Characteristics of Wi-Fi

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1. Abstract

In today's technology, Wi-Fi, known as Wireless Fidelity, is a well known term for everyone and its presence is often around us; in a coffee shop, at school, and also at home. Nevertheless, we have often experienced the speed of wireless transmission is not really what we expected; therefore we are interested in analyzing and investigating the aspect of Wi-Fi Delay and Throughput. The main direction for this project will be focused on "Wi-Fi."

2. Introduction

2.1. Wi-Fi overview

Wi-Fi is one type of wireless communication systems and was introduced by Wi-Fi Alliance. Since Wi-Fi is part of wireless communication, IEEE had to standardize a protocol called “802.11” under the title of “IEEE 802.11” specification [1]. There are several types of 802.11 are popular in the industrial product standard; a, b, g, n. Majority of the household wireless routers have moved on to the standard of 802.11g and 802.11n from 802.11a and 802.11b for a better transmission from the last 5 years. For the specification, the content of “Transmission” is often referred to the few important aspects of communication; interference, power consumption, speed, and reliability. For example, a good transmission means low interference/noise, low power consumption, high speed/bps, and low error rate.

2.2. Transmission Qualities

1. Radio signal is the bridge for both sender and receiver to communicate. Wi-Fi’s communicating method is similar to broadcasting; sending a signal to multiple receivers and the method is called “Spread Spectrum”. Wi-Fi uses 2 types of spread spectrums; Frequency Hopping Spread Spectrum (FSSS) and Direct Sequence Spread Spectrum (DSSS) [1]. In this project, DSSS will be discussed because it provides a better transmission; lower power consumption and noise interference. 802.11 operates on frequency 2.4 GHz and DSSS can cover up from 2.4 to 2.5 GHz. Between that spectrum range under North America standard, it is divided into 11 channels and each channel has approximately 22 MHz [1]. If many users under the same Basic Service Set (BSS), the users may experience a significant transmission loss or failure due to the over lapping of adjacent channels [2].

2. Data format is important during communication because it is an indication to navigate the data to the destination on the Internet. Data is usually divided into many smaller pieces called packet. To establish a reliable communication, the data is usually contained with a header called

checksum. Checksum has the number of entire bytes number of data, so if the value of checksum differs from the actual received bytes value, the receiver would send a command NAK to request retransmission from sender. Once the values do match, receiver would send ACK to confirm the information is correct. This process is called “Hand Shake”. Packet is put into frame with many different headers in order to reach destination. However, these headers use up the bytes in the frame to transmit. 802.11 can usually send out 11M bps but because the headers are included, the actual data or packet can only be sent with amount of 7M bps or other random bps lower than 11M bps [1].

3. Network Structure is the physical aspect that users might experience a bad transmission. If a user is under Extend Service Set (ESS), this user might experience the Wi-Fi is constantly switching to different Access Point and this would cause connection failure as well.

3. Discussion

We will be analyzing and discussing the following 3 ideas;

1. Number of Users: How the delay and throughput changes with respect to the number of users.
2. Distance: How the delay and throughput changes with respect to the distance from a mobile workstation to an Access Point.

3. Number of Access Points: How the delay and throughput changes with respect to the number of Access Points (AP).
4.

4. OPNET

4.1. Overall Topology

Our top net topology consisted of a subnet a FTP server and a IPcloud (Figure 1 and 2). This was fixed to all our cases and scenarios.

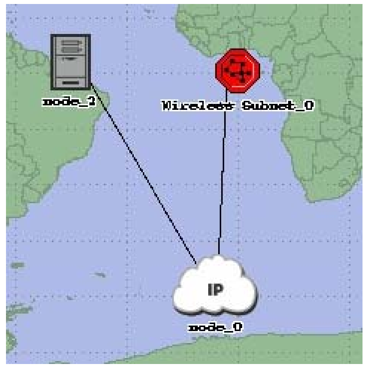

Figure 1: Overall Topology

	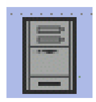	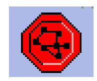	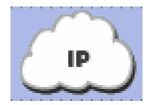
Icon type	FTP	Subnet	IPcloud
OPNET	Ppp_server	Subnet	Ip32_Cloud

Figure 2: Top Net

As show in Figure 3, one or more of these icon types were used in order to analyze different cases.

