

Effect Of Distance On Wi-Fi Signal Quality In The Home Environment

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ABSTRACT

This study aims to analyze the effect of distance on Wi-Fi signal quality in a home environment. With the increasing use of wireless devices and applications that rely on internet connectivity, Wi-Fi signal quality has become crucial to support daily activities such as streaming, online gaming, remote work, and smart home automation. This research employs an experimental method by measuring signal strength and data transmission speed at various distances from the Wi-Fi router. Measurements were taken at several points, ranging from 1 meter to 15 meters from the router, in different rooms and through different obstacles like walls and furniture. To conduct the analysis, a Wi-Fi analyzer was used to measure signal strength (in dBm) and a speed test was employed to determine data transmission speed (in Mbps) at each distance. The results showed that the greater the distance from the router, the Wi-Fi signal strength decreased significantly, leading to a corresponding decrease in data transmission speed. In addition, obstacles such as walls and electronic interference further degraded the signal quality. This study concludes that optimizing router placement and using signal booster devices, such as Wi-Fi extenders or mesh networks, can be effective solutions to improve Wi-Fi signal quality at home. It also highlights the importance of understanding and managing home network infrastructure to maximize Wi-Fi usage efficiency. By strategically placing routers and employing additional network hardware, users can ensure a stable and fast internet connection throughout their home, enhancing the overall user experience and productivity. Research provides valuable insights for homeowners and technology enthusiasts on how to achieve optimal Wi-Fi performance in various home environments.

INTRODUCTION

In the digital era, internet connectivity is a basic need in various places around the world. Network technology is currently developing very rapidly starting from networks that use cables to wireless (Mohammad Andi Sampurno & Poerbaningtyas E., 2022). Wi-fi stands for Wireless Fidelity which goes through a high-speed data transmission process (Suci Andriyani et al., 2024). WiFi signal quality is often affected by several kinds of factors such as signal interference, maximum number of clients, coverage power, and signal obstructions (Fritz Gamliel & P. Yudi Dwi Arliyanto, 2023). A large number of challenges in wireless communication can be attributed to the privacy and security of sensitive information (Rommesra et al., 2023). Various information in the current development is very easy to obtain (En&g Dwi Saidah et al., 2023).

The development of internet network technology has changed the way people think in finding information and communicating that is not limited by space and time (Dinda Listya et al., 2023). Wireless network is one of the network technologies where the transmission media uses radio frequency or infrared to provide a network connection to all users in the surrounding area (Fajar Setyawan et al., 2022). which is useful for connecting to the internet such as YouTube, Chrome, Whatsapp, Twitter and other internet-based applications (Rikkie Dekas. 2022). Telecommunications operators offer Wi-Fi extenders to reach every corner of every corner of the house with a Wi-Fi network (Maria Rikitianskaia, 2022), ensuring an uninterrupted connection throughout the area (Ahmad Yusuf Faiz Azmi et al., 2022), The number of mobile phone and laptop users is one proof of technological development in the information & communication (ICT) section which has brought great changes (Ayu Puspita Athaya Syahda & Agustuti Handayani, 2024), Various information today is very easy to obtain thanks to the internet (H, Susanto & L. Nurhidayat, 2022), technology is certainly side by side with a protocol, as well as wireless networks. Technology gives birth to various innovations that improve the quality of human life (Chan M. K., 2022).

Wi-Fi is currently needed because of its benefits to daily human activities (Prakoso B & Wijaya, 2023). A small example is the use of Wi-Fi at home (Ermizahadiwidastra & Dedy Syamsuar, 2022). Although Wi-Fi technology has



developed rapidly, signal quality problems still occur frequently (Mihtahur Rahman et al., 2023), especially in environments with many obstructions or a long distance from the signal source (Ika Mei Lina & Gilang Ryan Fernandes, 2022). As one of the important factors affecting signal quality (Shivani Ghadage et al., 2022), it has an effective range limit which if exceeded can result in a significant decrease in transmission speed and signal state (Muhammad Yasin Simargolang et al., 2023).

The study of the effect of distance is important because it provides a basis for recommendations on the placement of Wi-Fi infrastructure in the home in order to maximize Wi-Fi coverage and performance (Mohammad Reza Ghadari, 2022). Using software to analyze Wi-Fi networks (Shayma Wail Nourildean et al., 2022). Using software to analyze Wi-Fi networks can help you find places in your home where the Wi-Fi signal is weak. That way, we can place routers or signal boosters in more effective places (Mnassar Alyami, et al., 2022). Research shows that the more people using Wi-Fi simultaneously, the slower the connection gets. This shows the importance of having a strong Wi-Fi infrastructure at home (Raharja I. T & Sari P. K., 2024).

