INTERFERENCE ANALYSIS 5GHZ WIRELESS CONNECTION ON TELKOM UNIVERSITY LANDMARK TOWER USING PPDIOO METHOD

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***Abstract* — This research is aimed at analyzing the quality of service (QoS) of 5Ghz wireless networks on Telkom University Landmark Tower (TULT) Building (Telkom University landmark tower).In this research, an interview was conducted with Mr. Sakti Putro Wisetyo as the IT infrastructure section at PUTI to obtain information about wireless network information at Telkom university landmark tower such as network infrastructure, network devices, network device placement, 5 GHz wireless deployment, and challenges in managing network infrastructure. This research uses the PPDIOO method in the implementation of wireless internet networks and as a consideration in developing wireless Internet networks. The results of this research are that the main cause of interference is due to over coverage, channel repetition, and wrong access point placement, where the access point type RG-AP130(W2) V2 is an access point that has a wall mount installed and not a ceiling mount so any of these problems can cause co-channel interference. This research will be useful in improving the efficiency of its business processes so that students and lecturers can be more productive in academic activities.**

***Keywords*— Wi-Fi 5Ghz, QOS, PPDIOO, Interference, TULT**

I. INTRODUCTION

In this modern era, the use of internet technology to access information in the form of text, images, and videos is needed by the community to interact in cyberspace. The development of the network used to use a Local Area Network (LAN) using cables, now it has switched to a wireless network. Wireless networks make it easier for people to use them by using wireless networks to reach a large area.

(IEEE) Institute of Electrical and Electronics Engineers is a standards organization for information technology. Each standard has a different code. One of them is the standardization of wireless networks which has the code 802.11. The first generation of 802.11b standardization runs using a frequency of 2.4 GHz but this standard can only use a maximum bandwidth of 11 Mbps. The second generation of standardization is 802.11a which is a standard that already supports bandwidth up to 54 Mbps and uses a frequency of 5 GHz.

Telkom University Landmark Tower (TULT) is a building built by Telkom University. This building has 20 floors which are used to support student academic activities. The TULT Building uses a Wireless network to help connect to the Internet. This wireless is used by the entire Telkom University community, each floor at TULT has two switches and access points that differ in the number of each floor. Observations that will be made at the TULT Building are carried out on floors 4, 5, 6 and 7. There are channel repetitions on each floor and the placement of the wrong access point, this can trigger interference with the access point.

Interference is the interaction between waves in an area. Interference can be constructive and destructive, interference can make the performance of the access point lose power when receiving and transmitting signals, and can cause some databases to be lost, resulting in errors in the bits of information that are being sent, the receiving client finds the error and causes a delay even though it will retransmit the data that occurred in the error.

If interference occurs, it will certainly reduce the Quality of Service at the access point. This research uses several measurements such as throughput, packet loss, and delay measurements. These measurements are taken to detect problems found on the wireless network.

II. LITERATURE STUDY

A. Wi-Fi

Wi-Fi is a wireless network protocol commonly used by computers to connect to the internet without using cables. The term Wi-Fi is a commercial naming for Wireless Local Area Networks (WLAN) based on IEEE 802.11 standardization. The function of Wi-Fi itself is to be able to connect a network of devices in one local area. Wi-Fi was first used as the use of wireless devices and local networks (LAN), but over time Wi-Fi is often used to access the internet. Users can connect to the internet network by

receiving and sending signals at radio frequencies through access points.
WLAN architecture is the same as cellular technology architecture by dividing the network into cells. Each cell on a WLAN is called a Basic Service Set (BSS) and is controlled by an access point. BSS and access points are connected via a backbone called the Distribution System. The backbone is ethernet or can also be wireless according to the statement from Yusantono [1].

B. WLAN

Wireless Local Area Network (WLAN) is a wireless local network that uses radio frequency as its signal transmission medium. WLAN is a technology that is often used to connect several electronic devices wirelessly, such as computers, smartphones, tablets, and others, on a local network. WLAN offers convenience and flexibility for its users because it is not bound by cables that limit device movement. In addition, WLANs can also cover a wider distance compared to local networks that use cables. WLANs are also often used to connect devices to the internet, especially in locations that do not have access to the internet network using cables.

