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An Analysis 5G Network Latency for Upload and Download: Case Study of 5G Network in Medan City

Fitria Nova Hulu[1], Muhammad Rusdi[2], Indra Yadi[3]
[1,2]Telecommunication Network Engineering Technology Study Program, Department of Electrical Engineering, Medan State Polytechnic
[3]Telecommunication Engineering Study Program, Department of Electrical Engineering, Medan State Polytechnic

ABSTRACT

This research analyzes 5G network latency for upload and download activities in Medan City. Using a quantitative approach, data is collected through latency measurements at various test points throughout the city. Measurements are carried out with special network test tools that are able to detect latency accurately. The research results show that the average data speed for download activities is 14.62 Mbps while uploading is 22.72 Mbps, with an average latency value of 46.6 ms from the combined upload and download processes. Latency variability was also analyzed based on location and time factors, showing that the city center area had lower latency than the suburbs. This study indicates that the implementation of edge computing technology can further optimize 5G network performance in Medan City. These findings are important for telecommunications service providers to improve service quality and user experience

Keywords: 5G, Upload, Download, Latency

Corresponding Author:
Fitria Nova Hulu
Department of Information Technology
Universitas Muhammadiyah Sumatera Utara
JL. Alma Mater No.1, Padang Bulan, Kec. Medan Baru, Medan City, North Sumatra
Email: fitrianova@polmed.ac.id

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1. INTRODUCTION

The development of telecommunications has a big influence on life. The digital revolution that is currently taking place has encouraged the creation of innovations in the field of mobile devices, transmission media using optical fiber and satellites, which has unknowingly brought us into the era of 5G technology and the Internet of Things (IoT). Since it was first discovered, telecommunications technology has experienced a fairly long development journey starting from generation zero to the fourth generation which has been implemented currently, and also the fifth generation which is planned [15]. The development of this technology makes information exchange connectivity faster, more reliable and more widespread, where this development not only facilitates communication between individuals, but also allows deeper integration between humans and technology, thereby creating an ecosystem that is increasingly smart (smart technology) and more efficient. The telecommunications sector continues to create various innovations that present the latest products in order to speed up the exchange of information in various fields which can support the exchange of information very quickly by combining many devices in a systemized network, which can be used both over short and long distances [6] . Entering a new phase of digital data connection has a big impact on people's lives, not only in Indonesia but throughout the world. Communication developed using wireless networks started with third generation (3G) and fourth generation (4G) communication networks. While society is currently enjoying the fourth technology network (4G), simultaneously a new platform with the fifth technology has also begun to be introduced, 5G technology will surpass previous technology, giving birth to a term called a networked society, namely a connection that can reach everything around us.[15].

4G and 5G systems have the same needs, namely the need for wide bandwidth, but to overcome the need for wide bandwidth, it is not enough to spend a small amount of money. To overcome this cost problem using the microstrip method, microstrip antennas tend to have a fairly narrow bandwidth.[7]. 5G technology is the latest generation of cellular networks that brings a revolution in the field of information and communication technology. It offers high speed, low latency, and high capacity which makes it possible to improve user experience and support new applications and services such as internet

of things (IoT), virtual and augmented reality, etc.[4]. 5G is the terminology used for 5th generation mobile technology[1]. To be able to meet mobile broadband access targets, the availability and adequacy of the frequency spectrum as a data transmission medium for wireless access is absolutely necessary. Although there are other options that can be taken to balance the ever-increasing growth in data traffic, namely by increasing the efficiency of the frequency spectrum (technology upgrade) and by further intensifying the reuse of the spectrum.[3].

Cellular technology is developing rapidly, leading to 5G cellular technology, as a result of which communication has become an important need for society (Majors et al., nd). There are several things that can affect network quality, including the large number of users and also the distance between the server and the user[10]. The application of 4G technology has developed in Indonesia, but upgrading to 5G technology in Indonesia must be carried out because of increasingly rapid developments[13].This technology is a challenge in itself for Indonesia itself because this technology requires Indonesia to build infrastructure and also various considerations, whether Indonesia is ready or not ready to experience the development of 5G technology.[8].

