.11 increases everywhere to support many applications using TCP, UDP, HDTV, and VOIP. There is a chance of high-speed wireless LANs, in which the physical layer rate may reach up to 600Mbps to get high efficiency at MAC layer. The idea behind this, is that the increase in the physical rate can result in an increase in the transmission at MAC link; thus, causing an increase in the overhead. With respect to the above-stated problem, this work presents a research effort to Mitigation the Overhead and Increase the MAC efficiency for IEEE 802.11n. In IEEE802.11, the throughput does not scale well with the increase of the physical rate. However, the throughput can achieve 100Mbps at a MAC layer. To achieve a wide performance enhancement or improvement of the IEEE802.11n, it is important to find the major problem that causes MAC inefficiency [5]. The IEEE 802.11Working Group adopts the IEEE 802.11n, which is a modified version of better output level and acceleration. IEEE 802.11n aims at providing better output level rather than greater frequency of data, including the PHY and improvements of medium access control (MAC), Moreover, IEEE 802.11n provides many enhancements in lowering the overhead of MAC layer, such as frame aggregation, Block acknowledgment (BA) and reverse direction transmission (piggybacking) [6], [7]. Block ACK protocol allows data frames to be grouped together, and it is the key to further efficiency improvements introduced in 802.11n. An easy enhancement under block ACK is to reduce the inter-frame space (RIFS) for transmissions during the data burst. Since the station remains in transmit mode for the duration of the burst, taking things a step further could eliminate the inter-frame space and preamble altogether and concatenate data frames in a single transmission. In 802.11n, this is referred to the aggregation, and it is the key throughput enhancing feature introduced in the 802.11n MAC. As illustrated in Figure 1, BA frame performed with piggybacked on each of the data frames, making up the aggregate. In this paper, we study the performance of the reverse direction transmission with single data frame and multi-data frames to improve the performance of IEEE 802.11n. Reverse direction transmission allows the responder to transfer the data frames after the initiator transmits the data frame and the frame of BAR. This protocol reduces the delay time of terminal destination station to respond to the source station.

2.0 FRAME AGGREGATION

Frame aggregation is defined as an application that allows combining a few frames into a larger, individual frame for transfer. The process is carried out by using two available procedures, namely the aggregation of MAC service data unit (A-MSDU) and the aggregation of MAC protocol data unit (A-MPDU). Moreover, MSDU can be mainly distinguished from MPDU in terms of its information transfer functions. MSDU corresponds to the import or export of data from the top most layer of MAC, while the latter depends on data transfer by the lower part of the MAC from or to the PHY [8].

3.0 BLOCK ACKNOWLEDGMENT

The block acknowledgement protocol, proposed with the 802.11e amendment, increases the efficiency by permitting the transfer of a block of data frames that are acknowledged with a single Block Acknowledgement (BA) frame, instead of an ACK frame for each of the individual data frames. In contrast to the regular acknowledgement mechanism, the block acknowledgement mechanism is session oriented. A station must establish a block acknowledgement session with its peer station for each traffic identifier (TID) in which block data transfer is to occur. Thus, a particular block acknowledgement session is identified by the transmit address, receiver address and TID as illustrated in Figure 2 [9].