Electronic devices such as microwaves and baby monitors can interfere with Wi-Fi signals (Rodriguez S et al., 2023). We should think about where to place the router to avoid this interference (Agung Dzulkarnain I. J & Putri D. A., 2022). An old and improperly positioned router can make the Wi-Fi signal at home weak. Routinely updating the router software and considering a better position can help (Dian Paramita Sari & Rizky Aditya, 2023). Routers that can use two frequencies at once, 2.4 GHz and 5 GHz, can reduce the problem of signals being overused by many devices (Kevin Sugiharto et al., 2022). The shape and arrangement of the house greatly affects the strength of the Wi-Fi signal. It is important to analyze where the router should be placed, according to the shape of the house (Lutfi Alarcon Pradipta & Dewi Sartika, 2023). Adding external antennas and signal boosters can help strengthen and extend the range of Wi-Fi signals, especially in homes that are large or have many obstructions (Reza Pahlevi et al., 2024).

Using a mesh Wi-Fi network at home can make the signal distribution more even, suitable for spacious or multi-story homes (Nabil Ihsan & Yuni Kartika. 2023). Building materials such as concrete and metal can severely hinder Wi-Fi signals. It is necessary to think about how to place the router so that there are not too many obstructions from these materials (Simon Fraser et al., 2023). Understanding the specific needs of a home Wi-Fi network can help in making better plans to improve signal quality and coverage in the future (Michael Davidson, 2023).

LITERATURE REVIEW

Wi-Fi Technology and Its Evolution

Wi-Fi, or Wireless Fidelity, has become an integral part of modern life, providing wireless internet access to a plethora of devices. Wi-Fi technology allows devices to connect to the internet and communicate with each other without the need for physical cables, using radio waves to transmit data (Mohammad Andi Sampurno & Poerbaningtyas E., 2022). The development of Wi-Fi has seen several iterations, with improvements in speed, security, and range. The latest standards, such as Wi-Fi 6 and Wi-Fi 6E, offer enhanced performance, especially in crowded environments, and provide better support for multiple devices simultaneously (Suci Andriyani et al., 2024).

Factors Affecting Wi-Fi Signal Quality

Several factors can influence Wi-Fi signal quality, including signal interference, the number of connected devices, coverage power, and physical obstructions (Fritz Gamliel & P. Yudi Dwi Arliyanto, 2023). Signal interference can come from various sources, including other electronic devices like microwaves and baby monitors, which operate on similar frequencies (Rodriguez S et al., 2023). The maximum number of clients connected to a single Wi-Fi network can also impact performance, as more devices compete for the same bandwidth (Raharja I. T & Sari P. K., 2024).

Privacy and Security in Wi-Fi Networks

Wireless networks present unique challenges in terms of privacy and security. The broadcast nature of Wi-Fi signals means they can be intercepted by unauthorized users if proper security measures are not in place. Issues such as data encryption, secure passwords, and regular updates to firmware and software are crucial to maintaining the security of Wi-Fi networks (Romi Mesra et al., 2023).

Impact of Distance on Wi-Fi Signal Strength

Distance is a critical factor affecting Wi-Fi signal strength and data transmission speed. As the distance between the router and the connected device increases, the signal strength typically decreases, resulting in slower internet speeds and potential connection instability (Muhammad Yasin Simargolang et al., 2023). Physical obstructions, such as walls and furniture, further exacerbate this issue by absorbing or reflecting the Wi-Fi signals, leading to reduced coverage and performance in different areas of a home (Ika Mei Lina & Gilang Ryan Fernandes, 2022).

Solutions for Improving Wi-Fi Coverage

Several solutions can help mitigate the issues of weak Wi-Fi signals in larger homes or areas with many obstructions. Wi-Fi extenders and mesh networks are popular options that can expand coverage and provide a more



stable connection throughout the home (Maria Rikitiaskaia, 2022). Mesh Wi-Fi systems, in particular, are effective in ensuring consistent signal strength across different floors and rooms by using multiple interconnected nodes to create a seamless network (Nabil Ihsan & Yuni Kartika, 2023).

Technological Innovations in Wi-Fi

Technological advancements continue to improve Wi-Fi performance. Dual-band and tri-band routers, which operate on multiple frequencies (2.4 GHz, 5 GHz, and sometimes 6 GHz), can handle more devices and reduce congestion on any single band (Kevin Sugiharto et al., 2022). Innovations such as beamforming, which focuses the Wi-Fi signal directly at the receiving device rather than broadcasting it uniformly in all directions, also enhance signal strength and range (Chan M. K, 2022)

Home Network Management

Effective home network management involves understanding the specific needs of the household and strategically placing network devices to maximize performance. Conducting a site survey to identify weak signal areas and adjusting router settings, such as changing channels to avoid interference or increasing transmission power, can significantly improve Wi-Fi quality (Sujono et al., 2022). Regular updates to router firmware and the use of advanced security protocols also play vital roles in maintaining a robust and secure home network (Dian Paramita Sari & Rizky Aditya, 2023).