C. Frequency and WLAN Channel

The 802.11b, 802.11g, and 802.11n protocols use the 2.4GHz frequency spectrum. While 802.11n and 802.11ac use a larger frequency spectrum of 5 GHz. Each frequency spectrum is divided into several channels, just like radio and television. The 2.4GHz frequency is divided into 14 channels with 5 MHz channel spacing. The last channel has additional rules or is not available according to the rules of each country.

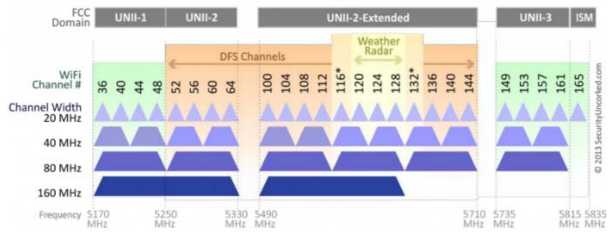


Figure 1 5Ghz Wi-Fi band

U-NII band covers 5 GHz (5.150 to 5.925), is unlicensed, and is used in Wi-Fi by 802.11a, n, ac, and ax. 11ac operates only in 5 GHz (dual-band 11ac APs are 11n in 2.4) [2].

D. PPDIOO (Prepare Plan Design Implement Operate and Optimize)

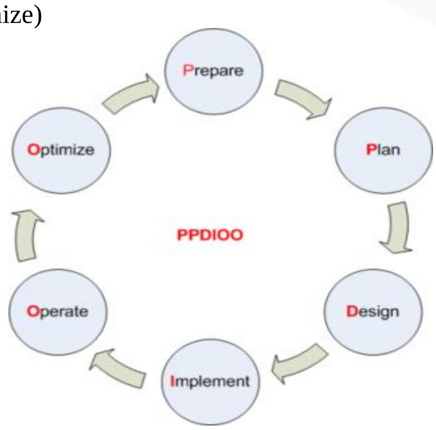


Figure 1 PPDIOO

1. Prepare

The Prepare phase is to determine the needs of the organization and the provision of internet network services, develop a network strategy, and propose a network architecture concept to support a government strategy.

2. Plan

The Plan phase is to identify network requirements based on network objectives, facilities, and needs. This phase describes the characteristics of a network, which aims to assess the network and compare performance as expected.

3. Design

Network design is developed based on technical requirements based on regional conditions that are detailed and meet technical requirements.

4. Implement

Implementation of the plan is to describe the field implementation, set-up, and configuration used by simulating and adding to the network design that has not been described.

5. Operate

The operation phase is the longest phase required in the PPDIOO phase because in this phase the company or internet service provider will monitor the flow of data and configuration.

6. Optimize

The Optimization phase can occur at any time after the network is operational. This phase usually occurs due to technical changes or technical requirements and network maintenance [3].

E. QoS

Quality of Service (QoS) is a mechanism used to manage and control the flow of data on a computer network. QoS is implemented to improve network quality of service and provide higher reliability for applications that require greater bandwidth or lower latency.

QoS implementation can help improve network performance and provide better services for applications that require greater bandwidth or lower latency. However, QoS implementation can also increase network complexity and require additional costs. Therefore, QoS implementation should be carefully considered and tailored to the existing network requirements. Here are three QoS parameters:

1. Delay

Delay QoS is a mechanism used to manage and control the flow of data on a computer network. QoS is implemented to improve network quality of service and provide higher reliability for applications that require greater bandwidth or lower latency [1].

Table 1 Delay [4]

Latency Category	Delay Size
Very Good	<150 ms
Good	150 up to 300 ms
Medium	300 up to 450 ms
Bad	>450 ms

2. Packet Loss

Packet Loss Quality of Service (QoS) is a mechanism used to control and regulate the level of packet loss on a computer network [1].

Table 2 Packet Loss [4]

Packet loss category	Packet loss (%)
Very Good	0-2%
Good	3-14%
Medium	15-24%
Bad	>25%

3. Throughput

Throughput is the speed or capacity of data that can be transmitted over a computer network in each period. Throughput can be measured in bps (bits per second) or bps (bytes per second), depending on the type of data being transmitted.