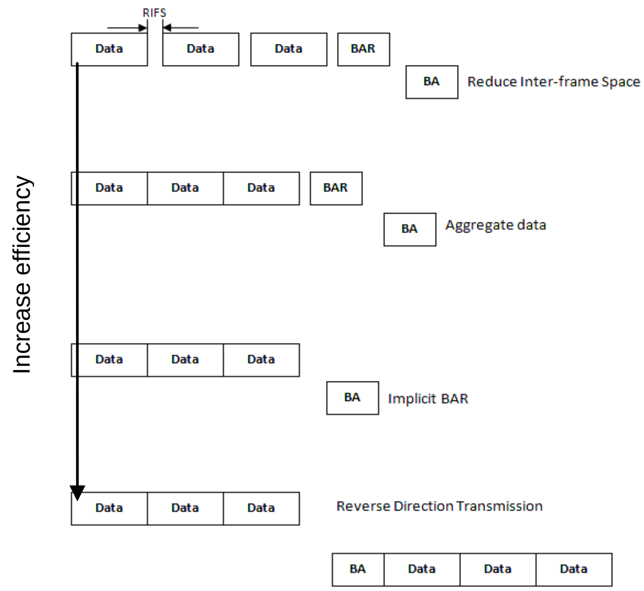

Figure 1: Basic output enhancements to the IEEE 802.11n

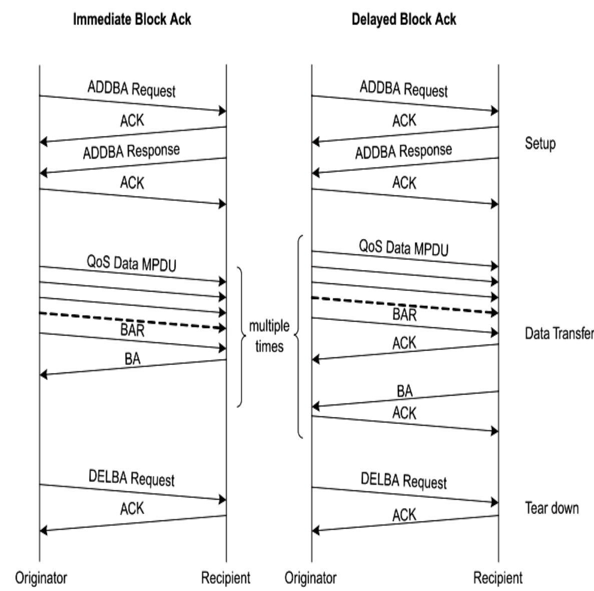

Figure 2: Immediate and delayed block acknowledgment

4.0 EVERSE DIRECTION TRANSMISSION WITH SINGLE DATA FRAME

A bi-directional data transmission approach is also specified by the following next generation of wireless LANs. The reverse direction data flow is very useful for traffic streams that have a bi-directional nature, such as the TCP traffic that has the backward TCP ACK flow. Moreover, reverse direction allows transmission in both directions from different application streams, such as a video stream in one direction and a video control in the backward direction and vice versa. The sender or transmitter is only allowed to send a single data frame when RTS/CTS are utilized due to the recent transfer sequence of RTS (Request to Send) - CTS (Clear To Send) – DATA (Data frame) - ACK (Acknowledgement). The recipient may necessitate a reverse data transfer in the CTS control frame in the bi-directional data transmission approach. Then, a certain medium time for the receiver on the reverse link can be provided by the transmitter as illustrated in Figure 3. The sequence of transmission will become RTS – CTS – DATA frame – Piggyback frame (DATA + ACK). In a very high speed WLANs environment, a selective bidirectional data transmission mechanism depending on a frame piggyback is adopted. In this part, we focus on only single data frame from the sender to receiver and reverse.

4.1 Performance evaluation for reverse direction transmission with single data frame

We implemented the reverse direction transmission in Network Simulator NS2. To enhance the channel utilization from the MAC layer, we concentrated on the MAC layer implementation. When the traditional transmission accrues, it means that the data has been transmitted to the receiver and a replay ACK, called DCF has occurred. When the receiver has a data to send to the sender, the ACK should be piggybacked in the data frame, and this process is called the Bi-directional Transmission BT. As shown in Figure 4, we evaluated the performance of BT, which is the bi-directional transmission with a number of stations from 10 to 80 stations. It also shows that the output of BT achieved high performance as compared to the previous protocol, which is a distributed coordination function (DCF). When BER=10^{-4}, the output of BT achieved around 10Mbps and it increased, when BER=10^{5} to 45Mbps. When the BER=10^{-6}, the output achieved 50 Mbps. The increase in BT compared to DCF ranged at 5Mbps at BER=10^{-4}, and ranged at 20Mbps at BER= 10^{-5} and BER = 10^{6}. In Figure 5, the BT protocol scored the lowest delay. As a result, the delay increased through an increase in the number of stations.

