Throughput and Goodput of Access point at different channel bonding and at different congestion level

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ABSTRACT

In today's world we often come across congested Wi-Fi networks, which thereby leads to poor network performance. In order to optimize this network performance, we have to understand the behavior of wireless portion of congested network. In this paper, we use mac layer information collected from various access points at various locations. Location such as university campus, home network, Starbucks café, etc. We are collecting 802.11 link layer Ethernet header to understand congestion at various channel bonding stages in wild environment. In this project we are going to find the goodput and throughput of a congested network at different channel bonding. We will be using channel busy time as a metric for channel utilization. In other words, collection of MAC layer frames at 20Mhz and 40Mhz channel bonding to find the throughput and goodput. Our study checks for congestion in the network with and without channel bonding. We have observed that there are many deployments in Albany area that have many 40Mhz deployment and as well as there are also many regular deployments with 20Mhz channel bandwidth. We have focused on data mainly on a Starbucks café on western Ave. we have observed that most of the traffic is on 40Mhz channel bandwidth. Due to the people using the advance capacity of the WIFI with 40Mhz channel bandwidth the congestion found in the public WIFI deployment goes to maximum of around 35% of channel utilization & the throughput of the WIFI goes upto 2.9 Mbps. While the utilization of accesses point with 20 Mhz channel bandwidth has utilization is under 15% and the throughput is under 0.8 Mbps. So we can say that WIFI with higher channel bonding has more throughput and goodput.

1 INTRODUCTION

According to paper implemented by Jardosh; the occurrence of a high density of nodes within a single collision domain of an IEEE 802.11 wireless network can result in congestion, thereby causing a significant performance bottleneck. Effects of congestion lead to poor network performance, affecting the throughput and goodput of a network. Therefore, to optimize the network performance there arises a need to understand the behavior of wireless portion of congested network. We will define congestion as the state in which transmission channel will be close to being completely utilized. Now this extent of utilization we will measure using channel busy time metric. This metric will be measured in a particular period of time and check whether the channel is busy. For this project, we have considered certain questions in mind like 1) Is there congestion? 2) Congestion obtained is with or without channel bonding? 3) What is the effect of throughput and goodput with respect to channel utilization? On basis of these questions our analysis is based on. We have analyzed the network and found congestion by checking if the channel is reaching to be utilized. To check whether the channel is utilized we use the metric of channel busy time.

The basic motivation of our project is to analyse congestion in a network at various access points. When there is lot of congestion in a network, the channel utilization of the network increases considerably. Channel utilization occurs when many users want to access the channel. This further leads to overhead thereby reducing the performance of the network, hence congestion is defined. We also analyze congestion on application of channel bonding. According to our study, when there is channel bonding the network performance increases which reduces the overhead of acquiring the channel. Through channel bonding up to 40 MHz is supported in the standardized 802.11, where two 20 MHz channels are combined into a single 40 MHz channel. Now since the two channels are bonded together to form one channel, the network performance increases. We support this argument by mentioning, in 2 GHz frequency there are altogether 11 overlapping channels. Out of which there are three different channels of 20Mhz each that are independent. On channel bonding any two of the three 20Mhz channels are bonded together to make a single 40 MHz channel. Transmitting data on this 40Mhz channel always results in higher performance of the network in comparison to the 20 MHz channel, thereby reducing congestion in a network. Another considering a 5 GHz channel frequency; if 24 channels of 20 MHz are used together by channel bonding there is an increase in throughput which leads to better performance of the network. Thus, channel bonding is beneficiary in a congested network, leading to improved performance.

Our analysis could be considered when there is huge WLAN deployment and there is a possibility of congestion. In order to improve performance of such deployments, the results obtained could be beneficiary. So in this project we have implemented analysis of congestion in a network. Congestion is primarily defined as above and then check upon the factors affecting it. We have specified a metric that helps us define congestion. On this basis we find out the throughput and goodput of the network, which helps us understand the performance of the network. Realization of channel utilization is also considered to better understand the performance of the system. We trying to improve our analysis by finding out how does congestion work in channel bonding. We found out that channel bonding is not implemented in most of the WLAN deployment inspite of having its benefits like better performance, increased data rate. In 5GHZ channel frequency, 40 MHz to 80 MHZ channel frequency is possible using channel bonding, yet it is not implemented in practical.