Basically, the application of 4G technology has developed in Indonesia, but improvements to 5G technology in Indonesia must be made because of increasingly rapid developments. [14].In contrast to previous cellular technologies, the main goal of 5G technology is to fulfill cellular communication services and provide technological support to economic and industrial sectors. 5G technology will create conditions where wireless connectivity changes from something that adds value to something that must be present in the industrial sector.

In 5G networks, spectrum availability is one of the main challenges to support the enormous traffic demand. Currently, the spectrum is starting to become scarce and congested. Especially in very dense deployments, higher frequencies will be required and use a larger portion of the free spectrum. What frequency bands are available, will help determine the business case for 5G[9]. There are several things that can affect network quality, including the large number of users and also the distance between the server and the user[10]. In this case the author conducted research related to the effect of latency on service quality and user experience. Latency or Delay is the time required for a system to process data, where if the latency is higher it will cause delays in sending data. Therefore, the author collected data at several locations in Medan City using the OpenSignal application to monitor how much latency is required to use the 5G network during the upload and download process.

2. METHOD

The research method used in this research includes various stages starting from determining the location of data sample viewing points, data collection techniques, to data analysis procedures. Choosing the right research method is very important to ensure that the research objectives can be achieved with validity and reliability. The qualitative method is a research process to understand human or social phenomena by creating a comprehensive and complex picture that can be presented in words, reporting detailed views obtained from informant sources, and carried out in a natural setting.(Admaja, 2018).

According to Zed (2004) there are four stages of library study, namely preparing the necessary equipment, preparing a working bibliography, organizing time and reading and recording research material. Collecting data by searching for sources and constructing them from various sources such as books, journals and existing research. The analysis method uses content analysis and descriptive analysis. Library materials obtained from various references are analyzed critically and in depth in order to support propositions and ideas. Specific stages of qualitative research include (Admaja, 2018) Problem identification; Researchers must start with what is the research target, meaning it involves the specification of the issue/phenomenon to be studied/researched. (AK & ZA, 2015) Literature review (library search); In this section, the researcher must look for material or reading sources related to the phenomenon to be researched, so that the researcher must be able to find novelty or advantages in his research compared to previous research. (Clarke, 2014) Determine the research objectives; Researchers must identify the main aims/objectives of their research. (Gani, 2023)Data collection; Researchers must pay attention in selecting and determining potential objects/participants, in order to reach participants' ability to be actively involved in research. (Hulu et al., 2022) Analysis and interpretation of data (interpretation); The data that has been obtained by researchers is then analyzed or interpreted to produce new ideas or theories. (Hulu et al., 2022) Reporting; Researchers make reports on the results

of their research with a descriptive style, because they use qualitative methods so they require broad descriptions in their reports and must position the reader as if they were people involved in the research.

The sample selection procedure used in this research uses a purposive technique, where research subjects are selected based on relevant criteria, one of which includes the 5G network technology service area. Using simulation tools, in this case the OpenSignal application, will make the monitoring and sampling data process easier so that the data obtained is more accurate. The data access speed testing process was carried out using the OpenSignal application. OpenSignal is a set of signal tools that shows how to get a better network connection instantly, find the nearest free WiFi hotspot, view signal maps so you can compare network performance and test the connection speed of mobile or WiFi.Data access speed using the internet network can be calculated by:

$$Speed = \frac{Jumlah\ Data\ (byte)}{Waktu\ (s)} \quad (1)$$

$$Amount\ Of\ Data = speed\ (bps) x time\ (s) \quad (2)$$

Figure 1 shows the research data collection procedure, starting from determining the sample viewing location point, activating the OpenSignal application to measure speed.*upload, download*And*latency*. Then proceed with looking at the test results, processing and analyzing the data to find out how much*latency*obtained at each monitoring point, so that influencing factors can be known*latency*ithe.

