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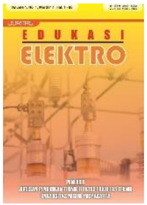

Performance of Chatbot Assistant for Stroke Patients Through Quality of Service Metrics

Azwar Rangga Arasaf (✉), Erika Loniza, Meilia Safitri

Department of Medical Electronics Technology, Universitas Muhammadiya Yogyakarta, Yogyakarta, Indonesia

azwarrangga.05@gmail.com

Abstract— Strokes can impede functioning by disrupting blood circulation, leading to functional deficits that may make communication difficult for stroke survivors. Communication issues can significantly lower the quality of life for stroke patients, who often depend on family and caregivers, who may struggle to understand their needs. A stroke patient communication tool using a chatbot assistant system is needed. This system enables patients and caregivers to communicate remotely without disrupting the caregiver's work. This study aims to assess the effectiveness of communication aid devices for stroke patients when integrated with a chatbot assistant system. It also aims to evaluate network performance through Quality-of-Service testing to ensure optimal connectivity for caregivers. The Quality of Service approach assesses the internet network's quality with the support of the Wireshark application. The average outcome for the delay parameter is 163.243 ms, with a 0% result for the packet loss parameter and a throughput value of 16.236 Kbps. Based on these findings, it achieves a score of 3 in one category and excels in delay and throughput. Concerning packet loss, it scores a four and is considered excellent in this area. Based on the findings related to delay, packet loss, and throughput, an average index of 3.33 has been calculated, indicating a positive outcome for Quality of Service evaluation.

Keywords: stroke, chatbot assistant, quality of service

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1 Introduction

Stroke is a sudden neurological impairment caused by a blockage or bleeding in the blood vessels, causing significant disturbances in blood flow to the brain [1]. The repercussions of such disruptions are varied, covering a wide range of functional impairments that can significantly affect an individual's quality of life. These impairments are classified into three main areas: physical, emotional, and cognitive [2]. Physical limitations often appear as a reduced ability to move or manage different body parts, significantly limiting mobility and self-reliance [3]. Emotional disturbances cover a broad spectrum of psychological and physiological responses, such as depression, anxiety, and mood changes, which can significantly impact the individual's emotional health [4]. On the contrary, cognitive impairments affect the person's capacity to understand information, find solutions, and carry out daily tasks, making it more difficult to manage everyday life [5].

These complex disruptions inevitably result in communication challenges for individuals who have experienced a stroke [6]. Effective communication is essential for human interaction and overall quality of life. Impairments in this area can significantly impact stroke patients, leading to further isolation from their social and support networks [7]. The literature, as demonstrated by a study conducted by Agianto et al., emphasizes the significant impact of familial support and caregivers on improving the post-stroke recovery process and the overall quality of life for these individuals [8]. Nevertheless, communication obstacles significantly impede the caregiver's capacity to understand and address the patient's needs precisely, creating a significant challenge to providing effective care [6][9].

Furthermore, the ongoing nature of caregiving, required by the patient's dependency, frequently conflicts with the personal and professional responsibilities of caregivers. This imbalance may result in caregiver burnout, marked by physical exhaustion and emotional fatigue, ultimately reducing the quality of care and adding more stress to the caregiver-patient relationship [10][11]. This intricate interaction of elements highlights the pressing requirement for creative solutions to close the communication divide between individuals who have had a stroke and those who care for them.

Addressing this pressing need, the emergence of chatbot assistant technology offers a hopeful opportunity to create a communication tool to meet the distinct challenges stroke survivors and their caregiver’s encounter. Through chatbot assistant, a system can be developed to allow remote communication between patients and caregivers, enabling smooth interaction regardless of the caregiver's location [12]. This study seeks to thoroughly assess the effectiveness of chatbot assistant for stroke patients, specifically examining network performance using Quality of Service (QoS) metrics [13]. Quality of Service (QoS) plays a crucial role in network engineering by measuring and guaranteeing the effectiveness, dependability, and general quality of service provision, following the standards set by TIPHON (Telecommunications and Internet Protocol Harmonization Over Networks) [14].

2 Research And Method

The research and methodology employed involve carefully designed experiments with multiple stages. These stages include prototype design, Telegram communication design for sending communication sentence notifications to the prototype, device response testing to examine the range and response of message delivery from the prototype to Telegram, and Quality of Service measurement to assess the quality of the internet network used in the system as depicted in Figure 1.