		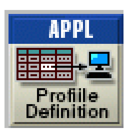	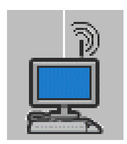	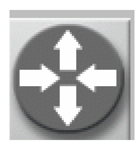	
Icon type	Application	Profile	Workstation	Switch	Router
OPNET	Application Config	Profile Config	Wlan_wkn_adv	Ethernet4_slip8_gtwy	Wlan_ethernet_slip4_router

Figure 3: Inside the Subnet

4.2. Case 1: Analyzing Number of Users

Our mission for this case was to find the threshold at which Wi-Fi is no longer at a reasonable performance. We tested for 4 different scenarios: 5 users, 30 users, 50 users, and 100 users. All these scenarios are the same except for one variable, the number of users. They all have 1 Access Point and are set 100m from the Access Point.

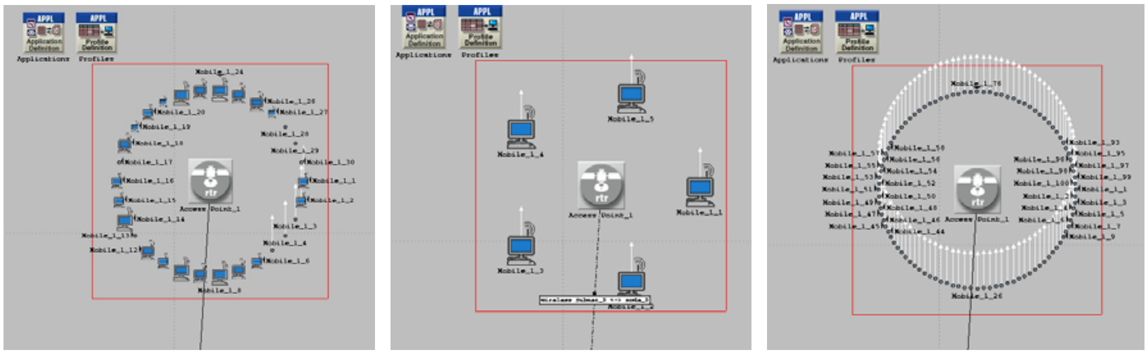

Figure 4: Topology for 5, 30, and 100 users

4.2.1. 5 Users vs. 30 Users

Comparing the 5 user scenario to the 30 user scenario we can see that the end-to-end delay of the 30 user scenario is 1.304 times to that of the 5 user scenario. This value is relatively small if we compare it to the amount of throughput; the 30 user scenario has 5 times more throughput. The ratio of throughput to delay is relatively high, about 3.84.