METHOD

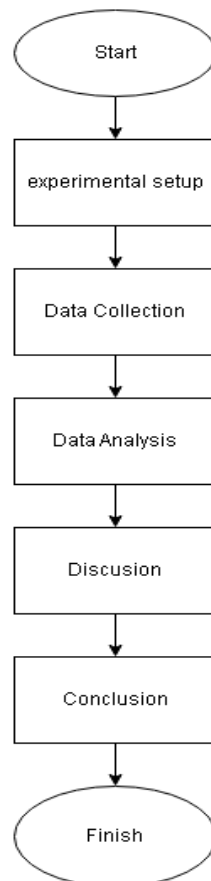


Figure 1. research stages

The methodology starts with "Experimental Setup" to prepare the equipment and determine the location of the router. Next, "Distance Measurement" is performed to define the main variables, followed by "Data Collection" on signal strength and transmission speed at various distances. After that, "Recording Interference Variables" records other factors that might affect the results. The collected data is then analyzed in "Data Analysis," and the results are discussed in "Discussion of Results" to understand the implications of the research. The research process concludes with "Drawing Conclusions," which summarizes the findings and recommendations, ending with the stage "Done."

Experimental Setup

The study was conducted in various rooms within the home environment to obtain relevant measurement variations. The rooms selected included the living room, bedroom, and kitchen, as they represent common areas of Wi-Fi usage at home. The equipment used in this study included a Wi-Fi router, a laptop/PC with speedtest software for signal strength measurement, and a mobile device for internet speed testing. Proper selection of equipment is essential to ensure the accuracy and consistency of the data obtained.



Figur 2. WiFi model type

The router used is an indihome model, which supports dual-band frequencies of 2.4 GHz and 5 GHz. The specifications of this router include the maximum achievable speed, effective range, and the ability to handle multiple devices simultaneously.

Distance Measurement

Distance Measurement was conducted, which included determining measurement points, selecting measuring instruments, and sampling strategies. Distances were measured accurately using a digital distance measuring instrument to ensure consistency and accuracy of the data. The measurement points were selected based on the representation of different areas in the house, such as the living room, bedroom, and kitchen, which have different physical characteristics in terms of wall material and potential interference. Measurements were taken at three different distances from the router: 1 metre, 3 metres, and 5 metres. Each measurement point was chosen by considering the areas frequently used by the residents of the house to get a realistic picture of the Wi-Fi signal quality in daily use. In addition, the distance measurement method involves several important stages. Firstly, each distance is measured from the router to the Wi-Fi signal receiving device using a tape measure or laser distance measuring instrument to ensure precision. Each measurement point is described in detail, including environmental conditions such as the presence of walls, furniture, and other electronic devices. Measurements were repeated for each distance, with three repetitions at each point to obtain consistent and reliable data.

Measurements were taken at the same time every day over a one-week period to avoid signal fluctuations caused by changes in environmental conditions or neighbours' use of the Wi-Fi network. In addition, signal variations that may occur due to weather changes, household activities, and the use of other devices that may interfere with the Wi-Fi signal were recorded. The data collected included signal strength (dBm) and download and upload speeds (Mbps) at each distance. To get a more comprehensive picture, measurements were taken at various indoor positions for each specified distance, such as on the floor, on a table, and at other heights that may be used by the occupants of the house. In this way, the data obtained will be more representative and can provide a more comprehensive insight into the effect of distance and position on Wi-Fi signal quality in a home environment.

Data Collection

Signal Strength Measurement Use the Wi-Fi analyser app to measure the signal strength (dBm) at each measurement point. The Wi-Fi analyser provides real-time data on Wi-Fi signal intensity, which is then recorded and analysed. The signal strength is measured at various times of the day to consider possible fluctuations.



Figure 3. web view from speedtest

Internet Speed Testing Using speedtest.net to measure download and upload speeds at each measurement point. Internet speed was measured multiple times at each point to ensure consistency and accuracy of results. The data obtained was then averaged for further analysis.