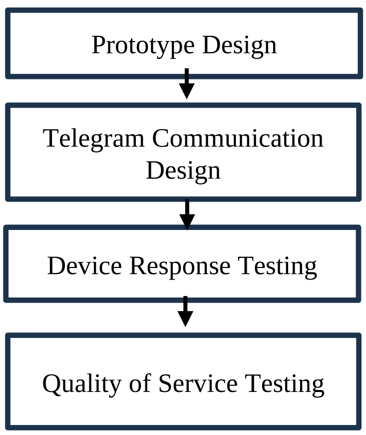


Fig 1. Flowchart research and method

2.1 Prototype Design

Creating a Communication Aid for Stroke Patients prototype requires utilizing multiple technology components to improve communication effectiveness. The prototype utilizes microcontroller boards, with the ESP32 Module as the central component responsible for processing inputs from sensor modules and other essential parts. The prototype can connect to the internet or WiFi networks, allowing it to link with messaging services such as Telegram, as seen in Figure 2.

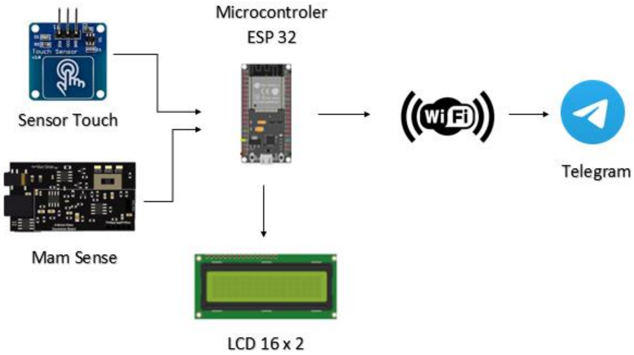


Fig 2. Diagram communication aid for stroke patients

Figure 2 illustrates the prototype's development with two input capabilities: the Mam Sense module and the Touch Sensor. The inputs facilitate the setup of two distinct operational modes in the prototype's menu: Mam Sense mode and Sensor Touch mode. It is essential to have an LCD screen as it displays the data from both inputs, providing a visual interface for user engagement with the device. The input readings can be transmitted to the Telegram application via the Wi-Fi connection established by the prototype. This innovative approach enables individuals who have suffered from strokes to effectively communicate their needs from a remote location, enhancing their ability to interact with caretakers and family members regardless of geographical constraints [15]. The MaM Sense sensor will detect the signal received via the electrodes by monitoring the movement of the eye muscles that generate motion. Figure 3 displays three reading modes: EOG, ECG, and EMG. ABPS employs the electrooculography (EOG) mode provided by Mam Sense. The Mam Sense can be linked to an analog-to-digital converter to obtain the output and generate a digital signal processor. The electrode affixed to the skin's surface detects the signal generated by the movement of the eye muscles during glancing. In order to capture the eye gaze signal, the electrode will be connected to the electrode wire, which is then connected to the apparatus. The measurement technique is depicted in Figure 3.

(a) (b)

Fig 3. Electrode placement for measuring (a) left face and (b) right face

For the Mam Sense sensor to accurately capture the subsequent gesture, it is essential to position it precisely. The electrodes are positioned in the following positions: below the left eye, below the right eye, on the right side of the right eye, below the left eye, and the earlobe[16], as depicted in

Figure 3. There are just four possible eye movements: upward, downward, to the right, and the left. Under the Mam Sense mode, we have categorized these four eye movements as communication phrases: expressing the need to feed, expressing the desire to drink, expressing the desire to bathe, and expressing the desire to use the toilet. The TTP223 touch sensor generates a digital signal. This sensor offers a substitute for tactile communication through finger touch. Select a sentence from the LCD screen and compose a message in the Telegram application using the chosen outcomes. In contrast to the Mam Sense mode, the touch sensor mode allows unrestricted movement control through finger contact. Through the creation of eight communication phrases, including "I Want to Eat," "I Want to Drink," "I Want to Bath," "I Want to Change Clothes," "I Want to Urinate," "I Want to Defecate," "I Feel Hot," and "I Feel Cold," we have established finger touch as a valuable tool for stroke patients in Sensor Touch mode.

2.2 Telegram Communication Design

Telegram's versatility and extensive accessibility as a top-tier cloud-based instant messaging service significantly increase its usefulness for personal communication and technology advancement [17]. Its compatibility with several platforms, such as Android, iOS, Windows Phone, Windows NT, macOS, and Linux, allows a wide range of users to access it, making it an excellent option for developers looking to add instant messaging features to their projects.

The Telegram Bot API is a highly appealing option for developers, especially those involved with hardware and IoT. This interface enables the development of bots that may engage with users via the Telegram app, serving as a smooth connection between human users and automated systems [18]. Connecting the Telegram Bot API with platforms like Arduino offers several opportunities for amateurs, educators, and professionals. It allows for managing simple and complicated prototypes using Telegram, making the development and engagement with automated systems more accessible to a broader audience. Figure 4 illustrates the communication design for stroke patients in the chatbot assistant.