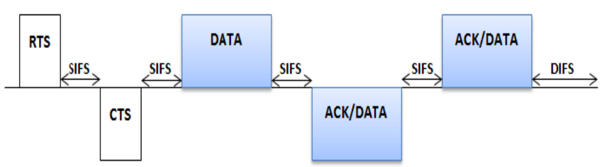

Figure 3: Bidirectional transmission systems with single data frame

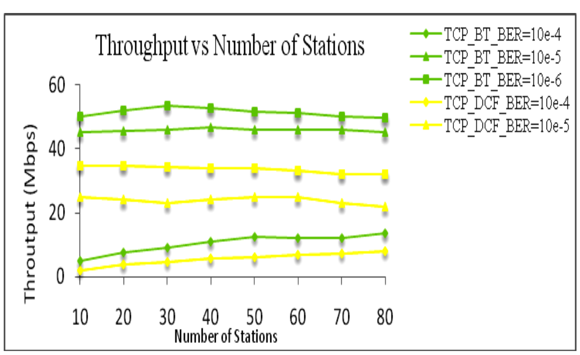

Figure 4: Throughput with number of stations

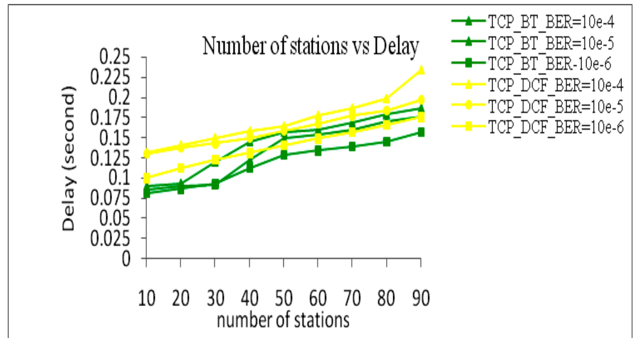

Figure 5: Delay with number of stations

4.2 Performance evaluation for reverse direction transmission with multi data frames

In block ACK, the physical header overhead exists for each data frame, whereby once the BA frame is received, the sender allows a DIFS interval and a backoff process before re-using the channel. At the same time, all the other STAs will wait until the completion of the BA transfer. Then another DIFS interval is allowed, before the countdown of their backoff counters for the next round of transmission is done. In a reverse direction transmission with a multi-data frame, the aggregation scheme is adopted, involving the use of packets and frames so that the overhead can be reduced. As shown in Figure 6, we evaluated the performance of reverse direction RD with 5 to 15 stations. It shows that the Throughput of RD achieved a high performance in comparison to the literature schemes. When BER=10-4, the Throughput performance of RD achieved 70, which is an increase as compared to block ACK (BA) with 20Mbps. There was an increase performance, when the BER=10-5 to 80Mbps. As shown in Figure 7, we found the delay performance of RD and compared it with the literature protocols. The RD protocol scored the lowest delay: The delay is increased through an increase in the number of stations.

5.0 CONCLUSION

The aggregation schemes, block ACK, Reverse direction Transmission are the most important schemes to improve the performance of MAC layer based on IEEE 802.11n. Unlike the reverse direction transmission, the aggregation schemes and block ACK have been taken into consideration in several studies. In this paper, we have implemented the reverse direction transmission with single and multi data frames with NS2 simulator and reported the result using TCP traffic. The simulation analysis evaluated the throughput and efficiency delay of bidirectional transmission with single data frame and reverse direction transmission with multi data frames in noisy channels and compared to the identical procedures in the previous studies.