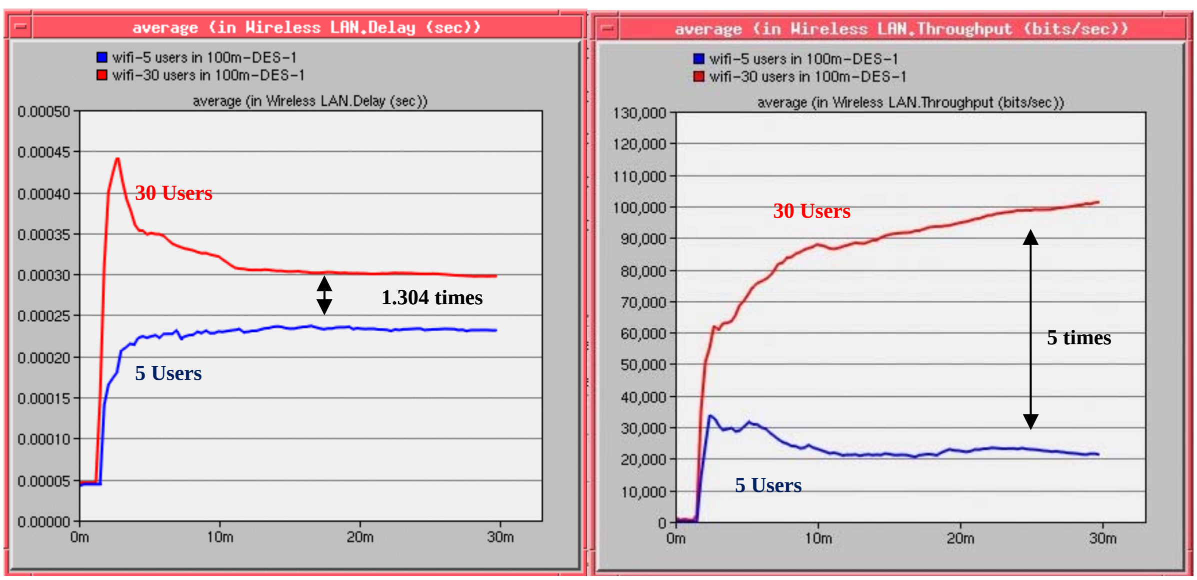

Figure 5: Delay (left) and Throughput (right) (5 users vs. 30 users)

4.2.2. 5 Users vs. 50 Users

Now, comparing the 5 user scenario to the 50 user scenario we see that the throughput for the 50 user scenario has increased slightly, 5.5 times that of the 5 user scenario, respectively. However, the delay has increased about 1.522 times, and therefore the ratio decreased to, 3.61. Evidently, we can see that a 30 user scenario is more efficient than that of a 50 user scenario, 3.84 to 3.61.

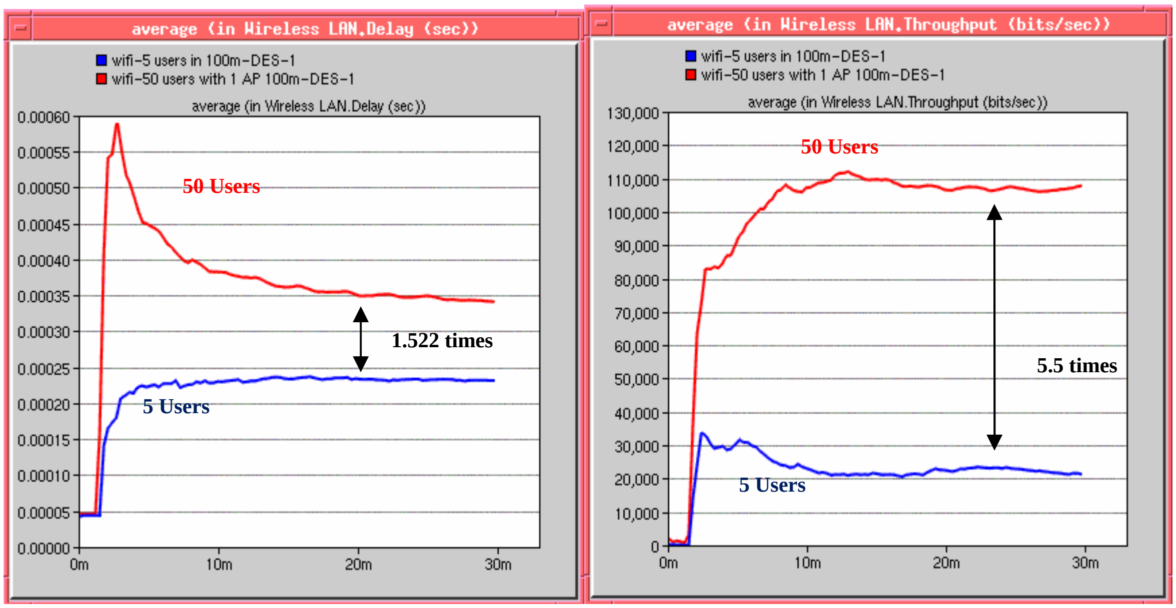

Figure 6: Delay (left) and Throughput (right) (5 users vs. 50 users)