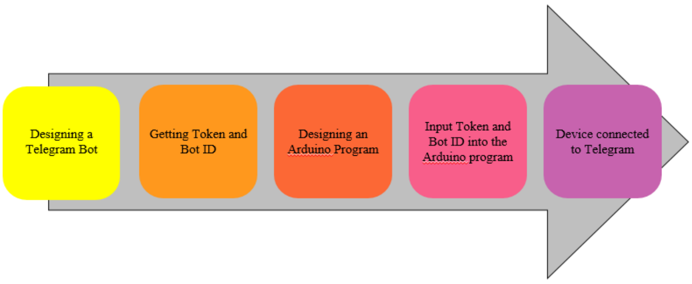


Fig 4. Telegram Communication Design

The design in Figure 4 is intended to establish a connection between the system and the Telegram application on a mobile device by utilizing the Token and Bot ID generated within the Telegram application. Next, enter the Token and Bot ID into the prototype program to establish a connection with the Telegram application designed for communication within this prototype.

2.3 Device Response Testing

The system response testing is conducted by performing two tests: message transmission testing based on distance and measurement of message transmission response time. The message transmission distance testing is carried out by placing the prototype inside the house, specifically in the patient's room. Then, the device/handphone containing the Telegram application intended to send messages is moved away from the prototype according to the specified distance, ranging from 1 meter to 30 meters.

The second test involves measuring the response time of message transmission by measuring the time it takes for a message to be sent from the prototype until it is received on the Telegram application. This measurement of message transmission time is performed using a timing tool, namely a stopwatch. The measurement is conducted by measuring the response time for each selection of communication sentences available on the prototype. There are twelve communication sentences, including four communication sentences in Mam Sense mode, namely "I Want to Eat," "I Want to Drink," "I Want to Bath," and "I Want to go to the Toilet." Furthermore, there are eight communication sentences in Sensor Touch mode, including "I Want to Eat," "I Want to Drink," "I Want to Bath," "I Want to Urinate," "I Want to Defecate," "I Want to Change Clothes," "I Am Feeling Hot," "I Am Feeling Cold". Response time measurements are conducted ten times on each communication sentence so that the average measurement can be calculated using a mathematical formula with Equation 1.

$$Average\ Response\ time = \frac{\sum Response\ Time}{Total\ Packet} \quad (1)$$

2.4 Quality Of Service Testing

Quality of Service (QoS) is a term that describes the total performance of a network or service, with a particular emphasis on the performance that the users of the network experience. By guaranteeing end users obtain optimal performance from network-based applications, quality of service aims to help. A collection of predefined performance characteristics often connected to a service is measured using Quality of Service (QoS). Delay, packet loss, and throughput are used in this study's QoS testing. THIPON is one Quality of Service (QoS) standard created by the European Telecommunication Standards Institute, or ETSI. Table 1 displays the QoS values. The QoS values are highlighted in Table 1 [14].

Table 1. Standard QoS cathegories

Cathegories	*Presentase (%)*	Index
Very Good	95 – 100	3.8 – 4
Good	75 – 94.75	3 – 3.79
Medium	50 – 74.75	2 – 2.99
Bad	25 – 49.75	1 – 1.99

Delay is the duration needed to transfer data from the transmitter to the receiver [19]. Table 2 shows the categories and delay indexes based on THIPON [14].

Table 2. Delay according to THIPON standard

Delay Cathegories	Delay (ms)	Index
Very Good	< 150	4
Good	150 – 300	3
Medium	300 – 450	2
Bad	> 450	1

Mathematically, the value of delay can be calculated using Equation 2 [19].

$$Average\ delay = \frac{\sum delay}{Total\ data\ packets} \quad (2)$$

Packet loss is the failure of one or more data packets to arrive at their intended destination successfully during transmission [19]. Table 3 shows the categories and packet loss indexes based on THIPON [14].

Table 3. Packet loss according to THIPON standard

Packet Loss Cathegories	Packet Loss (%)	Index
Very Good	0 – 2	4
Good	3 – 14	3
Medium	15 – 24	2
Bad	>25	1

Mathematically, the value of packet loss can be calculated using Equation 3 [19].

$$Packet\ loss = \frac{(Package\ Sent - Package\ Receive)}{Package\ Sent} \times 100 \quad (3)$$

The average pace at which a node gathers data throughout the course of an observation period is known as throughput. The effective data transmission rate over a certain time period, as determined by downloading files via a particular internet path, is called throughput [20]. Table 4 displays the categories and throughput indexes according to THIPON [14].