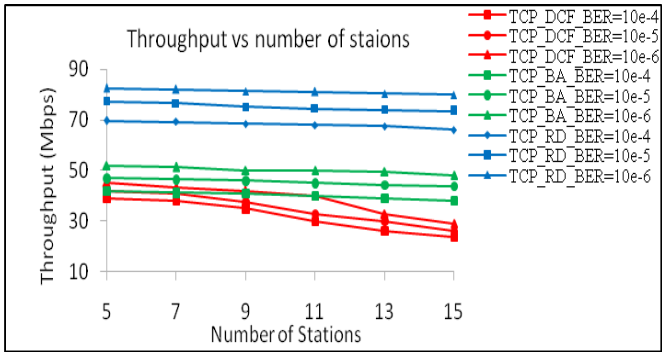

Figure 6: Throughput with number of stations

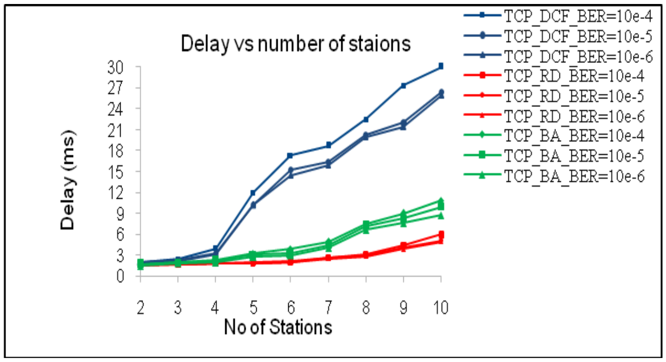

Figure 7: Delay with number of stations

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REFERENCES

[1] *IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC)and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Higher Throughput.* IEEE Std 802.11n-2009 (Amendment to IEEE Std 802.11-2007 as amended by IEEE Std 802.11k-2008, IEEE Std 802.11r-2008, IEEE Std 802.11y-2008, and IEEE Std 802.11w-2009), 2009: p. 1-565.

[2] Group, I.W., *IEEE Standard for Information Technology–Telecommunications and Information Exchange between Systems–Local and Metropolitan Area Networks–Specific Requirements–Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments.* IEEE Std, 2010. 802: p. 1-51.

[3] Xiao, Y., *IEEE 802.11 n: enhancements for higher throughput in wireless LANs.* Wireless Communications, IEEE, 2005. 12(6): p. 82-91.

[4] *Draft Amendment to IEEE Std 802.11, 1999 Edition (Reaff 2003) IEEE Standard for Information technology Telecommunications and Information Exchange Between Systems LAN/MAN Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Spectrum and Transmit Power Management Extensions in the 5GHz band in Europe (Amendment to IEEE Std 802.11, 1999 Edition).* IEEE Std P802.11h/D3.11, 2003.

[5] Milad, A.A., et al., *Reverse Direction Transmission in Wireless Networks: Review.* Middle-East Journal of Scientific Research, 2013. 18(6): p. 767-778.

[6] Milad, A.A., et al. *Design a novel reverse direction transmission using piggyback and piggyback with block ACK to improving the performance of MAC layer based on very high speed wireless lans*. in *Information & Communication Technologies (ICT), 2013 IEEE Conference on*. 2013. IEEE.

[7] Milad, A.A., et al., *Transmission Control Protocol Performance Comparison Using Piggyback Scheme In Wlans.* Journal of Computer Science, 2013. 9(8): p. 967.

[8] Saif, A., et al., *Frame aggregation in wireless Networks: Techniques and Issues.* IETE Technical Review, 2011. 28(4): p. 336.

[9] Group, I.W., *IEEE P802. 11n/D1. 0 Draft Amendment to Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan Networks-Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Enhancements for Higher Throughput.* Local and Metropolitan Networks, Specific Requirements, Part, 2006. 11.