ET4394:Rate Control Algorithm for Low Latency Devices

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1 Introduction

IEEE 802.11 is the most popular WLAN system in the world today and it is likely to play an important role in the next generation of wireless and mobile communication systems. There are many reasons for the highly volatile nature of the wireless medium used by the IEEE 802.11 standard: fading, attenuation, interference from other radiation sources, interference from other 802.11 devices in an ad hoc network, etc. If one decides to move to an other office, thus approaching the AP (Access Point), the attenuation will decrease and this will have a longer lasting effect on the energy of the radio signal that will probably decrease the BER (Bit Error Rate). This, in turn, will allow higher application-level throughput since the PER (Packet Error Rate) is lower. Various rate control algorithms can be designed depending upon following parameters :

- Power Consumption : Mobile devices a have a fixed power budget thus it is very important to minimize the amount of energy consumed.
- Throughput : Higher 802.11 have high throughput and more BER, High BER requires more retransmission for error free transmission.

There are two classes of rate adaption algorithms for 802.11 devices Low Latency Systems(allows per packet adoption algorithms) and High Latency Systems(requires periodic analysis of transmission characteristics and updates to transmission parameters). This report is organized as follows Section 3 presents the methodology used for the algorithm, Section 4 deals with the simulations performed and Section 5 deals with the conclusion. In this report we work on the Low Latency System.

2 Methodology

In typical working environment best rate to choose to optimize throughput is highest rate whose PER is low enough such that number of retransmissions are low. Typically, higher rates can achieve higher throughput but their higher PER's generate more retransmissions, which then decreases the throughput. Our major focus in implementing this algorithm was to reduce the PER without compromising with the throughput.

In our algorithm the SNR threshold is continuously changed to better reflect the channel conditions. This mechanism increases the amount of history available to the algorithm which helps it to make better decisions. The threshold is adapted using Binary Exponential Backoff(BEB).

When the transmission of the packet fails, we switch back immediately to the previous lower rate but we also multiply by two the number of consecutive successful transmissions required to switch to a higher rate. This threshold is reset to its initial value of 10 when the rate is decreased because of two consecutive failed transmissions. The effect of this adaptation mechanism is to increase the period between successive failed attempts to use a higher rate. Fewer failed transmissions and retransmissions improves the overall throughput.In order to use this algorithm we took help from the AAFR [2] and also studied various algorithm like AMRR, Onoe, Hybrid Rate control Algorithm [1] and AFR, along with MiSer and RABR [3].

3 Algorithm

While designing our algorithm, we decided to focus mainly on Low Power and Low Latency devices. These devices do not need a throughput in the order of 20 Mbps. However these devices need extremely reliable transmission when they do transmit. Hence PER becomes a more crucial aspect that overall throughput. For example, devices that enable the "Smart Home", wearable devices, etc. These devices are also most often powered by a battery, or need to be connected to a power supply 24/7 if they are not. In that case power saving also becomes an important parameter.

Rapid change in the MCS values will lead to higher power consumption and thus lower battery life.

For all of these reasons, we have decided to base our algorithm that changes its values on the basis of its BER and use Binary Exponential Backoff (BEB) to reset the threshold for rate change after a failed transmission.

We hard-code these threshold and retry values in our code to test its functionality. This can be changed from device to device depending on its individual characteristics.

4 Observations

In this section we intend to present a comparative analysis with the default Rate Control Algorithm we were provided with v/s our new proposed algorithm. Our analysis is based on large number of observations that we ran in-order to study that our algorithm successfully helps in reducing PER without compromising much with throughput for all possible channel configurations. We have also provided the graphs that show the comparison of our proposed algorithm with the default in order to support this claim. As we had to make a trade-off between throughput and PER we gave preference to PER and tried to minimize as much as we can. Given below is the comparison of BER for various delay profiles at a specific bandwidth of 40MHz. We have performed similar analysis for all channel bandwidth. We got significant reduction for delay profiles A,D,E and F. Delay Profile D had most reduction in PER of 94.

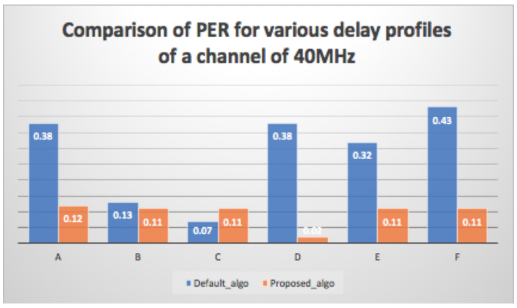

Figure 1: Comparison of BER for various Delay Profiles at 40MHz

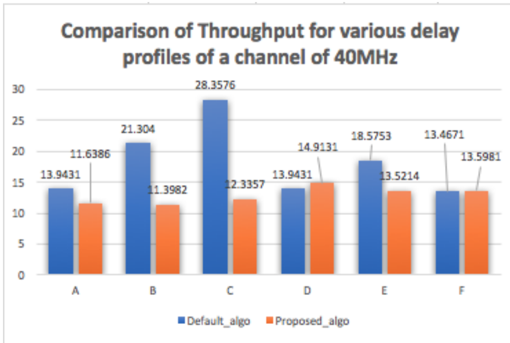

Figure 2: Comparison of throughput for various delay profiles

We also did a comparison of throughput for various delay profiles for the bandwidth of 40MHz in order to analyze the effect on throughput we had in process reducing the PER. For delay profiles A, D, E and F we saw marginal reduction in throughput, however there was significant reduction in throughput for B and C as shown in figure below.