Table 4. Throughput according to THIPON standard

Throughput Categories	Throughput	Index
Very Good	>2.1 Mbps	4
Good	1200 kbps – 2.1 Mbps	3
Medium	700 kbps – 1200 kbps	2
Bad	338 kbps – 700 kbps	1
Very Bad	0 kbps – 338 kbps	0

Mathematically, the value of throughput can be calculated using the formula Equation 4 [21].

$$Throughput = \frac{Amount\ of\ data\ sent}{Data\ transmission\ time} \quad (4)$$

3 Result And Discussion

3.1 Protoype Test and Telegram Communication Design

Device testing is conducted to evaluate the circuitry and synchronization of components, as depicted in Figure 5. The Mam Sense sensor detects EOG signals using electrodes connected to the patient. On the other hand, the Touch Sensor registers the patient's finger touch and transmits the collected data to the Telegram application via Wi-Fi.

Readings are acquired using the touch sensor in Sensor Touch Mode, while the Mam Sense module is utilized in Mam Sense Mode to do the reading procedure. The Mam Sense module utilizes the Electrooculogram (EOG) method to analyze signals obtained from ocular muscle activity. The electrodes are strategically placed on the patient's face: just above the right eye, below the left eye, on the right side of the right eye, on the left side, and below the earlobe [16]. This positioning may be observed in Figure 5 in Mam Sense Mode. These electrode placements enable accurate tracking of eye movements in the left, right, upward, and downward directions. To facilitate communication for stroke survivors, we utilize four specific eye motions to convey four essential sentences. We provide clarification on the direction of eye movement associated with specific desires: rightward for "I Want to Eat," leftward for "I Want to Drink," upward for "I Want to Bathe," and downward for "I Want the Toilet."

(a) (b)

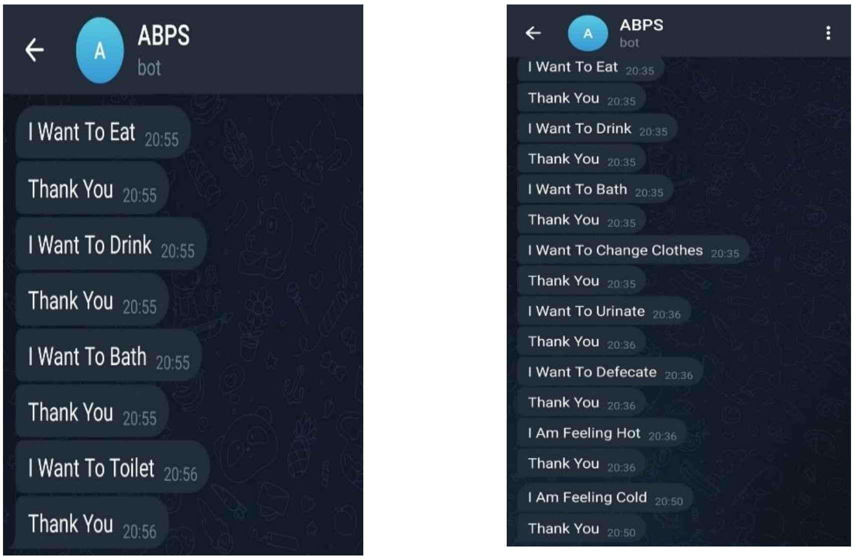
Fig 5. Device testing process for mam sense mode (a) and device testing using touch sensor mode (b)

In Sensor Touch Mode, finger touches are detected and processed using the touch sensor. Figure 6 displays eight communication phrases on the prototype LCD in this mode, with the words automatically transitioning from the first to the eighth. Once patients choose the suitable communication term on the LCD screen, they can activate the Sensor Touch by pressing the touch sensor.

(a) (b)

Fig 6. Display of sentence selection in sensor touch mode (a) and (b)

Once the user has read from the Mam Sense Mode and Sensor Touch Mode, the chosen communication sentences will be transmitted to the Telegram Bot that has been formed. The outcome of the Telegram communication design is the visual interface present in the Telegram program. The interface of the Telegram application, developed using the Telegram Bot, is depicted in Figure 7. This Telegram Bot is utilized to exhibit notification messages of communication transmitted by the Communication Aid for Stroke Patients. The bot created within the Telegram application is programmed to receive and show the prototype's messages accurately. When the prototype sends the communication sentence "I Want to Eat," the Telegram bot reproduces and displays this message precisely as communicated. This functionality is consistently observed in all predefined communication sentences, including the four separate sentences assigned to Mam Sense mode and the eight sentences designated for Sensor Touch mode.



(a) (b)

Fig 7. Telegram notification in mam sense mode (a), telegram notification in sensor touch mode (b)

3.2 Device Response Testing

The device response test is performed to evaluate the outcomes of the system design execution. Tests involved assessing the distance of message transmission from the prototype to the Telegram application and measuring the reaction time of message transmission from the prototype to the Telegram application.