2 RELATED WORK

2.1 Channel Bonding

In this section we are going to describe how the channel bonding work and what are the best way to apply channel bonding. 802.11n Wlan has capability of combining two 20MHz channel into a single 40MHz channel which provide us with better data rate in ideal condition. But based on various studies there have been we can say that utilization of channel bonding better performs in 5GHz band deployment [2]. We have also observed while using channel bonding in 2.4 GHz wi-fi deployment where we can only find one 40MHz independent channel leveraging this factor to improve network performance is not best for dense deployment but if the deployment is done with help of intelligent channel bonding decisions based on transmitter's surrounding, inference pattern and channel utilization the network performance can be increased [2]. But they lack to explain how this kind of network which utilize intelligent channel bonding will perform in congested networks.

2.2 Congestion in 802.11 network

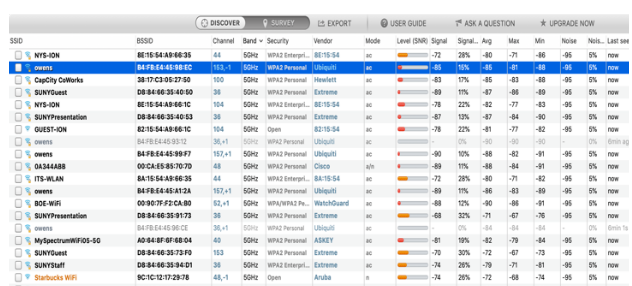
Second most relevant work that relates to our work is how the congestion is defined Wlan networks what are the factors to be considered in the while defining congestion in Wlan network at Link layer. Studies show understanding congestion at link layer is to consider a time window unit and how much traffic you can see in that time which is referred as Channel Busy Time(CBT) [1]. There have been studies on how the congestion will work in case of 802.11b network deployment which shows the rate adaptation in case of congested network should only consider rate adaptation when the packet loss is due to signal-to-noise(SNR) or bit errors and not due to congestion. At the state of congestion data rate should be higher [1]. While we are analyzing our data, we observed that there are very few frames that have been transmitted at the higher data rates we think the reason behind such rate adaptation was due to the channel quality of the network. Now we know that how the network without channel bonding implementation will perform in the congestion states. But there have been no studies on how the network with capacity to perform channel bonding can perform in state of congestion. We have planned to sniff the various networks to find channel bonding implementation where we can find congestion and collect data at such location and then analyze that data for performance of network with channel bonding capability in congested traffic conditions.

3 DESIGN AND IMPLEMENTATION

3.1 Data Collection Theory and Background

In this section we have described how we collected data at which location and what were the challenges faced by us at the time of data collection. We collected our data in various location primarily, to identify the network capability to perform channel bonding. Then we collected data during two different traffic conditions in network i.e. first where the high number of users were using network and second with small amount of traffic in network. so, we can observe difference in congestion state in network, and if the network is capable of performing channel bonding then what triggers channel bonding. For data collection we used our own sniffer that can collect all data from Access Point to the client device and vice-versa. There are challenges for developing your own sniffer and collecting data on that sniffer. The sniffer can not collect all the frames to and from Access Point it faces challenges such as hidden terminal problem due to power capacity of sniffer.

We used sniffer tool of mac OS which is really good tool. To sniff the data. We had just one sniffer according to us that should be enough to sniff the data collected at the Access point. To sniff the network and its capability and on what frequency the network is operating we used a tool called NetSpot which displays what all data are available. Here is the picture of what the NetSpot looks like in Figure 1. After deciding which WIFI network to sniff we run the Inbuilt tool of macOS which is Wireless diagnostic which has in built sniffer. This sniffer can operate in such a way you can select the channel number you want to sniff and the bandwidth you want to sniff.



the main problem we faced when we started sniffing the Accesses Point for the first time we couldn't scan the network for more than 5 min and so we decided to so sniffing for five min each and then combine the output.