Figure 1. Research Flow Diagram

3. RESULTS

Testing and data collection was carried out with the aim of determining the availability of the 5G network and seeing the extent of latency obtained from each location point where the sampling data was taken. Tests carried out at several locations in the city of Medan include:

- Jalan Abdullah Lubis
- Prof. Street HM Yamin (PT. KAI Medan City)
- Podomoro City Medan
- Medan City Government Service Housing, Jalan Sudirman
- Tobacco Road Perumnas Simalingkar

The data retrieval process is by utilizing the OpenSignal application, where the data retrieval process is by activating the application and viewing the service display via a map, then several BTS will be obtained (*Base Transceiver Station*) as a transmission medium for both the transmitter and receiver, which then moves on to the upload, download and latency features. The measurement results data are shown in Table 1 as follows:

Table 1. Upload, Download and Latency Observation Data

Location	Measurement		
	***Upload*(Mbps)**	***Downloads*(Mbps)**	***Latency*(ms)**
Jalan Abdullah Lubis	28.7	14.8	43
Prof. Street HM Yamin (PT. KAI Medan City)	33.3	17.5	39
Podomoro City Medan	15.5	8.8	63
Medan City Government Service Housing, Jalan Sudirman	34.8	28.2	54
Tobacco Road Perumnas Simalingkar	1.3	3.8	34

*Upload*is the process of placing files/data from one place (server/unit) to another place (server/unit) by utilizing the internet network. Downloading is a process of retrieving/retrieving files/data from one place (server/unit) to another place (server/unit) by utilizing the internet network. Meanwhile Latencyor what is better known as delay is the amount of time needed for a data packet to travel from one point to another [5]

Table 1 shows the results of data speed monitoring during upload, download and latency. So it is known that the highest data speed during upload and download is when data is collected in the Medan City Government Service Housing area, namely Jalan Sudirman, this is because this place/area is the center of government so the 5G network connection is stronger and more stable. Latency in this area is around 54 ms with a data transmission speed of 34.8 Mbps and a data reception speed of 28.2 Mbps.

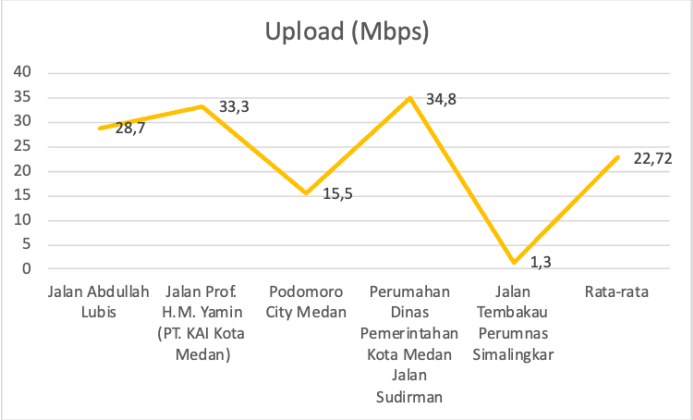

Figure 2. Data Speed Graph during Upload

Figure 2 is a graph of data speed during upload where it is shown that the highest upload data speed is at the Medan City Government Service with a speed of 34.8 Mbps. Then at PT. KAI is also quite high, this can be seen from the data speed obtained, which is around 33.3 Mbps. Jalan Abdulah Lubis recorded a data speed of 28.7 Mbps, Podomoro City Medan obtained a data speed of 15.5 Mbps, while the lowest data speed was on Jalan Tobacco around Perumnas Simalingkar Jalan Tobacco Medan with a data speed of 1.3 Mbps. So it is known that city centers, government areas, industry and services have a more stable and high 5G network connection. The internet network connection using 5G technology in the Perumnas Simalingkar area is slightly low, this is because the 5G network coverage still needs to be improved in that area.

