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RESEARCH ARTICLE

Reliable and Efficient Multicast Protocol for MPEG - 4 Transmissions over IEEE 802.11n

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Abstract— *Multicasting is the communication between single sender and multiple receivers. The legacy multicasting over the WLAN standard IEEE 802.11 has two problems- poor reliability and low transmission rates. Existing multicast protocols for 802.11 are not so efficient when they are used along with the frame aggregation of IEEE 802.11n WLANS. Therefore we propose a new multicast protocol for WLAN standard IEEE 802.11n, named as Reliable and Efficient Multicast Protocol (REMP), which selectively retransmits the errored multicast frames. In addition, we propose the extension by transmitting MPEG-4 video transmission over IEEE 802.11n. In our proposed approach, (1) P and B frames will be discarded by the MPEG 4 decoder at the receiver if the corresponding I frame is lost; (2) the individual MPEG-4 frames are prioritized at the receiver in such a way that I frames have a higher priority than P frames, which have higher priority than B frames.*

Keywords**—-** *IEEE 802.11n, MPEG-4, Multicast, Wireless Local Area Networks.*

1. INTRODUCTION

The IEEE 802.11n wireless local area network has been one of the most popular wireless access technologies due to its advantages of high data rate, low cost and easy deployment. One of the key enhancements of IEEE 802.11n is the frame aggregation, which maximizes the throughput. We focus on multicast transmissions over 802.11n WLANs. Most of the existing multicast protocols have been designed on the 802.11 MAC. Since 802.11n MAC has a backward compatibility with the 802.11 MAC, the existing multicast protocols can be used in 802.11n.

However it will not be used as since it causes serious problems as frame aggregation is employed in 802.11n. Hence we propose a multicast protocol named Reliable and Efficient Multicast Protocol (REMP) [1]. In this paper, we extend REMP for transmitting MPEG-4 video frames over IEEE 801.11n WLANs [2]. The remainder of the paper is organized as follows. In section 2, we describe about the frame aggregation involved in IEEE 802.11n. Section 3 presents the brief introduction about MPEG-4 frames. Section
4 presents the protocol operations of REMP and section 5 presents the prioritized MPEG-4 frames over IEEE 802.11n WLANs. Simulation results are presented in section 6 and concluded in section 7.

2. FRAME AGGREGATIONS IN IEEE 802.11n

IEEE 802.11n supports up to 600 Mbps at the PHY layer by using the MIMO technology and wider channel bandwidth. The throughput limitation is due to the large overhead of IEEE 802.11 MAC. Frame aggregation is used in 802.11n to overcome the large overhead. Frame aggregation is a process of packing multiple MSDUs or MPDUs together to reduce the overheads and average them over multiple frames, in order to increase the user level data rate. There are two methods to perform frame aggregation: A-MSDU [aggregate MAC protocol service unit] and A-MPDU [aggregate MAC protocol data unit]. In A-MSDU aggregation, multiple MSDUs are appended in a single MPDU. A-MSDU aggregation shows improved performance only when there is more number of smaller MSDUs. But if the receiver unable to decode any one of the subframes then the entire A-MSDU has to be re-transmitted again.

In case of A-MPDU aggregation, multiple MPDU sub frames are joined with a single leading PHY header. A-MPDU uses FCS field, which is used to verify each subframes and uses Block acknowledgement to acknowledge the individual subframes. Thus A-MPDU aggregation is an unique feature in IEEE 802.11n WLANs and reduces larger overhead when compared to legacy 802.11 WLANs [3]. The A-MPDU aggregation is shown as follows:

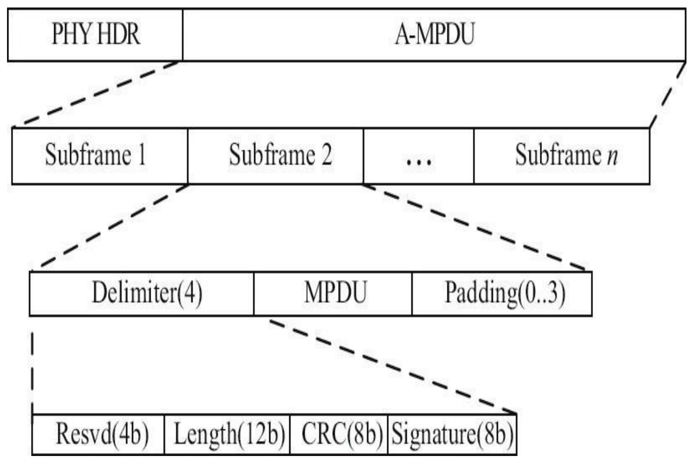

Figure 1: A-MPDU Aggregation in 802.11n

3. MPEG-4

One of the most significant improvements in video compression has been the MPEG suit of standards, of which MPEG-4 is the newest. The main methods of compression used by MPEG-4 is to remove redundant information found in the individual frames that comprise the video and to predict changes from one frame to the next. MPEG-4 encodes an input stream into a sequence of frames known as GOPs. The main concept here is that, one frame or picture to the next, very few changes may occur in short time between frames. MPEG-4 takes a sequence of raw frames at any rate and splits the frame into a sequence of pictures called a GoP. One second of video may be decomposed into several GoPs depending on the complexity of the overall scene and the compression rate. A sequence of scenes from the raw video is decomposed into several GoPs. Figure 2 illustrates how a GoP is further decomposed into I, B and P frames. A brief discussion of individual frames is given as follows:

(1) I (Intra coded picture): This is a single still compressed image that is used as a starting point for the next sequence of frames (B and P types). This single image is also used to resynchronize the entire scene at the receiver. In the event that a GoP is lost or corrupted, the next GoP has a fresh image from which it may start.

(2) P (Predicted pictures): These are the pictures that are compressed and used as a reference point for B frames. The compression used here involves motion-compensated prediction.

(3) B (Bi-predictive pictures): These provide the highest level of compression. Using the previous I or P frames, the B frames may be predicted with a weighted average. The B frame may be predicted by using both the forward and backward directional changes in motion.

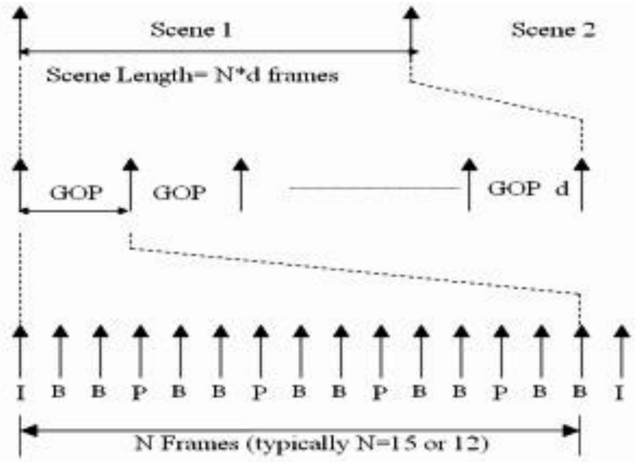

Figure 2: Scene is broken into a GoP

I frame acts as a reference point used to start the next GoP and to resynchronize the video errors in transmission. The P frames are compressed versions of the I frame and they contain some predicted information. The B frames are compressed even further and are comprised mostly of predicted information from neighboring I and B frames up to the next I frame are of no use.

4. REMP OPERATIONS

REMP basically adopts the leader-based approach. Access Point [AP] maintains a list of receivers for each multicast group and selects one leader for a multicast group. In order to maintain the multicast group, the AP maintains a Group Table which has six fields. They are Group address field, Leader address field, Address List field, SNR list field, Timestamp field and T_{delay} field. Group address field denotes the MAC addresses of multicast group whereas Leader address field denotes the leader's address of corresponding group. Address list field maintains the address of multicast receivers; Timestamp field stores the last transmission time for the group. T_{delay} field stores the recent waiting time for accessing the channel. The initial value of T_{delay} field is zero whereas Timestamp field is given by the product of the size of minimum congestion window and the time length of one time slot. The leader selection procedure for a multicast group is as follows: leader for a multicast group is selected by using Multicast Feedback Request (MFR) and Multicast Channel Acknowledgment (MCA) frames by the AP. First, the AP sends MFR frames to the multicast receivers. After receiving MFR, the multicast receivers in the group report the current SNR value to the AP by sending MCAs one by one according to the order in MFR. Based on the received MCAs, the AP selects a receiver having the worst SNR as the leader. After that, the Leader address field and SNR list field in the Group Table will be updated by AP [5]. After the leader selection, the transmission of A-MPDU frames to the destination group is as follows: AP waits for a channel contention and sends a Multicast Transmission Announcement (MTA) to the multicast receivers. The receivers receiving the MTA frame can learn that the Group G will be the target of the following A-MPDU transmission and who is the leader of Group. After sending MTA, the AP waits for a reduced inter frame space (RIFS) and then sends an A-MPDU frames. The various frame formats of control frames are shown as follows:

Frame control (2)	Duration (2)	RA (6)	TA (6)	Type (1/8)	#of receivers (7/8)	Addresses of receivers	FCS (4)

Figure 3: MCR Frame format

Frame control (2)	Duration (2)	RA (6)	TA (6)	SNR (1)	FCS (4)

Figure 4: MCA Frame format

Frame control (2)	Duration (2)	RA (6)	TA (6)	LA (6)	FCS (4)