Packets Type: Here we have described the packets that are important for analyzing such capture setup. While capturing data in wild you get lots of unwanted frames that are captured which can reduce the efficiency of analyzing if considered during calculation of channel utilization. We have collected many frames out of which this few frames are important for analyzing channel: Beacon frames, Request to transfer(RTS), Clear To send(CTS), Acknowledgement frames, Data frames. We also found some probe request and response frames in the captured network traffic. We have chosen to ignore such request and response because they are not necessary in the analyzing the data.

Beacon frames are management frames that are broadcasted by access point after some specific time interval. They are used to keep the network in sync and contains information such as SSID, list of allowed data rates for transmission, etc. this frame is counted towards the throughput of the network.

RTS & CTS frames this both frames are pair of frames used for avoiding collision in network. RTS has the transmitter address as well as receivers address while the CST just has the receivers address. To find the CTS frames for RTS requested by some device can be done with the help of comparing transmitter address of RTS frame and receiver address of CTS.

Data and ACK frames this both frames are most crucial frames as Data is frames contains the data that is been sent with all the information such as length of frame, source and destination of frame. While the ACK frames are sent to confirm successful transmission of frames so it just has the receivers address and we can use same logic for painting Data and ACK frames. This will help us in finding goodput of the network.

3.2 Data collection

We collected data at various cafes located near university campus. We were looking for congestion in wild to collect our data so we chose the place where we can find a greater number of users and so we opted to select University library and cafes near university where we can find congestion due to high probability of users present. Our main focus was on data collected at the Starbuck café on western Ave where there was always rush of user to use the public WIFI. We also collected some trace at the residential place where we can find less traffic and how the network performs in such condition.

Users whose data we collected were of different back ground some were continuously transmitting and were actively using network but some of them were passively using network and were ideal for most of the time. Due to this kind of difference in user types we collected data in wild was good for analysis.

3.3 Data Analyzing Methodologies

After the collection of data, we tried to analyze data with the help of calculating channel utilization which can be found out with the help of channel busy time this is one of the metric we are using to analyze data we collected [1]. Another metric we are using is throughput and goodput of the data collected at individual access point. To do so we developed an python program which can be used to calculate goodput, throughput. And channel utilization of the network for given time frame per second. This program will generate a csv file and then with the help of the Matlab we plot all the data graph and understand the trends in data.

4 Testing and Evaluation

In this project we are finding the goodput and throughput of a congested network at different channel bonding. In other words, collection of MAC layer frames at 20Mhz and 40Mhz channel bonding. This section discusses how congestion affects network characteristics, channel busy-time, reception of frames of different sizes transmitted at different data rates, and acceptance delays for data packets. In order to define congestion, we have specified the metric called the "channel busy time" to understand and measure congestion in a network.

4.1 Channel Busy Time

In this project we are finding the goodput and throughput of a congested network at different channel bonding. In other words, collection of MAC layer frames at 20Mhz and 40Mhz channel bonding. This section discusses how congestion affects network characteristics, channel busy-time, reception of frames of different sizes transmitted at different data rates, and acceptance delays for data packets. In order to define congestion, we have specified the metric called the "channel busy time" to understand and measure congestion in a network.

4.2 Channel Utilization

Channel utilization is another metric that we have designed for our analysis of congestion. It is computed on a percentage scale for a set period of time. Utilization will be calculated in percentage as a fraction of channel busy time over one second interval. Based on this percentage (utilization threshold) levels of congestion would be determined. In this section we have based our analysis on the above two metrics. Collected data from areas with different access points, example Main library, University at Albany. For our analysis we used delay component values suggested by Jun et al.[4]. Table 1 shows the delay in microseconds for delay components of the IEEE 802.11 b protocol. Further we will evaluate the frames of how channel busy time will be computed: (as per Understanding Congestion in IEEE 802.11b Wireless Networks Amit P. Jardosh Krishna N. Ramachandran Kevin C. Almeroth Elizabeth M. Belding-Royer)

Table 1: Delay components specified in microseconds

Delay component	Delay(μsec)
D_{DIFS}	50
D_{SIFS}	10
D_{RTS}	352
D_{CTS}	304
D_{ACK}	304
D_{BEACON}	304
D_{BO}	0
D_{PLCP}	192
D_{DATA}(SIZE)(RATE)	D_{PLCP}+8x($\boxed{(34 + size)/RATE}$)

1. Data frames: For the channel busy time computation of a data frame, the DIFS interval is used. DIFS interval occurs before each data frame and the formula is given as below:

CBTDATA = DDIFS + DDATA(Size)(Rate)

Delay of data is calculated as DPLCP added with 8 times fraction of 34+size of the frame to the rate of frame transmitted.