Based on observations for data speed at the time of upload, all places can enjoy the available 5G network connection. So, based on the measurement results, it was found that from several data sampling locations, it was found that the average data speed during upload was around 22.72 Mbps.These results show that the 5G network in Medan City consistently provides significant upload speeds, allowing users to upload content in a shorter time. This high upload speed really supports various cloud-based applications, video conferencing, and other activities that require fast and reliable data transmission. Thus, the existing 5G infrastructure is able to meet user needs for high data speeds and low latency, strengthening Medan City's position as a city with an advanced telecommunications network.

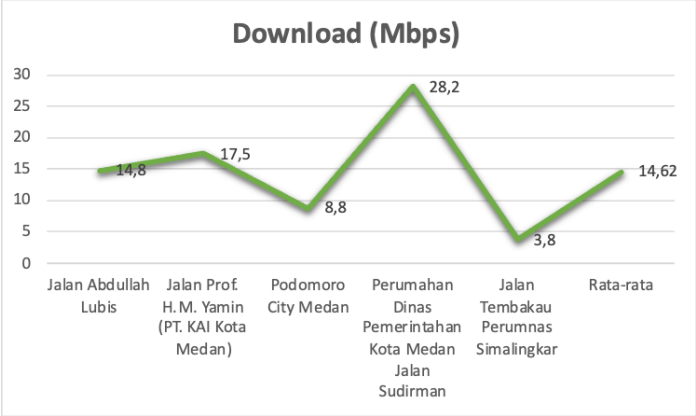

Figure 3. Data Speed Graph during Download

Figure 3 is a graph of data speed during download, where it is shown that the highest download data speed is at the Medan City Government Service with a speed of 28.2 Mbps. Then at PT. KAI is also quite high, this can be seen from the data speed obtained, which is around 17.5 Mbps. Jalan Abdulah Lubis was observed to have a data speed of 14.8 Mbps, Podomoro City Medan had a data speed of 8.8 Mbps, while the lowest data speed was on Jalan Tobacco around Perumnas Simalingkar, Jalan Tobacco Medan with a data speed of 3.8 Mbps. So it is known that city centers, government areas, industry and services have a more stable and high 5G network connection. The internet network connection using 5G technology in the Perumnas Simalingkar area is slightly low, this is because the 5G network coverage still needs to be improved in that area.

Based on observations for data speed during download, it is known that all places can enjoy the available 5G network connection. So, based on the measurement results, it was found that from several data sampling locations, it was found that the average data speed during download was around 14.62 Mbps.These results show that the 5G network in Medan City is able to provide consistent and adequate download speeds in various locations. An average download speed of 14.62 Mbps allows users to access digital content, stream video, and download large files quickly and seamlessly. This is very important in supporting daily activities that depend on fast data access, such as e-learning, remote work and digital entertainment. With strong 5G infrastructure, Medan City is ready to face future technological developments and meet the ever-increasing communication needs in the digital era