Table 3 Throughput [4]

Throughput category	Throughput
Excellent	>2.1 Mbps
Good	1200 kbps-2.1Mbps
Fair	700-1200 kbps
Poor	338-700 kbps
Bad	0-338 kbps

F. Wireshark

Wireshark is a network analysis software application used to monitor and analyze data traffic in computer networks. In this research, Wireshark is used to retrieve data delay, throughput, packet loss on floors 4-7 of the TULT building. Here are some common features and uses of the Wireshark application:

1. Network Administrators use wireshark to troubleshoot network problems.
2. Network Security uses wireshark to solve network security problems.
3. Developers use it to debug protocol implementations.
4. Users use it to learn its internal network protocol.
5. Diagnose the problem.
6. Capture network information.
7. Decode the frame.
8. Perform filtering on trace files [5].

G. Signal Strength

Signal strength refers to the strength of the wireless signal received by a WiFi or mobile network device. This term describes how strong or weak a device receives a signal from a Wi-Fi access point, router, or cell tower.

Table 4 Signal Strength [6]

Signal Strength	Quality	Description
-10 - -57 dBm	Excellent	The best achievable signal. Users may exist and will not be far from the vicinity of the AP.
-75 - -58 dBm	Good	Achievable good signal.
-85 - -76 dBm	Fair	Minimum requirements for applications that require a reliable network.
-95 - -86 dBm	Bad	Too much interference. will not work.

III. RESEARCH METHOD

This study is using conceptual model, conceptual model is an approach that uses basic concepts and theories to explain and understand phenomena. This contrasts with the empirical approach which emphasizes more on data collection and direct observation. Conceptual methods are often used in the fields of social science, philosophy, and theory, where it is not possible to conduct direct experiments. This method is useful for developing theories and understanding complex phenomena more deeply.

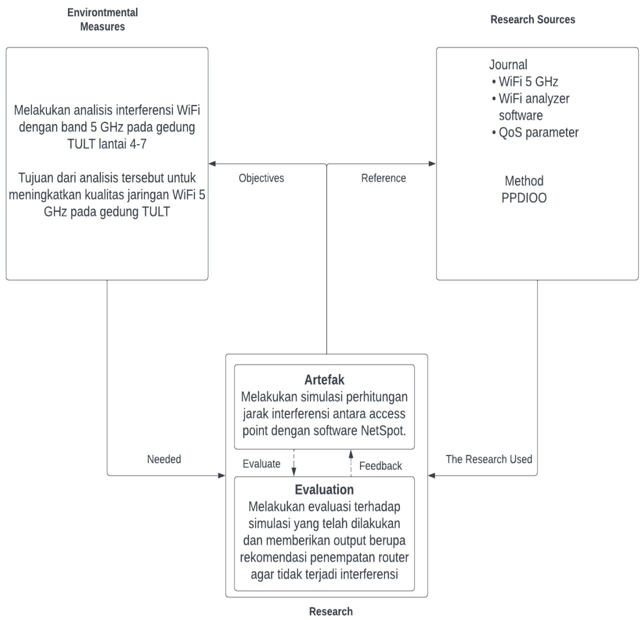


Figure 2 Conceptual Model

The basic information used is based on several references such as Wi-Fi, 5 GHz radio frequency, interference, and PPDIOO. The method in this research uses PPDIOO which focuses on improving the performance of 5 GHz Wi-Fi networks based on interference and coverage.

Figure 4 Systematic Research

The research systematics explains the stages of the research from beginning to end. This research uses the PPDIOO method, here are the stages:

1. Research Stage

This stage includes the selection of research topics, problem formulation, research objectives, and data collection, in data collection, there are two parts, namely data collection in the form of observation and literature study.

2. Analysist Stage

The analysis phase includes condition analysis of the TULT Building floors 4 - 7, and interference analysis in which there are 2 parts, the first part is the access point where the number, position, and frequency of the access point are analyzed, in the second part is the QoS parameter analysis.

3. Design Stage

This stage includes the evaluation of the wireless network after analyzing the interference in the analysis stage, this stage will recommend the right location for the access point so that no interference occurs.

4. Final Stage

The final stage includes making a report from the previous stages, at this stage, there are also conclusions and suggestions from the research.

5. Data collection

Data collection was conducted using observation, and document study methods. The observation method involves observing the phenomenon that is happening, either directly or indirectly, while the document study method involves collecting data from written sources such as books, journals, reports, or other documents.

6. Data analysis or development process of product/artifact

The data obtained will be processed and analyzed using the PPDIOO method and will focus on the design and optimize stages.

7. Evaluation method

The evaluation method will use network monitoring tools, namely Wireshark for the wireless sniffer and Ekahau for the packet analyzer to monitor traffic and network conditions in real time.