4.2.3. 5 Users vs. 100 Users

Again, we see that as the number of users increase, the throughput and the delay increase, the ratio then becomes smaller, for the 100 users scenario the ratio came to be 2.99.

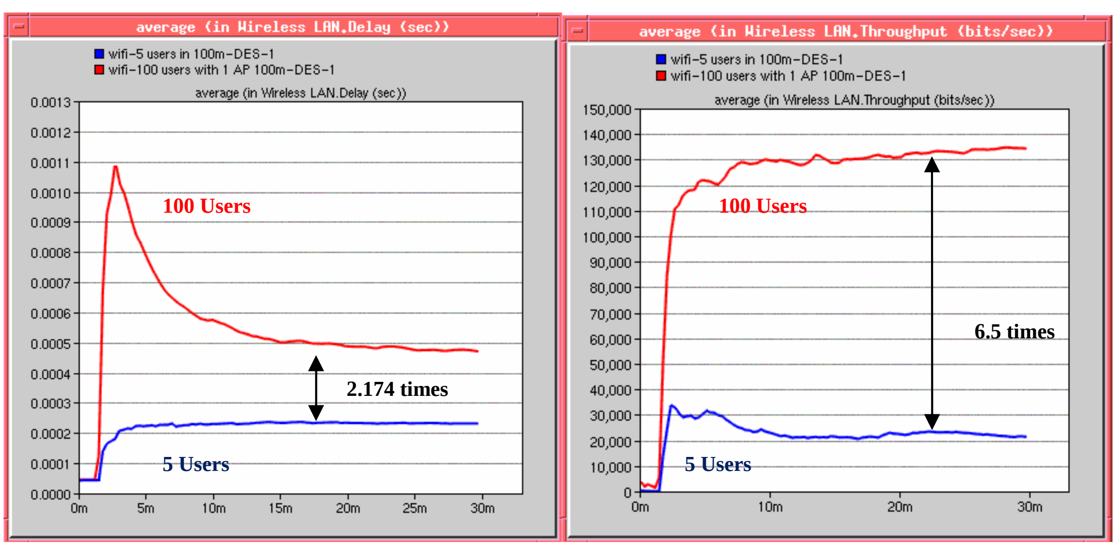

Figure 7: Delay (left) and Throughput (right) (5 users vs. 100 users)

4.2.4. Discussion

Figure 8 is a useful graph that shows the relationship between Users vs. Ratio. The ratios are the values that were calculated in the previous scenarios, where the 5 user scenario was fixed. It is a linear relationship, therefore easy to predict the ratio at any given number of users, respectively.