Table 5. Distance testing of message transmission and reception

Distance (meter)	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
1	√	√	√	√	√	√	√	√	√	√
2	√	√	√	√	√	√	√	√	√	√
3	√	√	√	√	√	√	√	√	√	√
4	√	√	√	√	√	√	√	√	√	√
5	√	√	√	√	√	√	√	√	√	√
6	√	√	√	√	√	√	√	√	√	√
7	√	√	√	√	√	√	√	√	√	√
8	√	√	√	√	√	√	√	√	√	√
9	√	√	√	√	√	√	√	√	√	√
10	√	√	√	√	√	√	√	√	√	√
15	√	√	√	√	√	√	√	√	√	√
20	√	√	√	√	√	√	√	√	√	√
25	√	√	√	√	√	√	√	√	√	√
30	√	√	√	√	√	√	√	√	√	√

Based on the test result shown in Table 5, the messages can be successfully transmitted and received within a range of up to 30 meters. The test is performed by sending and receiving messages ten times for each distance parameter consecutively without any breaks during each test.

Table 6. Response time in mode mam sense

Communication Sentences	Test 1 (s)	Test 2 (s)	Test 3 (s)	Test 4 (s)	Test 5 (s)	Test 6 (s)	Test 7 (s)	Test 8 (s)	Test 9 (s)	Test 10 (s)	Avg (s)
I Want to Eat	1.40	1.65	1.58	1.39	1.77	1.7	1.8	1.2	1.68	1.92	1.61
I Want to Drink	1.61	1.78	1.83	1.56	1.56	2.1	1.66	1.9	1.77	1.44	1.72
I Want to Bath	2.51	1.68	1.71	2.07	1.58	1.73	1.77	1.64	1.76	1.85	1.83
I Want Go to Toilet	1.56	1.77	1.45	1.89	1.68	1.44	1.97	1.59	1.86	1.92	1.71

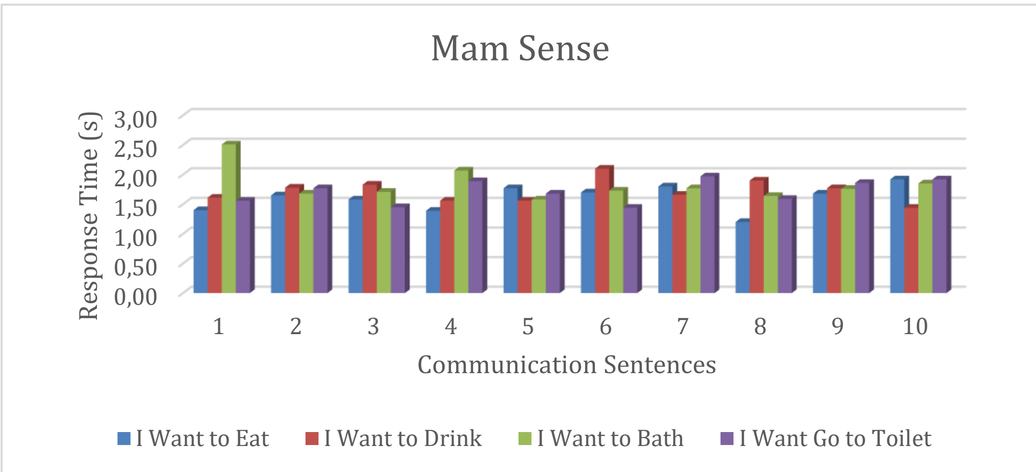


Fig 8. Graph response time testing in mam sense mode

Table 6 and Figure 8 show the response time for message transmission from the prototype to the Telegram application, measured using a stopwatch. The data points demonstrate the effectiveness of the communication aid by presenting the average response times for four different communication sentences. The observed times range from 1.61 seconds to 1.83 seconds. The range demonstrates a consistently quick response, highlighting the prototype's usefulness in enabling fast communication between stroke victims and their caregivers via the Telegram service.