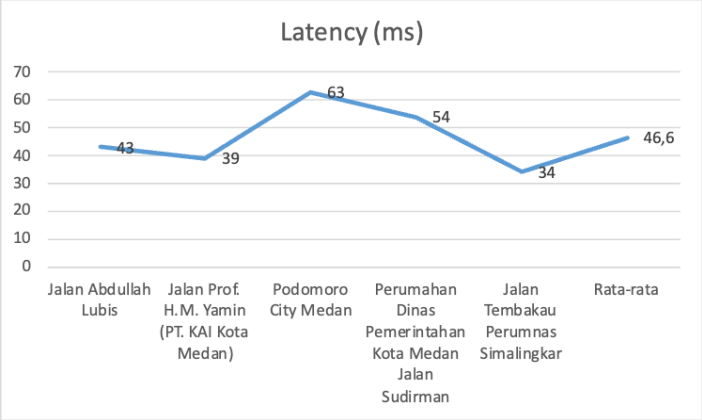

Figure 4. Latency graph

Figure 4 is a graph of latency or better known as delay, where it is shown that the latency at the Medan City Government Service is 54 ms. Then at PT. KAI is obtained around 39 ms. Jalan Abdulah Lubis was monitored at 43 ms, Podomoro City Medan had a latency of 63 ms, while on Jalan Tobacco around Perumnas Simalingkar it was 34 ms.This data shows variations in latency in various locations in Medan City, indicating that even though the 5G network is available, there are differences in performance which may be caused by environmental factors, user density and local infrastructure. Lower latency on Jalan Tobacco and PT. KAI showed better network performance in the area, while higher latency in Podomoro City Medan indicated the need for further optimization to improve service quality. This analysis is important to understand how network performance is distributed across the city and to determine the improvement steps needed to ensure that all users can enjoy optimal 5G services

Based on the measurement results, it was found that from several data sampling locations, the average latency was around 46.6 ms.This value provides a general overview of 5G network performance in Medan City, showing that although there are variations in various locations, the average latency is still within acceptable limits to support real-time applications such as video streaming, online gaming, and video conferencing. By continuously monitoring and optimizing the network, service providers can further improve connection reliability and speed, ensuring a better user experience and supporting further technological developments in the future. This analysis also provides a basis for policy makers and network operators to make infrastructure improvements in areas that show higher latency, so that service quality gaps can be minimized.

Latency is an important factor that influences the quality of 5G network services. Based on measurement results in various locations in Medan City, the average latency is around 46.6 ms. Even though the city's 5G network is available and provides significant download and upload speeds, there are still considerable latency variations between locations. Locations such as Jalan Tobacco show better performance with a latency of 34 ms, while Podomoro City Medan has the highest latency of 63 ms.

These differences indicate the need to optimize and improve infrastructure in certain areas to ensure that all users can enjoy optimal 5G services. Overall, although there are several areas that require further attention, the 5G network in Medan City is already having a positive impact on user experience with fast speeds and relatively low latency. Continuous improvement measures and network optimization strategies will be critical to ensuring that performance remains consistent and reliable across the city.

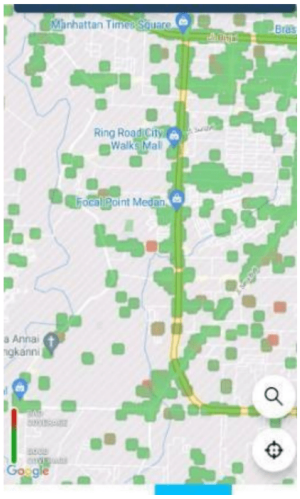

Figure 5 Visualization during the data collection process

Figure 5 shows a map of data sampling locations when we are at the location where the 5G network is available. So this map also shows the available internet network connections and can see connections between BTS devices, both transmitters and receivers. From this map, we can identify areas with strong 5G network coverage as well as areas that still depend on 4G or 4G+ networks. The map also shows the distribution of existing telecommunications infrastructure, providing insight into the distribution of BTS towers and signal strength in various locations. With this visualization, we can better understand how the 5G network is spread across Medan City and where there are still coverage gaps. This is important for planning more effective telecommunications infrastructure development, especially in overcoming areas that have weak connections or high latency. In addition, this map also helps in monitoring connectivity between BTS devices, which is very important to ensure the quality and consistency of 5G network services.

Information from these maps can be used by service providers to determine network upgrade priorities and ensure that investments are made in areas of greatest need. In this way, it is hoped that it can accelerate the full implementation of the 5G network throughout Medan City, providing greater benefits for the community and supporting digital economic growth in the region.