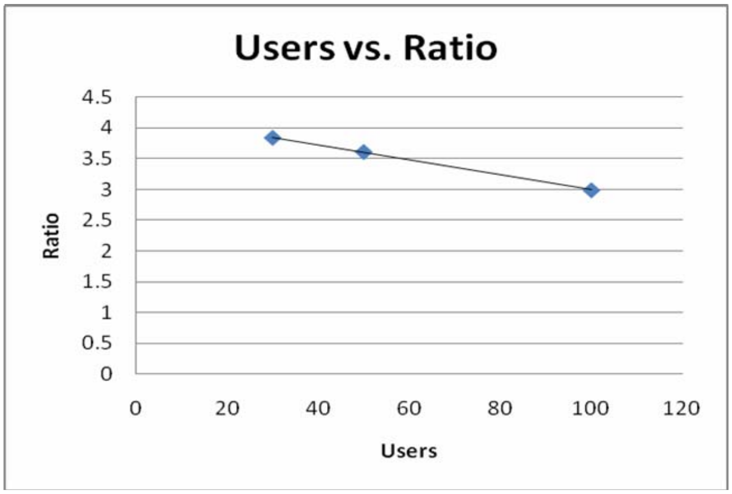

Figure 8: Users vs. Ratio graph

4.3. Case 2: Analyzing Distance

Another case that we analyzed is the distance from the access point to the mobile nodes. It is trivial to say the further you move away from a router the throughput will decrease, but by how much? We will analyze the following case in the same manner as case 1, comparing 1 fixed scenario to the rest, and then comparing their ratios with each other.

All these scenarios have a fixed number of users, 5, and is using just 1 Access Point.

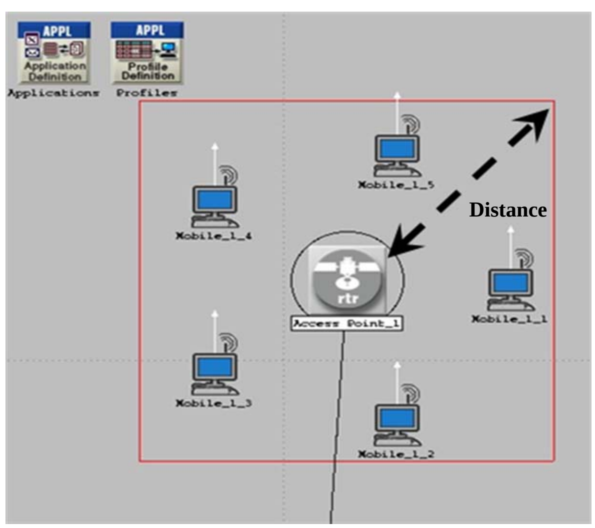

Figure 9: Topology for distance

4.3.1. 1 meter vs. 100 meters

It is evident by the graphs in Figure 10 that the 1 meter and 100 meters scenarios are relatively close to each other, for analysis purposes we will assume they are equal in delay and in throughput.

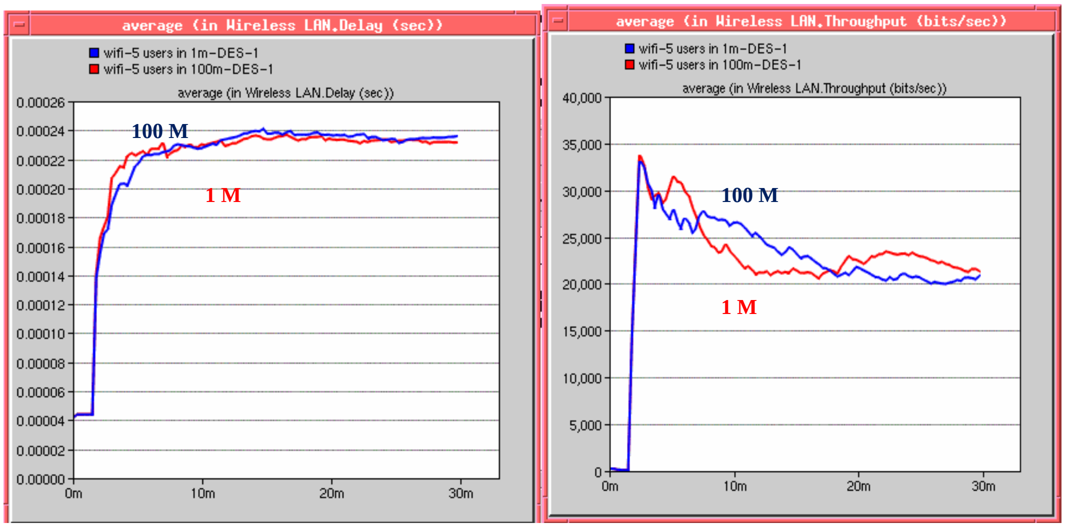

Figure 10: Delay (left) and Throughput (right) (1 meter vs. 100 meters)