Table 7. Response time in mode sensor touch

Communication Sentences	Test 1 (s)	Test 2 (s)	Test 3 (s)	Test 4 (s)	Test 5 (s)	Test 6 (s)	Test 7 (s)	Test 8 (s)	Test 9 (s)	Test 10 (s)	Avg (s)
I Want to Eat	1.20	1.65	1.58	1.39	1.77	1.7	1.8	1.2	1.68	1.92	1.59
I Want to Drink	1.61	1.78	1.83	1.56	1.56	2.1	1.66	1.9	1.77	1.44	1.72
I Want to Bath	2.51	1.68	1.71	2.07	1.58	1.73	1.77	1.64	1.76	1.85	1.83
I Want to Change Clothes	2.03	1.56	2.17	1.64	1.57	1.62	1.82	1.74	1.89	1.67	1.77
I Want to Urinate	1.25	2.14	1.73	1.67	1.74	1.87	1.11	1.51	1.57	1.8	1.43
I Want to Defecate	2.01	1.59	1.84	1.49	1.86	1.52	1.52	1.55	1.69	1.54	1.66
I Am Feeling Hot	1.46	1.38	1.48	1.66	1.82	1.5	1.46	1.15	1.36	1.47	1.47
I Am Feeling Cold	1.74	1.73	1.69	1.77	1.86	1.13	1.57	1.25	1.74	1.63	1.61

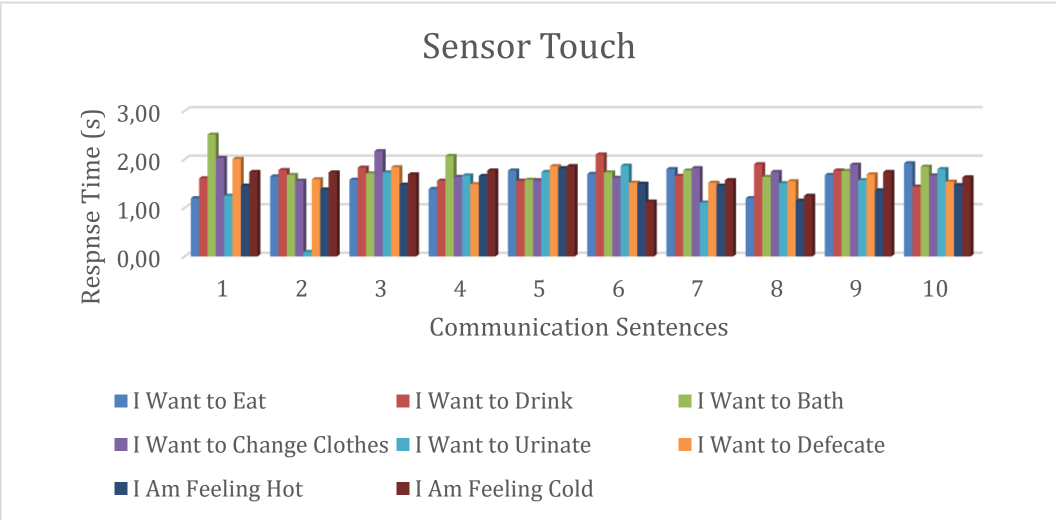


Fig 9. Graph response time in sensor touch mode

The response time range for the eight communication sentences in Table 7 and Figure 9 is 1.43 to 1.83 seconds. The variability in response time for each communication sentence is attributed to the speed of the internet network and errors made by the tester in utilizing a stopwatch during the test.

3.3 Quality Of Service Testing

During the quality of service test phase, data was obtained from data transmission testing from the prototype to Telegram using the Wireshark application, with parameters including delay, throughput, and packet loss. Below is the image and table of the delay testing using Wireshark software, as shown in Figure 10.