8. Justification of methods

The reason for choosing the PPDIOO method is because, in the PPDIOO method, there are design and optimize phases and has an integrated structure that can help manage analysis risk by ensuring the stages are carried out correctly to reduce the possibility of problems or analysis failures.

IV. RESEARCH RESULTS

A. Topology

Network management in the TULT building is managed by the Pusat Teknologi Informasi (PuTi), this topology design was obtained from interviews with Sakti Putro Wisetyo as the head of IT network infrastructure affairs at PuTi. The following is the current network topology design on TULT floors 4 to 7.

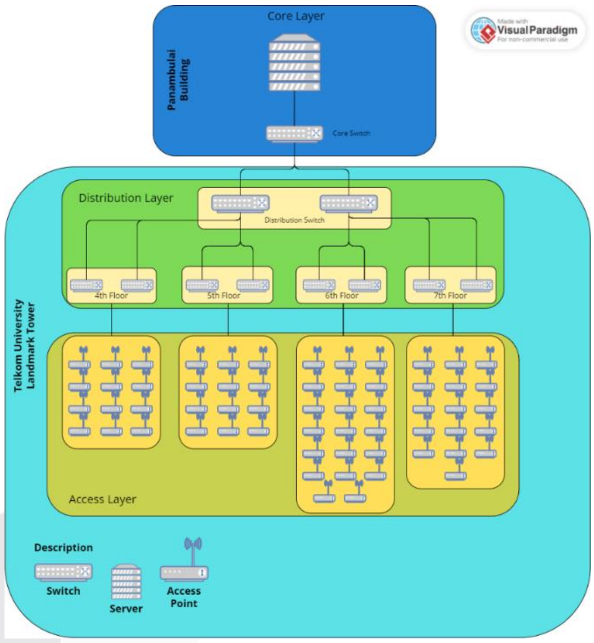


Figure 3 Network topology

B. Wireshark Testing During Peak Time and Free Time

Wireshark testing is done to find out the QoS of each floor and what will be analyzed here is delay, throughput, and packet loss by streaming video using the YouTube platform which will be accessed at peak time (10.30 WIB) and free time (15.30 WIB). Streaming using YouTube takes up a lot of bandwidth which can be seen in the QoS parameters, namely delay, throughput, and packet loss.

C. QOS Analysis Result

QoS testing is done to find out how good the network is and to find out if interference occurs, the measurement methods that will be used are Delay, Packet loss, and Throughput. The analysis is carried out using the wireshark application, the analysis is carried out when it is free time and when it is peak time, 10.30 is a peak time situation while at 15.30 when it is free time. The following are the formulas for calculating Throughput, Packet Loss, and Delay.

$$\text{Packet loss} = \frac{(\text{Packet Received} - \text{Packet Lost})}{\text{Packet Received}} \times 100$$

$$\text{Average delay} = \frac{\text{Time Span}}{\text{Packet Received}}$$

$$\text{Throughput} = \frac{\text{Bytes}}{\text{Time Span}} \times 8$$

Figure 4 QoS Formula [7]

1. QOS Analysis 4th Floor

Peak or Free	Time	Throughput(KBps)	Packet Loss (%)	Avg. Delay (sec)
Peak time	10.30 WIB	4.166	0.00073	0.001633 sec
Free time	15.30 WIB	5.931	0.00073	0.001278 sec

Figure 5 QoS analysis 4th floor

In the Figure above, we can see the results of the analysis that has been carried out, with throughput results of 4166 KBps when it is peak time and 5931 KBps when it is free time, for packet loss 0.00073% when peak time and 0.00073% when free time, for delay 0.001633/s when peak time and 0.001278/s when free time. From the data obtained on the 4th floor, the throughput results from the peak and free time above are excellent because it is less than 262.5KB according to the TIPHON standard, packet loss is excellent because the value ranges from 0% - 2% according to the TIPHON standard, and for peak time delay it is equivalent to 1.633 milliseconds and for free time it is equivalent to 1.278 milliseconds which means excellent according to the TIPHON standard.