4.3.2. 1 meter vs. 1 kilometer

Comparing the 1 meter scenario to the 1 kilometer scenario we can see by the graphs, Figure 11, that the 1km scenario hasn't reached a steady state yet, it is still increasing in delay. Let's assume the steady state begins at the highest peak, so therefore the 1km scenario has 4 times more delay than the 1 meter scenario. Unlike case 1 (Analyzing Number of Users) the throughput for the 1 KM scenario is lower than the 1M scenario by 1.33 times. The ratio therefore gives us a negative value of - 0.33. This ratio tells us that at 1KM the delay is higher and the throughput is lower.

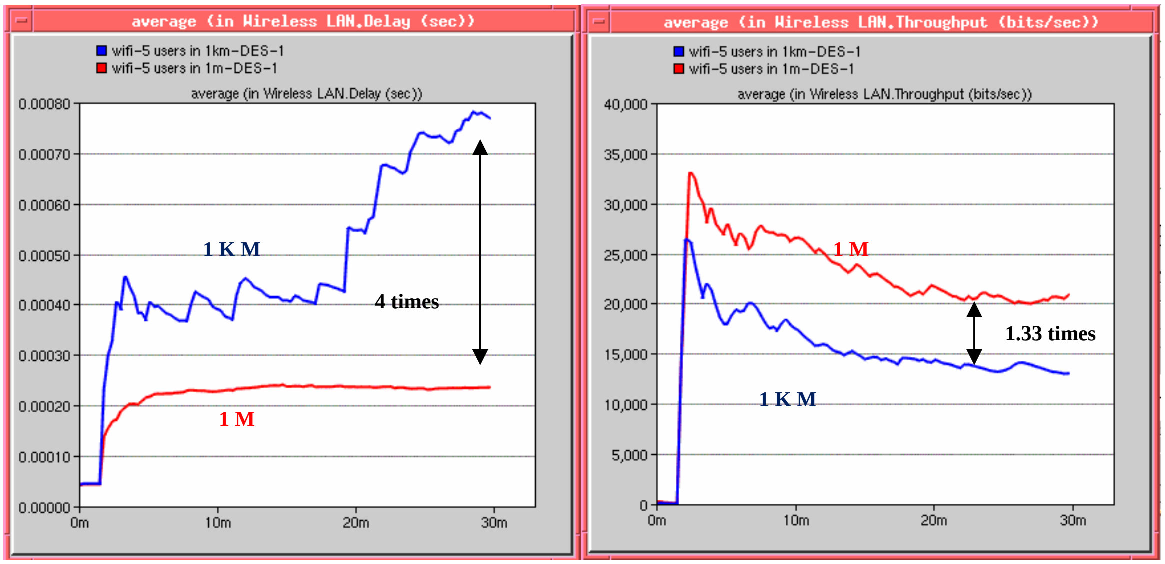

Figure 11: Delay (left) and Throughput (right) (1 meter vs. 1 kilometer)

4.3.3. 1 meter vs. 10 kilometers

The 10 Kilometer scenario has infinity delay with zero throughput, as expected. It is obvious that a mobile workstation can't transmit or receive at a distance 10 km away from a single access point, and the graph proves it, figure 10.