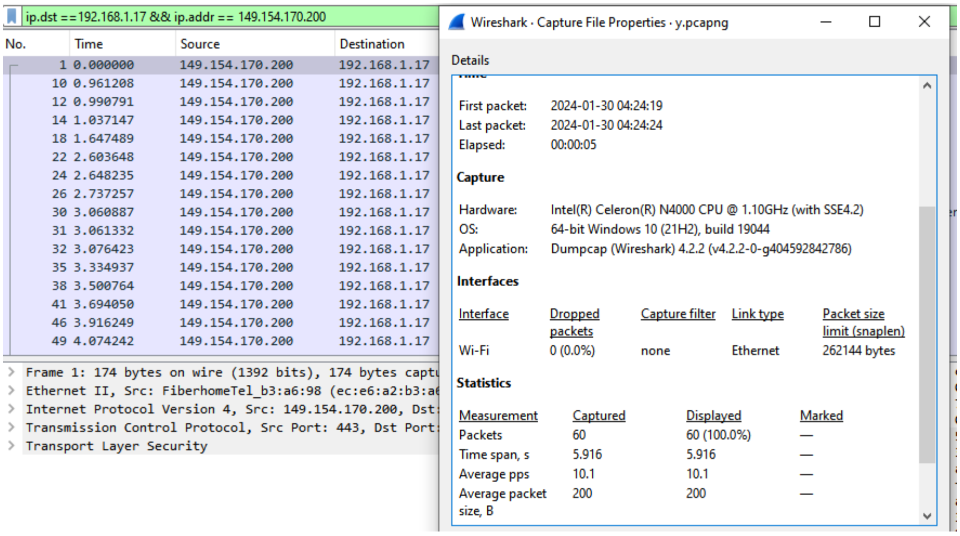


Fig 10. Display of delay testing in wireshark

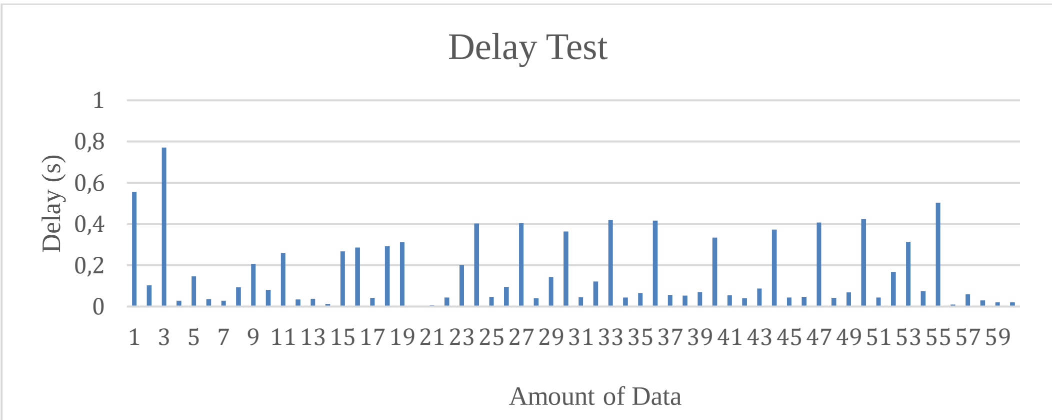


Fig 11. Graph of *delay testing*

Figure 7 and Figure 10 show the result of delay test values, with 60 packet data used for delay testing. Calculations are done using Equation 2 to find the average delay.

$$Average\ Delay = \frac{\sum delay}{Total\ Data\ Packets}$$

$$Average\ Delay = \frac{9.794571}{60}$$

$$Average\ Delay = 0.163243\ \times 1000$$

$$Average\ Delay = 163.243\ ms$$

From the calculations above, the average delay testing result is 163.243 ms. Therefore, the delay testing result falls into the "Good" category and obtains an index of 3 according to the THIPON standard because it falls within the range of 150 ms – 300 ms.

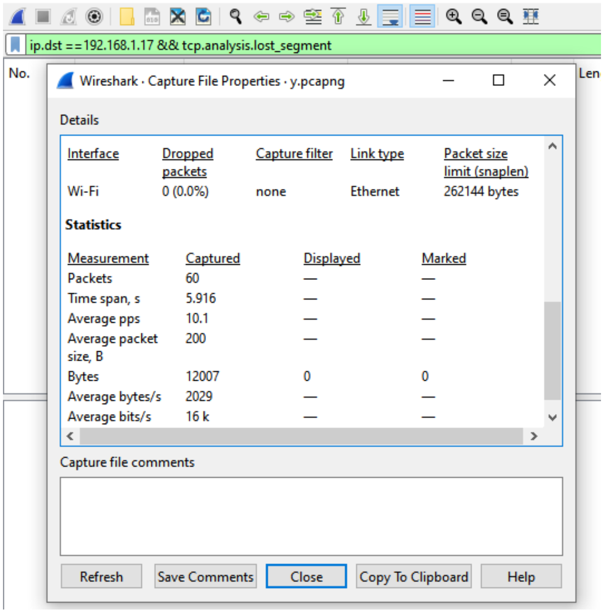


Fig 12. Display of wireshark packet loss properties

Figure 12 shows the results of a network performance examination, confirming that no packets were lost throughout the assessment. Packet loss can be determined with Equation 3.

$$Packet\ loss = \frac{(Package\ Sent - Package\ Recive)}{Package\ Sent} \times 100$$

$$Packet\ loss = \frac{(60-60)}{60} \times 100$$

$$Packet\ loss = \frac{0}{60} \times 100$$

$$Packet\ loss = 0\%$$

Based on the analysis performed using the packet loss test, it shows a 0% loss rate. The packet loss performance is classified as 'Excellent' according to the TIPHON standard criteria. Therefore, this performance level receives a rating of 4 on the TIPHON grading scale, indicating the most excellent network stability and efficiency grade.

