INVESTIGATION OF IEEE 802.11AC SIGNAL STRENGTH PERFORMANCE IN WIFI COMMUNICATION SYSTEM

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Abstract- Emergence of IEEE 802.11, Wifi has made a huge impact on wireless networking and are implementing widely in today society. Due to rapid increased in mobile devices and internet user, IEEE have come up with the latest technology of IEEE802.11ac which belief to have highest throughput, wider range and capacity. Unfortunately, since this technology is just recently released, the maximum performance is yet to be explored. This paper will be focusing on designing experimental setup to investigate the maximum performance of this new technology by conducting several line of sight experiments using high gain antennas in order to determine the throughput and other performance metric. We proposed that this technology will be able to provide good signal quality with regard to distances of up to 1 km as compare to previous technology of 802.11n. The finding of this investigation is useful as references and potential implementation of 802.11ac technology.

Index Terms- IEEE 802.11, Wifi, Received Signal Strength.

I. INTRODUCTION

With tremendous increase in wireless networking in recent years, the current IEEE802.11n have been fully deployed and become very popular. Over the years, IEEE has released succeeding technology (802.11a/b/g/n) that belief could overcome the lack of previous technology [1,2]. The main key that motivated to improve network capacity, range and reliability are:

• More devices are joining the network with end users and business-critical applications rely on a Wi-Fi network that works 24/7 anywhere, anytime at many locations despite neither outdoor nor indoor.
• Higher data transmission increased massively thanks to; HD video and audio streaming, online gaming and online file access and storage.

To overcome these problems, IEEE have come out with a new technology, IEEE802.11ac is the latest WLAN standard that is rapidly being adopted due to its ability to deliver very high throughput (VHT) through larger channel width (20/40/80/160MHz), modulation of 256QAM and spatial stream up to 8 x 8 [3]. 802.11ac increases the throughput by 91% compared to the best performance that 802.11n can achieve this is due to the larger channel width [4]. This provide better network services as compare to the famous 802.11n which deliver high throughput (HT) with channel width of (20/40MHz) and streams limited to 4x4. A few foremost smartphone and laptop manufacturer such as Apple MacBook Air [5] and Samsung Galaxy S4 [4] have deployed this new technology in their product in order to give better services and satisfaction to their customers.

This paper will focus more on the experimental design for investigating the maximum performance of 802.11ac links at 5.18GHz as well as the investigation of link length effect at various distances within 200m to 1 km using maximum performance metrics. We propose that 802.11ac will provide better signal quality over distances as compare to previous technology of 802.11a/b/g/n. The finding of this investigation will be beneficial for references and future deployment of 802.11ac at outdoor areas.

II. LITERATURE REVIEW

Throughout the years since the release of IEEE802.11n till the release of IEEE802.11ac in early of 2013 many researches and conference papers have been published regarding these two technologies. According to paper [1] which is conducting signal strength experiment, investigating the performance of 802.11n at rural areas in Jelebu, Johor is implemented. There are also many related papers that comparing the performance of both technology 802.11n and 802.11ac. Paper [3] confirmed that 802.11ac increases the throughput by 91% compared to the best performance that 802.11n can achieve and that no performance improvement can be gained using 256 QAM beyond 10m. There have been many papers comparing the performance within 802.11a/b/g/n/ac.

For instance [6] have stated that 802.11ac is formally an IEEE draft amendment that belief to break the 1 GBps barrier by improving the Wi-Fi’s spectral efficiency, and expanding capabilities introduced by 802.11n such as MIMO radios, wider channel bandwidths, and faster Wi-Fi. Another empirical study are executed in [7] on UDP/TCP performance of IEEE802.11n in comparison with IEEE 802.11g. The result has given insights on the achievable UDP/TCP throughput values for both IEEE 802.11g/h standards. Related research is conducted in Bradford University regarding the throughput analysis of IEEE 802.11n MIMO dual band system within indoor areas [8]. This paper reported an investigation on 802.11ac characteristics.
in an open environment [9]. The results provide the fundamental understanding for the design, the maximum performance and potential implementation of various IEEE 802.11ac applications in future. Another paper presented on wifi performance evaluation and comparisons of IEEE802.11b,a,g,n [10] next generation high speed wireless LAN technology [11], but those systems are complex and maximum performance is yet to be explored.

III. EXPERIMENTAL SETUP

A. Hardware and Software setup

Our experiments are conducted in an urban area in Putrajaya, Selangor, Malaysia. Our work has some important and novel ideas compared to the pioneering studies currently, where we are focusing more on the outdoor experiment design and analysis for the performance of the new wifi technology 802.11ac. We presented a better alternative ways for the system characteristic and performance metrics for IEEE802.11ac in 5.18GHz frequency band through 80MHz bandwidth in multiple points with different distances regard to line of sight. Then measurement for different performance metric such as Received Signal Strength Indication (RSSI) and data rate are conducted. Result gained will then be analyzed and discussed. The experimental setup, measurement methodology and equipment used in the experiment are discussed in the succeeding section. It is important to study and probe the location chosen before starting the measurement, this will ensure the location have suitable parameter and ensure no lack of interference in selected frequency.