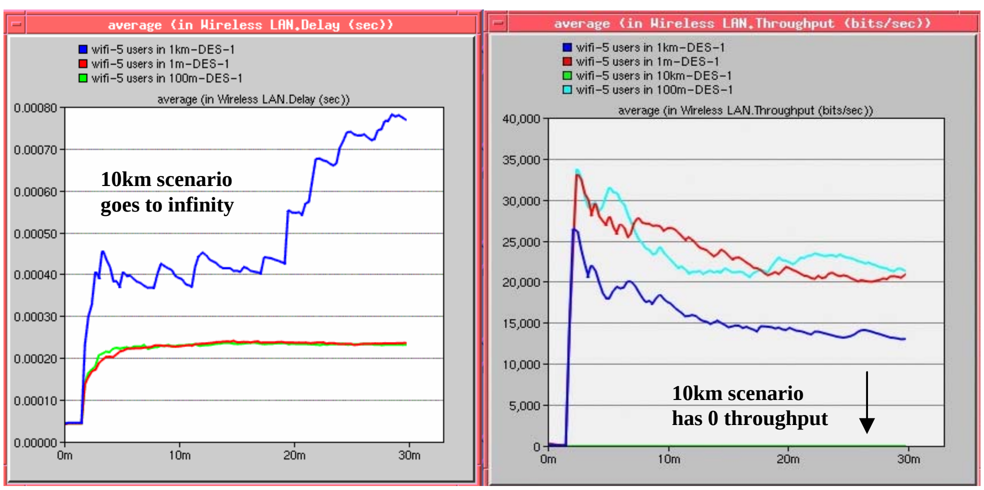

Figure 12: Delay (left) and Throughput (right) (1 meter vs. 10 kilometer)

4.3.4. Discussion

An interesting point between the delay of 1m and 100m is that although they might be almost identical, the users in 100m would experience the maximum steady-state delay quicker than users in 1m. With 100 times further away from our distance basis, the delay did not increase at all; however, once the scenario enters 1000 times, the delay starts to increase drastically. Unfortunately, our simulation is only up to 30 minutes but the delay in 1km is still growing unpredictably. The users from 10km cannot even detect any signal. It is difficult to figure out what is the satisfying trade off for the distance and quality of signal and wi-fi does not firmly cut off its signal. Part of users in long distance might experience unstable signals and connectivity. It is hard to determine the range of protocol IEEE 802.11g, but it is safe to say closer distance to the AP would receive better quality

4.4. Case 3: Analyzing Access Points

The following case will analyze the number of access points (AP). This was analyzed comparing 2 scenarios with fixed number of users, 15, and fixed distance, 100meters. The two scenarios are: 1AP, and 3AP's.