Figure 5: MTA Frame format

Frame control (2)	Duration (2)	RA (6)	TA (6)	SNR (1)	BA control (2)	BA information (10)	FCS (4)

Figure 6: MBA Frame format

After receiving the A-MPDU, the leader replies with a Multicast Block Acknowledgement (MBA) frame to report the current SNR as well as to acknowledge the received A-MPDU to the AP. The non-leaders do nothing if all MPDUs in the A-MPDU are successfully received. If not, they send NAK that has the same frame length as MBA. Three cases can be observed in this transmission procedure. They are as follows:

(i) AP does not receive any frame from the receivers, this case occurs when either the leader does not receive MTA or MBA sent by the leader was lost due to the worse channel conditions. Since the AP cannot receive any feedback from multicast receivers, it transmits MTA and the A-MPDU again after channel contention.

(ii) The second case is that AP receives MBA frames only from the leaders. This means that, all the nonleaders received all the A-MP DU frames successfully. In this case, SNR value of the leader is updated in the SNR field and the current time is stored in the Timestamp field by the AP.

(iii) The third case is that some of non-leaders receive errored frames and they send NAK to the AP. In this case, leader change procedure is performed again. The leader change procedure is same as discussed above, the only change is multicast receivers send MBA [Multicast Block Acknowledgement] instead of MCA. In this case, AP transmits only errored sub frames in response to the Block acknowledgements.

5. PROPOSED MPEG-4 FRAMES TRANSMISSION

In the above section we studied the transmission of A-MPDU frames over IEEE 802.11n by using REMP. In order to make the system more reliable, we propose the transmission MPEG-4 transmission over 802.11n. It inherits the basic features of REMP such as leader selection/change procedures. In this section we extend the REMP by the transmission of MPEG-4 frames and applying following modifications.

In MPEG-4 frames, we observe that I, P and B frames are in decreasing order of importance. If an I frame of MPEG-4 video is lost, the next N-1 frames are useless, where N is the total frames within one GoP. First, the P and B frames must be discarded by the MPEG-4 decoder at the receiver on the account of the lost I frame. Therefore we propose the following protocols to improve MPEG-4 transmission over 802.11n WLANs.

(i) P and B frames will be discarded by the MPEG-4 decoder at the receiver if the corresponding I frame is lost since all the frames become useless once I frame is lost.

(ii) The individual MPEG-4 frames are prioritized in such a way that I frames have a higher priority than P frames which have a higher priority than B frames at the MPEG-4 decoder.

The individual MPEG-4 frames could be prioritized in such a way by assigning higher priority to I frames. Priority can be assigned by the following way:

Retry-limit of I frames > retry-limit of P frames > retry-limit of B frames; e.g, the retry-limit of frames can be the same as the retransmission limit in the normal 802.11 standard frame (i.e., 7 for I frames, 3 or 4 for P frames. 1 or 2 for B frames). First, I frames must have the higher priority and thus the most retransmission retries because a lost I frame affects so many later P and B frames. Second are the P frames; if one of these is lost, only the least important B frames are affected. If a B frame is lost, no other frames are affected; however, the decoder may experience a delay as it waits for a B frame that will never arrive. Finally it would be least effective to drop B frames by only attempting one retransmission.

6. SIMULATION RESULTS

We performed simulations using the ns-2 simulator and compared the performance of REMP with DPMM (Double Piggyback Mode Multicast protocol), only existing multicast protocol for IEEE 802.11n and the legacy 802.11n multicast protocol. We have evaluated the parameters like unicast throughput and multicast throughput. Multicast throughput is the average throughput received by multicast receivers whereas unicast throughput is the average throughput received by AP from unicast sender.