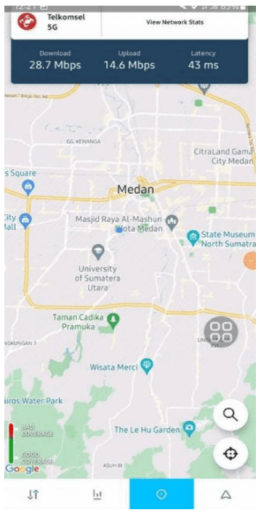

Figure 6. Visualization of data collection on Jalan Abdullah Lubis

Figure 6. Visualization of data collection on Jalan Abdullah Lubis provides a detailed view of network conditions in the area. Through this visualization, data sampling points and the quality of surrounding

connections can be detailed. This information becomes the basis for service providers to evaluate and improve existing networks. From this visualization, it can be concluded that the network connection on Jalan Abdullah Lubis is relatively stable with a measurable latency level. This data is the basis for service providers to determine the corrective steps needed to maintain or improve service quality

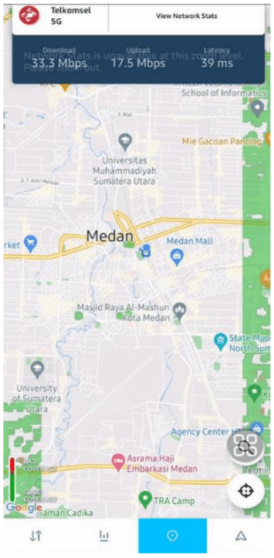

Figure 7. Visualization of Data Collection on Jalan Prof. HM Yamin (PT. KAI Medan)

Figure 7. Visualization of Data Collection on Jalan Prof. HM Yamin (PT. KAI Medan) provided a more detailed description of the network conditions at that location. Using this visualization, we can clearly see the data sampling points and the quality of the connections around them. This information is very valuable for service providers to evaluate and improve existing networks.

From this visualization, it appears that the network connection on Jalan Prof. HM Yamin (PT. KAI Medan) is quite stable with measurable latency levels. This data can be a reference for service providers to decide on corrective or enhancement steps needed to ensure that service quality remains optimal. By keeping these visualizations in mind, service providers can more effectively address network quality issues and ensure a better user experience in those locations.

Apart from that, this visualization also provides a better understanding of connectivity patterns around PT locations. KAI Medan, including network coverage and possible factors influencing service quality. Thus, visualizations like this can be a useful tool in planning and managing telecommunications infrastructure, enabling service providers to make more informed and efficient decisions in improving the quality of network services.

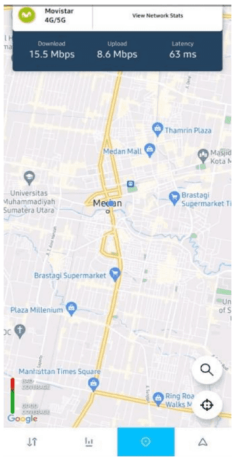

Figure 8. Visualization of Data Collection in Podomoro City

Figure 8. Visualization of data collection in Podomoro City provides a more detailed picture of the network conditions at that location. This visualization shows the data sampling points and the quality of the connections around them clearly. The information presented is very valuable for service providers to evaluate and improve network quality in the area. From this visualization, there appears to be variation in connection stability and latency levels measured in Podomoro City. This can be a basis for service providers to plan the necessary improvement steps to ensure optimal service quality for users in that location.

4. CONCLUSION

Latency is an important factor that influences the quality of 5G network services. Based on measurement results in various locations in Medan City, the average latency is around 46.6 ms. Even though the city's 5G network is available and provides significant download and upload speeds, there are still considerable latency variations between locations. Locations such as Jalan Tobacco show better performance with a latency of 34 ms, while Podomoro City Medan has the highest latency of 63 ms.

These differences indicate the need to optimize and improve infrastructure in certain areas to ensure that all users can enjoy optimal 5G services. Overall, although there are several areas that require further attention, the 5G network in Medan City is already having a positive impact on user experience with fast speeds and relatively low latency. Continuous improvement measures and network optimization strategies will be critical to ensuring that performance remains consistent and reliable across the city.

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