4.4.1. 1 AP with 15 users

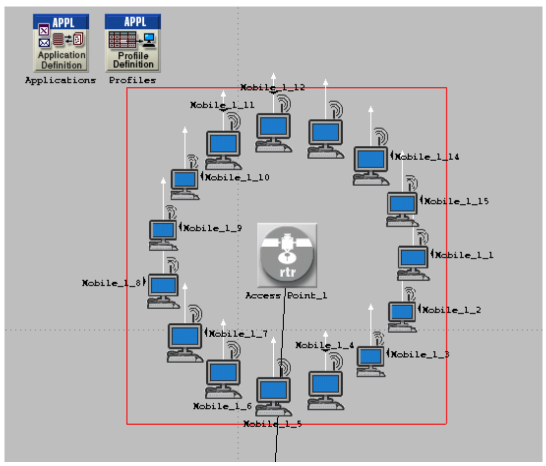

Figure 13: 1 AP with 15 users

4.4.2. 3 AP’s with 15 users

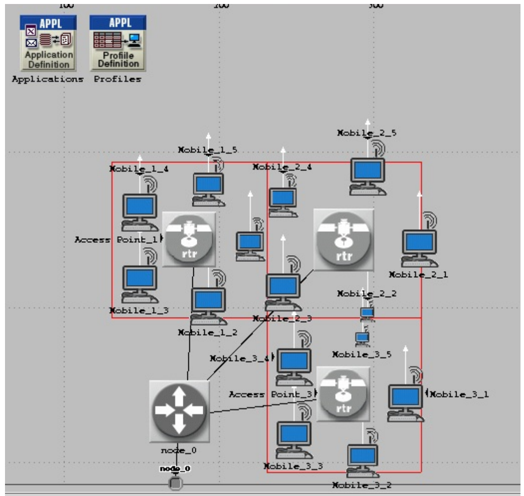

Figure 14: 3 AP's with 15 users

4.4.3. Results and Discussion

People assume that by adding 1 switch it might increase the overall delay, but in fact more Basic Service Sets (BSS) can reduce the overall delay time because the load on 1AP is shared by 3 APs. Looking at the graph, we can see that it takes less time for 3 AP’s to transmit bytes to 15 workstation (each AP having 5 dedicated workstations) than just 1 AP to transmit bytes to 15 dedicated workstations.

As for the throughput the 1AP scenario peaks faster than the 3AP’s scenario but quickly decreases, while the 3AP’s scenario is continuously increasing and eventually by passes the 1AP scenario at the 20th minute, it has not yet reached a steady state.

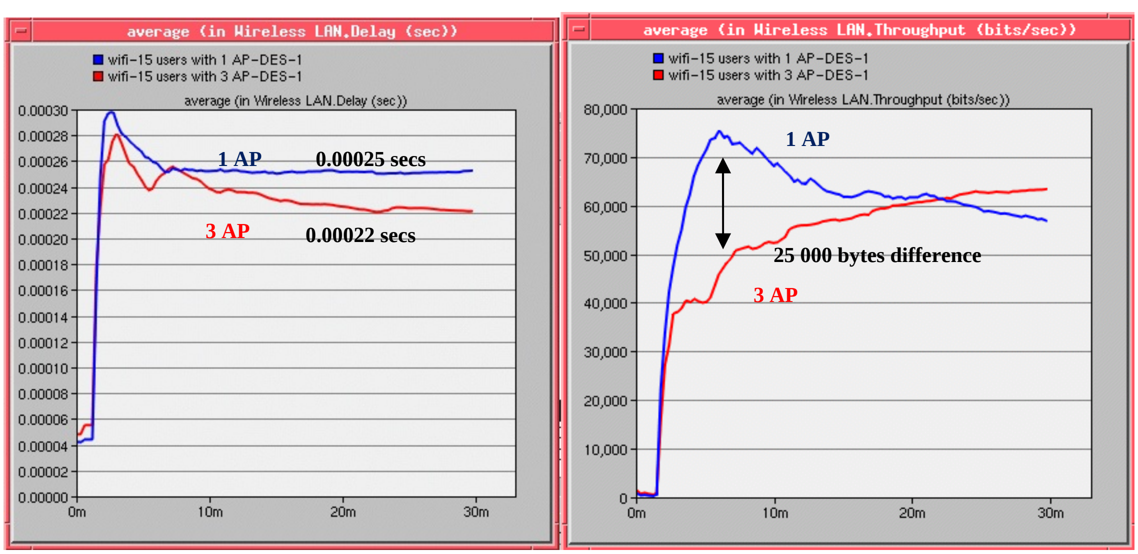

Figure 15: Delay (left) and Throughput (right) (1 AP vs. 3 AP)

5. Conclusion

We have accomplished on simulating performance of Wi-Fi network on OPNET. We focused on infrastructure mode with scenarios in distance, numbers of users and access point. The results were pleasant and it was a great experience.

Here comes to another question of Wi-Fi, what is the role of it and can it be better. To consider better adaptation for Wi-Fi, distant service should be increased. However, the idea of large Wi-Fi has been addressed into another technology, WiMAX, so the Wi-Fi can only provide in local area. Another way is to improve bandwidth with different protocols; e n standard.

With all the scenarios that we have completed for the Wi-Fi, we have to review the question that triggered us to investigate this communication system; is Wi-Fi able to satisfy majority of community with its functionality? We would say yes in this case Wi-Fi performed in this project that this technology is capable handling with large amount of users under reasonable service length all with 1 router.

6. References

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