2. QOS Analysis 5th Floor

Peak or Free	Time	Throughput(KBps)	Packet Loss (%)	Avg. Delay (sec)
Peak time	10.30 WIB	9.826	0.0025	0.007877
Free time	15.30 WIB	6.432	0.0026	0.001144

Figure 6 QoS analysis 5th floor

In the Figure above, it can be seen the results of the analysis that has been carried out, with throughput results of 9826 KBps when it is peak time and 6432 KBps when free time, for packet loss 0.00025% when peak time and 0.00026% when free time, for delay 0.007877/s when peak time and 0.001144/s when free time. From the data obtained on the 4th floor, the throughput results from the peak and free time above are excellent because it is less than 262.5KB according to the TIPHON standard, packet loss is excellent because the value ranges from 0% - 2% according to the TIPHON standard, and for peak time delay it is equivalent to 7,877 milliseconds and for free time it is equivalent to 1,144 milliseconds which means excellent according to the TIPHON standard.

3. QOS Analysis 6th Floor

Peak or Free	Time	Throughput(KBps)	Packet Loss (%)	Avg. Delay (sec)
Peak time	10.30 WIB	12.092	0.0012	0.006483
Free time	15.30 WIB	9.459	0.0010	0.008244

Figure 7 QoS analysis 6th floor

In the Figure above, it can be seen the results of the analysis that has been carried out, with throughput results of 12092 KBps when it is peak time and 9459 KBps when free time, for packet loss 0.0012% when peak time and 0.0010% when free time, for delay 0.006483/s when peak time and 0.008244/s when free time. From the data obtained on the 4th floor, the throughput results from the peak and free time above are excellent because it is less than 262.5KB according to the TIPHON standard, packet loss is excellent because the value ranges from 0% - 2% according to the TIPHON standard, and for peak time delay it is equivalent to 6.483 milliseconds and for free time it is equivalent to 8.244 milliseconds which means excellent according to the TIPHON standard.

4. QOS Analysis 7th Floor

Peak or Free	Time	Throughput(KBps)	Packet Loss (%)	Avg. Delay (sec)
Peak time	10.30 WIB	5.869	0.0012	0.001232
Free time	15.30 WIB	2.890	0.0034	0.002185

Figure 8 QoS analysis 7th floor

In the table above, we can see the results of the analysis that has been carried out, with throughput results of 5869 KBps during peak time and 2890 KBps during free time, for packet loss 0.0012% during peak time and 0.0034% during free time, for delay 0.001232/s during peak time and 0.002185/s during free time. From the data obtained on the 4th floor, the throughput results from the peak and free time above are excellent because it is less than 262.5KB according to the TIPHON standard, packet loss is excellent because the value ranges from 0% - 2% according to the TIPHON standard, and for peak time delay it is equivalent to 1.232 milliseconds and for free time it is equivalent to 2.185 milliseconds which means excellent according to the TIPHON standard.

V. DESIGN AND RECOMMENDATIONS

Wi-Fi design recommendations on floors 4-7 of the TULT building in the form of channel distribution and the positioning of the installed access points to minimize interference between access point devices. Simulation of this recommendation using the Ekahau application.

Channel repetition is a major problem factor for TULT, especially floors 4-7, channel repetition can indeed make the use of frequency more efficient. However, channel repetition can have an impact on co-channel interference, co-channel interference can reduce the quality of the network. The distance between channels is needed at the access point to overcome co-channel interference.

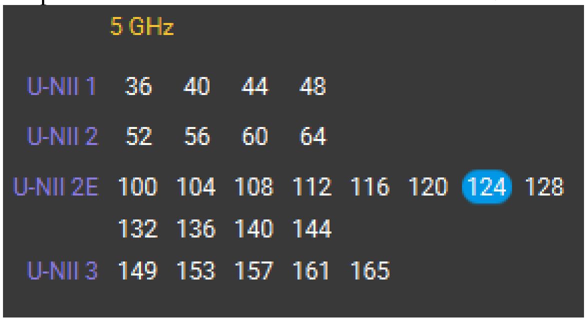
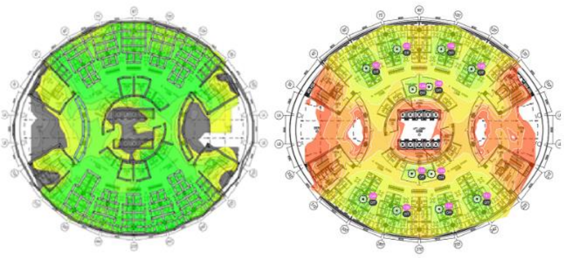


Figure 9 Ekahau channel

Adjusting the positioning of the access point, changing the position of the access point from ceiling mounting to wall mounting access point, especially for access points that are of the Ruijie RG-AP130(W2) V2 type because this access point only supports wall mounting but there are still some that are used for ceiling mounts, wall mounting can reduce the occurrence of channel overlapping between the upper and lower floor access points.