2. RTS frames: RTS frames are encountered and their channel busy time is computed as follows:

CBTRTS = DRTS

3. CTS frames: CTS frames are transmitted following an SIFS delay after the RTS frame is received. The channel busy time is computed as follows:

CBTCTS = DSIFS + DCTS

4. ACK frames: ACK frame is transmitted after the SIFS delay after the previous data frame was received.

CBTACK = DSIFS + DACK

5. Beacon frames: a beacon frame is sent each access point in the network at 100 millisecond intervals.

CBTBEACON = DDIFS + DBEACON

6. Total CBT: Now, the total CBT is calculated over the same one second interval as follows:

CBTTOTAL(t)= (r(t)* CBTRTS) + (c(t) * CBTCTS) + (a(t) * CBTACK) + (b(t) * CBTBEACON) + (∑i=0 d(t) CBTDATA (Si)(Ri))

7. Percentage of channel utilization:

U(t) = (CBTTOTAL(t) / 106) * 100

In theory basis, using all these formulas above we will be presenting the computed results in form of graphs:

I. Time and Utilization: We will obtain two graphs one without channel bonding (i.e. 20 MHz) and other with channel bonding (i.e. 40Mhz). The data will be recorded during low and high congestion. On the X-axis there will be time interval that we are considering and on Y-axis channel utilization in percentage.

II. Main metric: This graph will be a resulting graph of the above two graphs. On the X-axis it will contain the utilization in percentage and on the Y-axis it will contain the throughput and goodput calculated of the network. The throughput and goodput is plotted for every time interval considered during the congestion levels over channel utilization. This was all about how congestion will be calculated.

Throughput of the network will be calculated for the channel over the time interval considered as the sum of total number of bits of all frames such as management, control and data frames transmitted.

Accordingly, goodput will be calculated for the channel as the total number of bits of all control and data frames that are successfully transmitted and acknowledged.

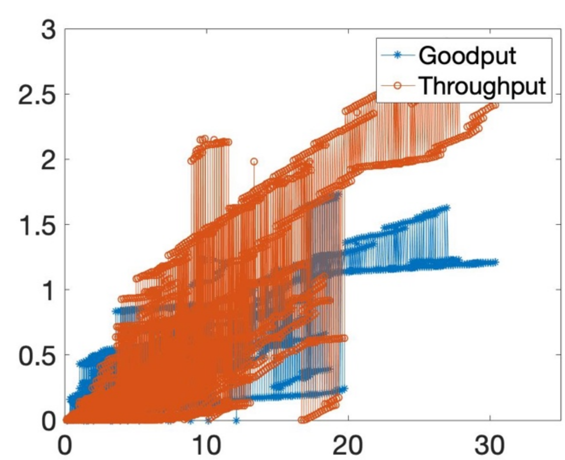


Figure 2: Calculated Throughput and goodput of Data collected at Starbuck with 40Mhz channel bandwidth X-axis is Utilization(%), Y-axis: Throughput(Mbps) and Goodput(Mbps)

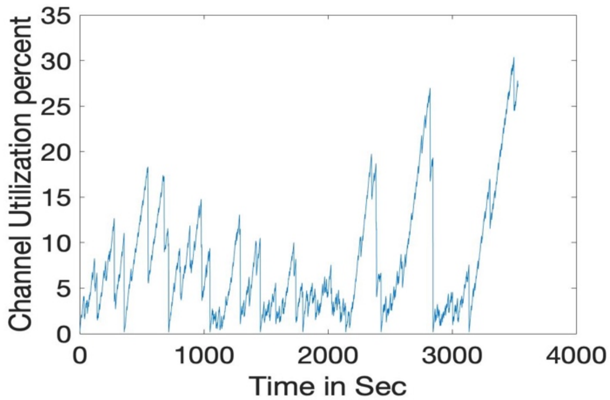


Figure 3: Calculated Utilization of Data collected at Starbuck with 40Mhz channel bandwidth X-axis is Time(s), Y-axis: Utilization(%)