This experiment is conducted in few points (A,B,C,D and E) as shown in Fig. 1. Point A is considered as the main point. An access point is configured and the mentioned performance metric are measured in the other points (B, C, D and E) as a client nodes with different distances. This is a line of sight experiment and Fig. 2 shows a connection for WPJ344. Multiple input and multiple output (MIMO) of 2 x 2 is implemented in this experiment in order to achieve high throughput. This will provides Spatial Division Multiplexing (SDM) to transfer independent data streams simultaneously to increase data rate between two points.

Antenna placement is one of the main concerns in this experiment. It seems there are many performed activities within our selected areas below 2.5m from ground. Therefore to avoid any interference, the experiments are conducted at the height of 3m from ground level. Fig. 3 shows the assembled of the antenna at height of 3m on top of the tripod. According to Fresnel clearance level [9] acceptable height would at least be 74cm, but our experiment is using much higher pole.

As for the equipment we have chosen to use the complex MMJ344LV [8] as the embedded system to provide efficient hardware resources suitable at any environment. This board come with processor of Atheros AR9334 and supported latest ath5k and ath9k. Fig. 3 shows the hardware setup. Based on technical data sheet, the embedded boards come with complex wireless adapter card, Athero 9334 suitable for range within 5.1GHz to 5.9GHz for 802.11ac technology. The Power over Ethernet (PoE) allowed the board to draw power and control the board firmware through Ethernet link.

An Uninterruptable Power Supply (UPS) Successive power supply are used for both nodes during experiment. Beside hardware setup, the firmware setup is another major concern in order to provide a reliable and easy to use firmware. Compex OpenWRT firmware [8], a highly extensible Open source software and linux distributions for embedded system is chosen. This firmware comes with many.
organized documentation, different packages and compatibility with wider range of hardware product. The board MMJ344LV is compatible with this firmware. The firmware is stored inside the 8GB storage that connected to the board through compact flash socket. All required packages and script to run the measurement and acquired result is also placed inside this compact flash socket. Table 1 summarizes the device and firmware configuration for both end point nodes. All configuration and setting are maintained for every location (A, B, C, D and E).

<table>
<thead>
<tr>
<th>Specification</th>
<th>Access Point</th>
<th>Client</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board/Model</td>
<td>Compex MMJ344LV</td>
<td>Compex MMJ344LV</td>
</tr>
<tr>
<td>Chipset</td>
<td>Atheros 9334</td>
<td>Atheros 9334</td>
</tr>
<tr>
<td>Firmware</td>
<td>Compex OpenWRT Linux Ubuntu 14.04</td>
<td>Compex OpenWRT Linux Ubuntu 14.04</td>
</tr>
<tr>
<td>Wireless adapter</td>
<td>WLE 250NX</td>
<td>WLE 250NX</td>
</tr>
<tr>
<td>Antenna Gain</td>
<td>2 x 2 MIMO</td>
<td>2 x 2 MIMO</td>
</tr>
<tr>
<td>Frequency/Channel</td>
<td>5.18GHz/36</td>
<td>5.18GHz/36</td>
</tr>
<tr>
<td>Channel bandwidth</td>
<td>40MHz</td>
<td>40MHz</td>
</tr>
</tbody>
</table>

B. Measurement procedure
In order to configure the wireless nodes, kmod-ath9k package is installed to provide essential Atheros drivers in OpenWrt. Once done with the installation, an access point (Point A) is configured based on the setting in Table 1 in master mode. The wireless client is at move from point to point, B (200m), C (400m), D (600m) and E (1000m). This wireless client mode will connect to the AP and required and IP address through the configured DHCP server in master node. OpenWrt is used to run the script and obtained the required results. We can gain the fundamental information by typing ‘iwconfig’ and ‘iwcommand’. There are two part for this experiment; measurement of selected performance metrics and wireless link characteristic. Iperf 2.0.5 [8] package is utilized in both the AP and client sides to verify the TCP, UDP throughput, packet loss ratio and jitter values for established wireless link. In order for the ‘iperf’ to present precise and reasonable results, system resources consist CPU and I/O buffer should be available. In order to create an UDP connection flow between AP and client, ‘iperf’ is executed in AP to operate in server mode. The length of the UDP datagram packet was 1470 bytes with buffer size set to default value of 150Mbytes. ‘iperf’ running interval is selected long enough about 300seconds to get high accuracy of acquired results in client side. The client will creates huge amount of UDP traffic to the ‘iperf’ server (AP) to obtain maximum achievable link throughput and other performance metrics. 150Mbps UDP traffic was transmitted from client to AP for 5 minutes due to possible large throughput value for 2 x 2 MIMO of 802.11ac technology. The same procedure is conducted to gain the TCP connection flow between the AP and the client for 5 minutes. Each measurement is conducted five times in order to ensure the accuracy for the throughput gained.