We also performed an analysis where the channel conditions were changed. For this we increased the channel disturbances by 10% and still we were able to observe our proposed algorithm performing better than the default algorithm. The results are shown in the figure below.

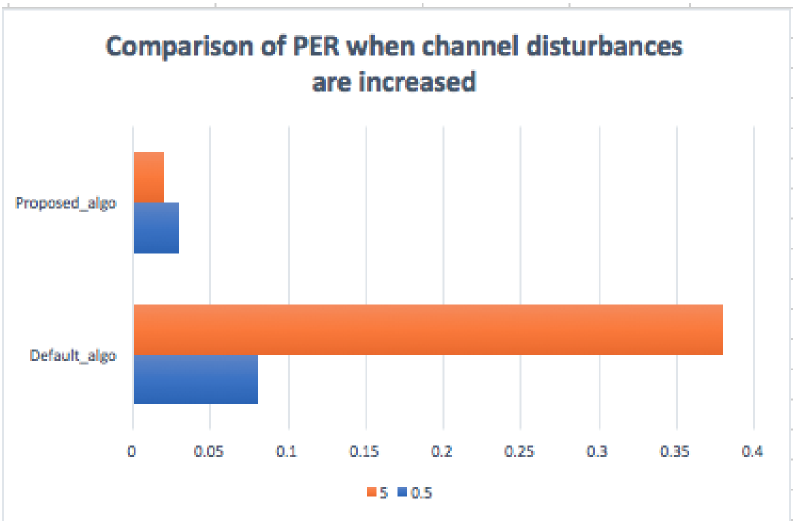

Figure 3: Comparison of BER when channel disturbances are increased

The following images show the simulation results for default algorithm and proposed algorithm respectively. Variation in MCS values with SNR and resulting throughput and BER can be clearly seen from the results.

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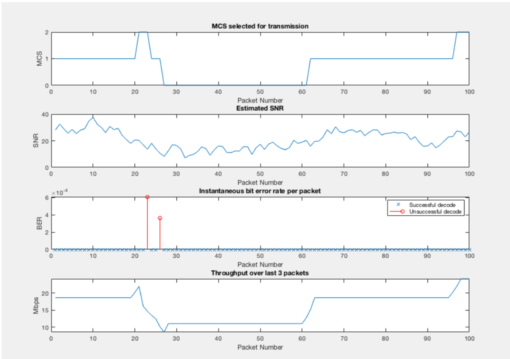

Figure 4: Proposed algorithm simulation results

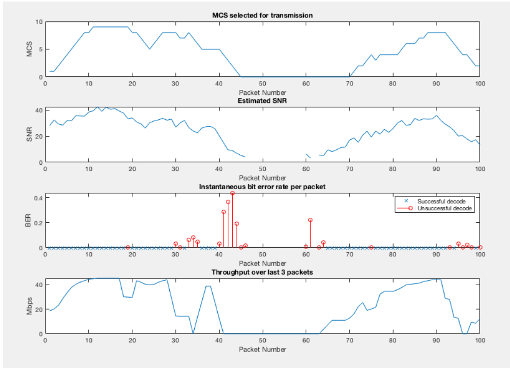

Figure 5: Default algorithm simulation results

We were able to observe a 94% reduction in PER with slight improvement in throughput of 6.5% for delay profile of model-D at 40MHz bandwidth. Similar kind of trend of trend was observed for all possible configuration with some outliers.

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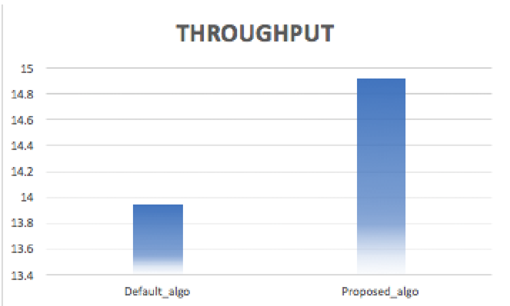

Figure 6: Throughput simulation results comparison for Model-D channel at 40MHz

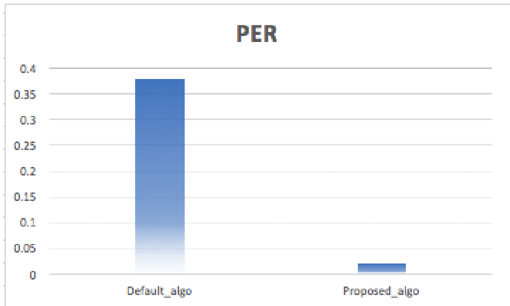

Figure 7: PER simulation results comparison for Model-D channel at 40MHz

5 Conclusion

We were successfully able to implement our rate control algorithm and able to improve upon the existing default algorithm that we were provided with.

1. The proposed algorithm shows decrease in PER upto 94% by making slight trade-off with the throughput for all possible channel configurations(increase was observed for model-D).

2. The proposed algorithm seems to perform better in channels having very high data traffic than the given default algorithm.

3. The proposed RCA shows improvements that we expected however in future we would like to extend algorithm to provide good throughput.

References

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