Figure 10 Ekahau access point positioning

A. Recommended Test Results on the 4th Floor of TULT

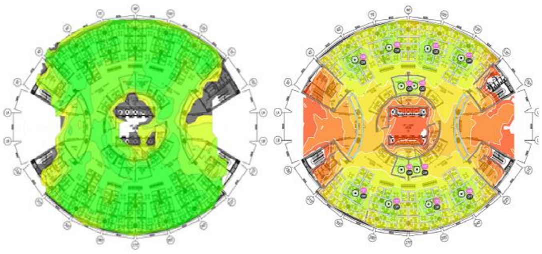


Location	Channel	Mounting
TUTL-0401 R. Sidang Skripsi top right	ac165	Wall
TUTL-0402 R. Sidang Skripsi top left	ac149	Wall
TUTL-0403 R. Sidang Skripsi bottom left	ac165	Wall
TUTL-0404 R. Sidang Skripsi bottom right	ac149	Wall
TULT-04 R. Kegiatan Dosen top right	ac149	Ceiling
TULT-04 R. Kegiatan Dosen top middle right	ac153	Ceiling
TULT-04 R. Kegiatan Dosen top middle left	ac157	Ceiling
TULT-04 R. Kegiatan Dosen top left	ac161	Ceiling
TULT-04 R. Kegiatan Dosen bottom left	ac149	Ceiling
TULT-04 R. Kegiatan Dosen bottom middle left	ac153	Ceiling
TULT-04 R. Kegiatan Dosen bottom middle right	ac157	Ceiling
TULT-04 R. Kegiatan Dosen bottom right	ac161	Ceiling

Figure 11 Reccomendation Channel and Mounting 4th Floor

In the picture is a comparison between the signal coverage from the survey results and the simulation results and channel distribution. For the survey results have a better signal than the simulation results. The use of the upper channel and give more space for the same channel reduces the signal coverage of the access point, the average signal for the simulation coverage is in the range of -65dBm - -60dBm as much as 20%.

B. Recommended Test Results on the 5th Floor of TULT

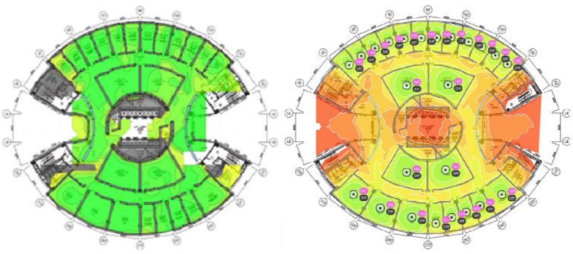


Location	Channel	Mounting
TUTL-0501 R. Sidang Skripsi top right	ac165	Wall
TUTL-0502 R. Sidang Skripsi top left	ac161	Wall
TUTL-0503 R. Sidang Skripsi bottom left	ac165	Wall
TUTL-0504 R. Sidang Skripsi bottom right	ac161	Wall
TULT-05 R. Kegiatan Dosen top right	ac161	Ceiling
TULT-05 R. Kegiatan Dosen top middle right	ac157	Ceiling
TULT-05 R. Kegiatan Dosen top middle left	ac153	Ceiling
TULT-05 R. Kegiatan Dosen top left	ac149	Ceiling
TULT-05 R. Kegiatan Dosen bottom left	ac161	Ceiling
TULT-05 R. Kegiatan Dosen bottom middle left	ac157	Ceiling

Figure 12 Reccomendation Channel and Mounting 5th Floor

In the picture is a comparison between the signal coverage from the survey results and the simulation results and channel distribution. For the survey results have a better signal than the simulation results. The use of the upper channel and give more space for the same channel reduces the signal coverage of the access point, the average signal coverage is in the range of -60dBm - -55dBm as much as 22.8%