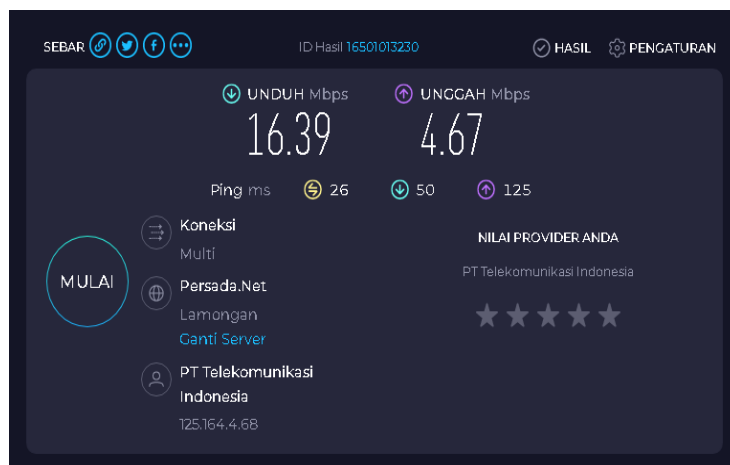


Figure 4. web view from speedtest

RESULT

Data Analysis

This research analyzes using an online website, namely: speedtest.net/id. Which is practiced and tested to measure the signal and network of an internet to make it easier to see the network speed. The collected data was analysed using statistical and visualisation methods to identify patterns and trends in the data. Bar charts, line plots and heatmaps were used to show the distribution of signal strength across homes. The analysis included calculations of mean, standard deviation, and correlation analysis to determine the relationship between distance, signal strength, and internet speed. In addition, statistical analyses were conducted to test the significance of differences in signal strength and data transmission speed at various distances. This analysis involved a t-test to compare the average signal strength and download/upload speed between different measurement points. In addition, a correlation analysis was conducted to identify the relationship between the distance from the router and the signal strength and data transmission speed. These correlations help in understanding the extent to which distance affects Wi-Fi performance and provide a basis for practical recommendations in the placement of routers and other network devices.

Table 1. Experiment test table

Location	Distance from the router	Mbps (Download)	Mbps (Upload)	Barrier
Living Room	4 m	46 mbps	17 mbps	Concrete wall
Living Room	6 m	45 mbps	19 mbps	Concrete wall
Bedroom	10 m	44 mbps	15 mbps	Concrete wall, Wooden cabinet
Bedroom	13 m	45 mbps	14 mbps	Concrete wall, Wooden cabinet
Kitchen	15 m	43 mbps	12 mbps	Concrete wall
Kitchen	17 m	43 mbps	15 mbps	Concrete wall
kitchen	19 m	42 mbps	11 mbps	Concrete wall
Bathroom	20 m	40 mbps	10 mbps	Concrete wall, door
Bathroom	20 m	34 mbps	7 mbps	Concrete wall, door (close)
WC	20 m	42 mbps	11 mbps	Concrete wall, door
WC	20 m	32 mbps	9 mbps	Concrete wall,door (close)

Table 1 shows that there is a trend of decreasing Wi-Fi signal quality as the distance from the router increases. This confirms the importance of considering the placement of routers and devices within the home environment to maximize the efficiency and quality of the internet connection. Further analysis will examine factors that may influence this variation (Luara Garcia & Simon Fraser, 2024), including interference from other devices and the influence of building structures.

DISCUSSION

From the resulting data, we can observe an exponential decrease in signal strength as the distance from the router increases (Haris Prakoso, 2022). This decrease is not only lineal but also affected by various environmental factors such as walls made of different materials, furniture that can absorb or reflect the signal (R. Joko Sarjanoko, 2022) and even interference from other electronic devices that can cause signal interference. In addition, the analysis shows that the frequency of the Wi-Fi signal also plays an important role in signal penetration and strength. Lower frequencies, such as those used in 2.4 GHz Wi-Fi (Retia Utari & Mukhlidi Muskhair, 2022), tend to have better range and more effective wall penetration compared to higher frequencies such as 5 GHz (Riad Sahara et al, 2022), which offer higher speeds but at shorter distances and with lower penetration. The practical implication of this finding is the importance of choosing the right frequency based on the usage needs and configuration of the house. For homes that are larger or have many obstructions, the use of Wi-Fi repeaters, extenders, or mesh systems may be necessary to ensure even signal distribution throughout the area.

Therefore, a practical recommendation for home users is to conduct a site survey to understand the signal dynamics in their neighbourhood and select a suitable network solution. Making adjustments to router settings, such as changing channels or increasing transmission power (Sujono et al., 2022), can also help in optimising signal quality. Finally, there is a need for further research that can delve deeper into the influence of modern building materials and home layouts on Wi-Fi signal distribution. This would be helpful in designing more effective and efficient network solutions for different types and sizes of home (He-Jun Lu & Yang Yu, 2022). With this more comprehensive approach, we can better understand and address the challenges faced in providing stable and fast Wi-Fi connections in increasingly complex home environments (Chen Min & Zhang Jinhan, 2022).

CONCLUSION

The conclusion of this study shows that the distance between the device and the Wi-Fi router affects the signal quality, which decreases as the distance increases. The use of technologies such as repeaters and mesh Wi-Fi systems are helpful in improving coverage and signal stability in the home, especially in areas that are large or have many obstructions. This conclusion supports the importance of selecting and placing the right Wi-Fi infrastructure in the home to maximise effectiveness and user satisfaction.

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