The second part of the measurement will be focusing on the Received Signal Strength (RSSI). There are around 5000 signal samples are captured at each point. A small script is written to capture the required data by running command at the client side. 100 RSSI sample are captured each time the script is run, to ensure the data are accurate the script is run for five times, meaning there will be about 5000 samples collected at each points. Each sample contains information about the established wireless link which signal strength and data rate are most important values for our experiment.

IV. RESULTS AND ANALYSIS
In analysis path, receiver signal strength indicator (RSSI) represents the strength of the signal as perceived as received by the client. It is an important criteria to measure the performance of a wireless link with different length. Each wireless adapter has its own specific amount of signal strength for attainable data rate which will determine the network speed for the wireless links, this can be refer in the wireless adapter technical data sheet. Table 2 represents the table for latest technology of 802.11ac according to [8,9]. From the MCS index, we can determine the specific number of spatial streams, coding rate, modulation type and physical data rate. In order to achieve maximum data rate for channel, the Short Guard Interval (SGI) of 400ns is applied during the experiments. Applying this parameter in the Atheros 9334 chipset has attained 866.7Mbps. This data rate achieved represent MCS index 9 which verified the above parameter by referring to Table 2.

<table>
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<tr>
<th>Table 2 802.11AC MCS Index</th>
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A. Analysis of Modulation and Coding Scheme (MCS)
In analysis path, a modulation and Coding Scheme (MCS) Index value are used together with channel width values allowing to instantly calculating the data rate of the wireless hardware. This MCS Index is used to determine the reliability of the results. Fig. 4 and 5 show the data rate peak versus different Modulation and Coding Scheme Indexes according to...
the latest MCS index for 802.11ac and 802.11n 2014. Each MCS index represents specific number of spatial streams, modulation type, data rates and coding rate. It should be highlighted that default setting mac802.11 utilized in ath5/9k drivers implement control algorithm that supports multiple rates retries and is one of the finest rate control algorithm [5]. From Fig. 4, it can be seen that the maximum data rate that should be obtained for 2 spatial streams 802.11ac is 866.7Mbps while for 802.11n maximum data rate is 300Mbps. Another result, Figure 6 shows signal strength against distance at height 3m for both 802.11ac and 802.11n. It is obviously that signal strength is decrease with the increasing of distance.

B. Throughput Comparison between 802.11ac and 802.11n

The following test results will compare the difference between the flows of TCP and UDP for both 802.11ac and 802.11n over various distances and RSSI levels. Fig.7 represents the throughput for TCP flows for both 802.11ac and 802.11n. Obviously, the TCP stream for 11ac is higher than 11n. The results show that 11ac overhead 802.11n for about 10 to 20% between distances of 200m to 1200m. Major difference is at range of 1500m where 802.11ac lead 802.11n for more than 70%. 802.11n is showing very weak signal thus very low TCP stream at distance of 1500m.

According to Fig.8, it is shows UDP stream for 802.11n is slightly higher than 802.11ac for about 10%. Nevertheless, at distances of 1500m 802.11n is unable to produce or transmit any throughput. The range for 802.11n is restricted to 1200m. UDP stop flowing beyond the range of 1200m. Fig.9 is showing the comparison of 802.11ac and 802.11n throughput (TCP) at distance ranging from 200m to 1500m. Here it can be seen clearly that TCP for 802.11ac is much higher and leading about 10% from 802.11n. TCP stream for 802.11n seems to drop drastically ranging from distances of 1200m to 1500m.

Meanwhile, Fig.10 is demonstrating the difference result for UDP flows for both 802.11ac and 802.11n. The result is the opposite of the captured TCP stream. 802.11n seems to lead 802.11ac values by less than 5%. However UDP for 802.11n stop at distances of 1200m and no more reading were captured beyond that. As for 802.11ac the reading continues up to 1500m proving that 802.11ac can provide throughput at wider range.
As a summary, from our designed experimental setup, this is proved that 802.11ac is found much better technology that comes with faster speed, very high throughput, wider range and capacity thus no doubt that it will overcome the current state of art, 802.11n. The outcome and finding of this investigation would be beneficial for future references and potential outdoor implementation of this 802.11ac technology.

CONCLUSION

This paper have successfully design an outdoor experiment and analyzed the performance of the new wifi technology 802.11ac. All experiments are successfully conducted and reliable results are attained. This paper has analyzed and discussed the performance of IEEE802.11ac at an open environment with regards to line of sight distances using up to 2 spatial stream. Experiment results prove the stability of this 802.11ac technology at a wider range and distances. The signal does decay with regards to distances however the signal at the maximum distances is still quite good. Our work will provide information and suitable references for future work in implementing IEEE802.11ac. This investigation explored the maximum performance of IEEE802.11ac at increasing distances and will help solve the doubt regarding performance stability of this technology and support potential deployment in today modern society.

ACKNOWLEDGEMENTS

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[5]. Sigurd S.,”An Introduction to 802.11ac, Quantenna White Paper, 2011.