C. Recommended Test Results on the 4th Floor of TULT

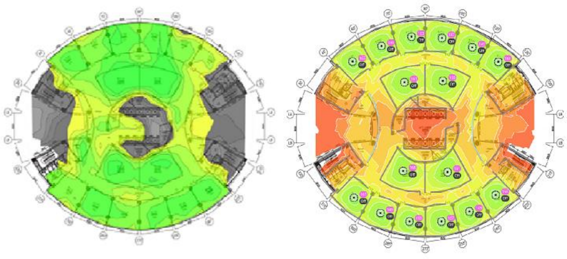


Location	Channel	Mounting
TUTL R. 6.01A	ac161	Wall
TUTL R. 6.01B	ac149	Wall
TUTL R. 6.02A	ac157	Wall
TUTL R. 6.02B	ac153	Wall
TUTL R. 6.03A	ac149	Wall
TUTL R. 6.03B	ac157	Wall
TUTL R. 6.04A	ac153	Wall
TUTL R. 6.04B	ac149	Wall
TUTL R. 6.05A	ac157	Wall
TUTL R. 6.05B	ac153	Wall
TUTL R. 6.06A	ac149	Wall
TUTL R. 6.06B	ac165	Wall
TUTL R. 6.07	ac165	Wall
TUTL R. 6.08A	ac157	Wall
TUTL R. 6.08B	ac153	Wall
TUTL R. 6.09A	ac149	Wall
TUTL R. 6.09B	ac157	Wall
TUTL R. 6.10	ac153	Ceiling
TUTL R. 6.11	ac149	Ceiling
TUTL R. 6.12	ac161	Ceiling
TUTL R. 6.13 Common LAB	ac165	Ceiling
TUTL R. 6.14 Common LAB	ac161	Ceiling
TUTL R. 6.15 Common LAB	ac161	Ceiling
TUTL R. 6.16 Common LAB	ac165	Ceiling

Figure 13 Reccomendation Channel and Mounting 6th Floor

In the picture is a comparison between the signal coverage from the survey results and the simulation results and channel distribution. For the survey results have a better signal than the simulation results. The use of the upper channel reduces the signal coverage of the access point, the average signal coverage is in the range of -55dBm - -50dBm by 19.8%.

D. Recommended Test Results on the 4th Floor of TULT



Location	Channel	Mounting
TUTL R. 7.01	ac165	Ceiling
TUTL R. 7.02	ac149	Ceiling
TUTL R. 7.03	ac153	Ceiling
TUTL R. 7.04	ac157	Ceiling
TUTL R. 7.05	ac149	Ceiling
TUTL R. 7.06	ac161	Ceiling
TUTL R. 7.07	Ac165	Ceiling
TUTL R. 7.08	ac149	Ceiling
TUTL R. 7.09	ac157	Ceiling
TUTL R. 7.10	ac153	Ceiling
TUTL R. 7.11	ac149	Ceiling
TUTL R. 7.12	ac161	Ceiling
TUTL R. 7.13 Common LAB	ac161	Ceiling
TUTL R. 7.14 Common LAB	ac165	Ceiling
TUTL R. 7.15 Common LAB	ac161	Ceiling
TUTL R. 7.16 Common LAB	ac165	Ceiling

Figure 14 Reccomendation Channel and Mounting 7th Floor

In the picture is a comparison between the signal coverage from the survey results and the simulation results and channel distribution. For the survey results have worse interference results than the simulation results. The results of the interference simulation on the 6th floor of the TULT building are 97.5% interference at index 0 and 2.5% at index 2, it can be concluded that the interference channel on the 6th floor simulation is very good.

VI. CONCLUSION AND SUGGESTION

A. Conclusion

The conclusion of this study is that the main cause of interference on floors 4-7 of the TULT building is due to over coverage, channel repetition, and wrong access point placement, where the access point type RG-AP130(W2) V2 is an access point that has a wall mount installed and not a ceiling mount so any of these problems can cause co-channel interference. This certainly has an impact on decreasing the performance of the access point.

The recommendation for this problem is to suppress interference on floors 4-7 TULT by providing distance between channels and changing the position of the access point type AP130(W2) V2 to wall mounting, and the researchers recommend for floors 4 and 5 add access points in the area the upper middle and lower middle because, in the results of the simulation, these areas have less signal strength.

B. Suggestion

1. For Telkom University, this research is expected to be a material consideration for the implementation of Wireless Networking, especially in the 5Ghz Wi-Fi

band in the form of changes in access point placement and channeling configuration.

2. For further researchers, author hope that this research design can be used as a reference in the implementation of the 5Ghz wifi band in the TULT Building

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