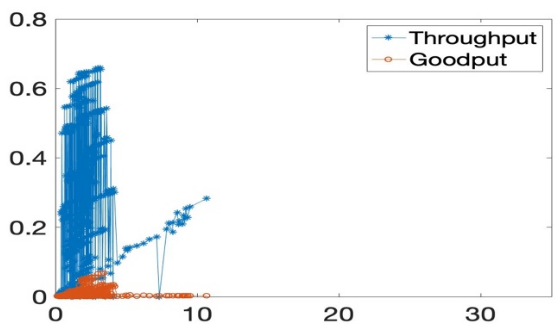


Figure 4: Calculated Throughput and goodput of Data collected at Starbuck with 20Mhz channel bandwidth X-axis is Utilization(%), Y-axis: Throughput(Mbps) and Goodput(Mbps)

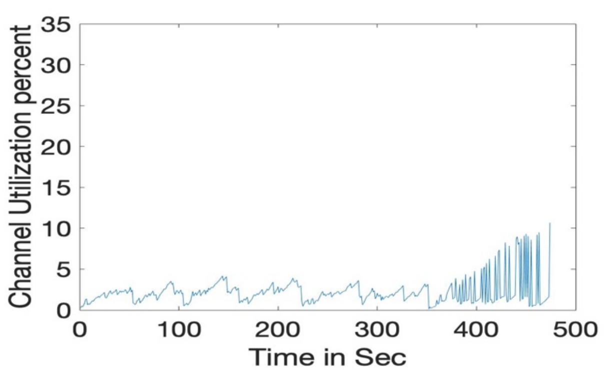


Figure 5: Calculated Utilization of Data collected at Starbuck with 20Mhz channel bandwidth X-axis is Time(s), Y-axis: Utilization(%)

4.3 Motivation behind the tests

The main motivation of why the tests are important and conclusive is that in 802.11 Mac layer there are various types of frames, namely Management, control and data frames. Out of these, Data frames, RTS frames, CTS frames, ACK frames and Beacon frames are primarily required in order to calculate the channel busy time. On this channel busy time computation channel utilization can be computed for the network, thereby leading to useful analysis of the network performance at different channel bonding and various congestion levels. dynamic matrix method which permits to calculate both the mode frequencies and the spatial profiles.

5 DISCUSSION AND CONCLUSION

5.1 Throughput at various congestion states gives an idea about how the network performs

We have found in our results that at various congestion levels that is when there is change in channel utilization throughput and goodput of the system varies accordingly. Here we can see that the network working with channel bonding has more utilization than the one without the bonding. We have also observer the throughput and goodput of network with 40Mhz bonding is gradually increases as the utilization increases so we can say that this utilization is not the highest that this network can handle.

We can also see in figure4 the throughput is way higher than the goodput and goodput is negligent we. Can say the network is idle and the most of the network used is one with the advance network capability and higher channel bonding.

5.2 Channel bonding provides us with higher bandwidth and so we achieve more throughput in network

Here we have compared the throughput and goodput against the utilization and the amount of frames transmitted through network can be considered as the comparison factor. We have compared both the 40mhz and 20mhz network and we have throughput and goodput of both the network. The one with the. Channel bonding provides higher throughput in comparison to that of the 20mhz channel bandwidth network the average throughput and. Good put is higher than 1Mbps. While for the average throughput is below 0.8Mbps and goodput is on average below 0.2Mbps for 20mhz channel bandwidth. Channel utilization is also more in 40mhz channel bonding around 30% and then also it provide better output than 20mhz.

6 CONTRIBUTION

Our project was consisted of three main tasks: one was to collect data; second was to analyse data using wireshark and tshark; third was to process data using programming language. We both went about places to collect data, collected data at our homes, collected data at the university whenever we felt that there could be congestion. Analyzing the collected data was done by Nilay. Nilay analyzed the data and separated the frames that were necessary for our analysis work. Using wireshark and tshark commands data was processed in csv files. Jerica calculated the throughput, goodput and channel utilization of the resultant csv file using python programming.

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