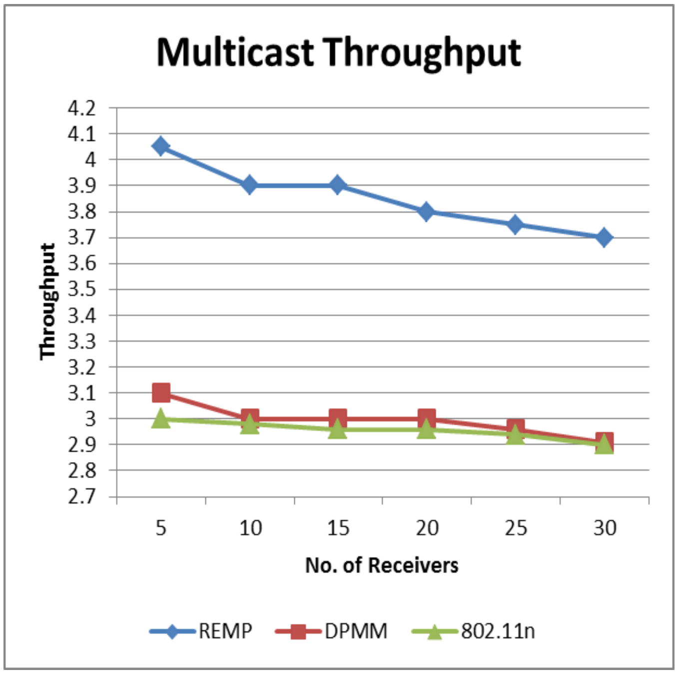

Figure 7: Multicast Throughput

We studied the performance when number of receivers varies from 5 to 30 and the maximum distance is limited to 150 m. It is observed that REMP shows higher performance than DPMM and the legacy 802.11n multicast protocol. In case of unicast throughput REMP and DPMM outperforms the legacy 802.11n multicast protocol since they make AP use shorter time for multicast transmissions.

Each sending station produces MPEG-4 traffic at the frame rate of 30 f/s. We have used cygwin environment to transmit video frames over 802.11n using ns-2. We have taken the qcif format video consisting of 1999 frames and applied MPEG-4 coding before transmission. PSNR value is most widely used technique for image and video quality measurement. Our proposed work exhibits good PSNR value for each frame. PSNR value is slightly lower for the frame 273 as the delay between the current frame and the previous frame is too long. However the overall PSNR achieved indicates the better quality of video reception. A PSNR value of 35 dB is generally considered good.

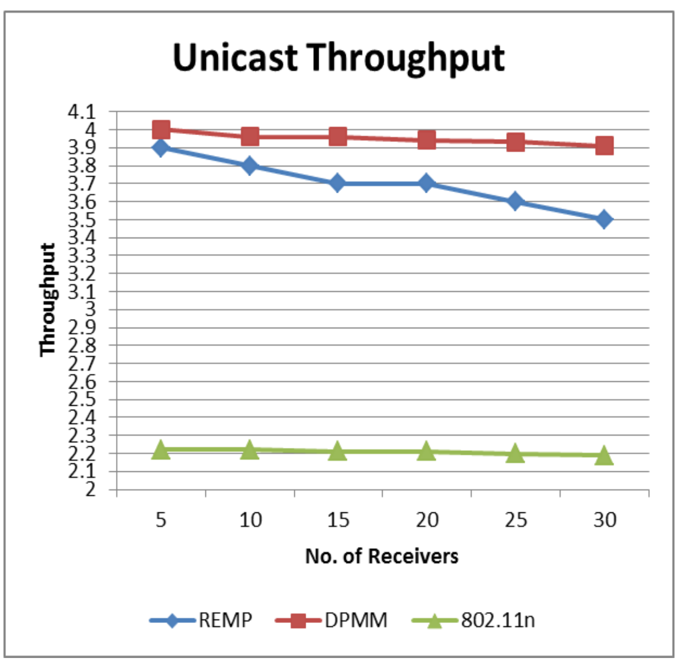

Figure 8: Unicast Throughput

For MPEG-4 transmissions, we present the simulation using ns-2 simulator in cygwin environment. The resultant PSNR for MPEG-4 transmission is entailed in figure 9.

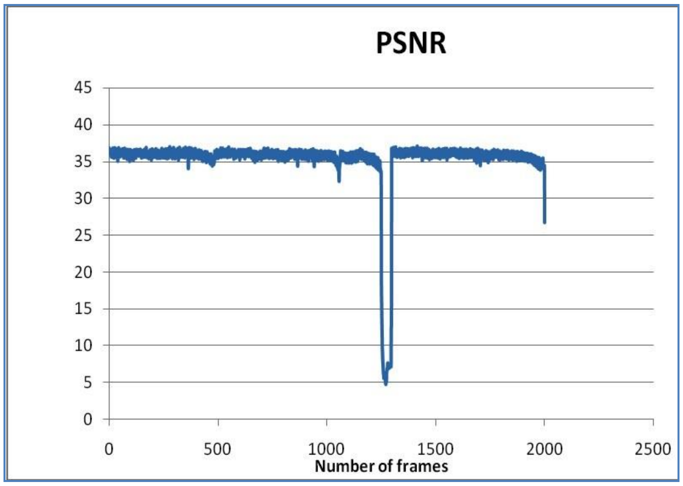

Figure 9: PSNR

7. CONCLUSION

We proposed a multicast protocol named REMP which enhances reliability and efficiency of multicast transmissions in 802.11n. Also, we extended the work by transmitting MPEG-4 video using the same transmission procedures. In the transmission of MPEG-4 video frames, we observed that if an I frame was lost, the next N-1 frames were uselss. In addition we observed that I, P and B frames were in decreasing order of importance. As our future work, this paper can be further modified by discarding the least important B frames if the delay between I and next P frame is too long.

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