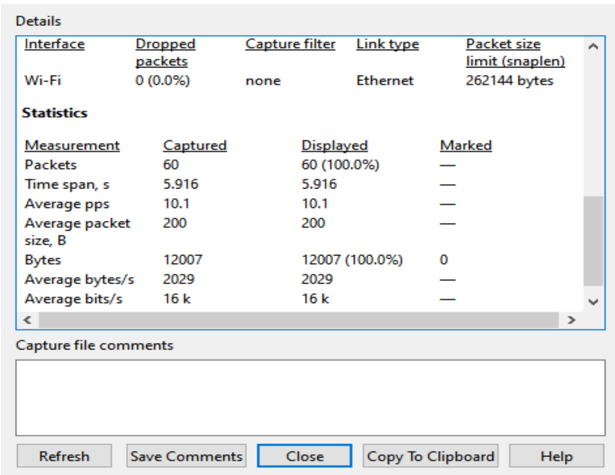


Fig 13. Display of wireshark throughput properties

In Figure 13, the Throughput result in the Wireshark application shows 16k. Besides being visible in Figure 13, the Throughput value can be determined using Equation 4.

$$Throughput = \frac{Amount\ of\ data\ sent}{Data\ transmission\ time}$$

$$Throughput = \frac{Amount\ of\ data\ sent}{Data\ transmission\ time}$$

$$Throughput = 2029.5807978363\ byte/s$$

$$Throughput = 2029.5807978363\ \times 8$$

$$Throughput = 16.236\ kilo\ byte/s$$

From the calculation above, the throughput result is 16.236 kbps. Therefore, the throughput testing result falls into the good category and obtains an index of 3 according to the THIPON standard.

3.4 Discussion

The system response testing for the designed prototype shows that it can reliably send and receive messages through Telegram in 10 trials, with an operational range of up to 30 meters. This feature is enabled by connecting the prototype to an internet network optimized for long-distance message transmission, while the mobile device running the Telegram application is also linked to any accessible internet network. The testing technique used Mam Sense mode to measure response times, resulting in an average response time of 1.2 seconds, with individual response times varying from 1.61 to 1.83 seconds. The Sensor Touch mode had response times ranging from 1.43 to 1.83 seconds, with an average of 1.63 seconds.

This study utilizes a Quality of Service (QoS) enhancement approach that follows the TIPON standard. The assessment of the network's performance based on this criterion uncovered the following: The delay parameter is 163.243 ms, categorized as 'Good' with an index of 3. The packet loss rate is 0%, defined as 'Very Good' with an index of 4. The throughput is 16236.646 kbps, likewise described as 'Good' with an index of 3. The assessments are founded on the THIPON standard.

An aggregate Quality of Service (QoS) score was produced by averaging the indices of three parameters: Delay, Packet Loss, and Throughput. The final QoS score of 3.33 is classified as 'Good' based on the THIPON standard, as shown in Table 8. This thorough assessment highlights the prototype's effectiveness and trustworthiness in enhancing communication, especially for applications like communication assistance for stroke patients, where prompt and reliable message delivery is essential.

Table 8. Quality of service value

No	Quality of Service	Description	
		Cathegories	***Index***
1	Delay	Good	3
2	Packet loss	Very Good	4
3	Throughput	Good	3
Avarage		Good	3.33

4 Conclusion

This study aims to assess the effectiveness and network performance of a prototype of an IOT-enabled communication aid for stroke patients. The conducted tests on the designed prototype provide critical insights into its performance, focusing on message transmission range, response times, and Quality of Service (QoS) according to THIPON standards. The prototype successfully transmits messages up to 30 meters, showcasing its effective range. Regarding response time, Mam Sense mode averages between 1.61 and 1.83 seconds, while Sensor Touch mode ranges from 1.43

to 1.83 seconds, indicating slightly faster responsiveness in Mam Sense mode. Quality of Service testing outcomes align with THIPON standards, achieving a 'Good' category with an average index of 3.33 across delay, packet loss (notably 'Very Good' with an index of 4), and throughput metrics. These results affirm the prototype's efficacy and reliability as a communication aid for stroke patients, demonstrating robust message delivery capabilities, prompt responsiveness, and high service quality within its operational context.

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6 Authors

Azwar Rangga Arasaf is an active student of the Electro-Medical Technology Study Program of Muhammadiyah University of Yogyakarta. Born in Wonosobo on the stairs 17 Januari 2003 (email: azwarrangga.05@gmail.com).

Erika Loniza received a Bachelor of Engineering degree from the Department of Electrical Engineering Universitas Muhammadiyah Yogyakarta in 2006, a Master's Engineering degree from the Department of Electrical and Information Technology Engineering, Universitas Gajah Mada Yogyakarta, Indonesia in 2016. She is a lecturer in the Department of Electromedical Engineering, Vocational Program, Universitas Muhammadiyah Yogyakarta, Indonesia. Her research interests are electrical engineering, instrumentation, and control (email: erika@umy.ac.id).

Meilia Safitri is a lecturer in Department of Medical Electronics Technology, Vocational Program, Universitas Muhammadiyah Yogyakarta. Born in Krui on May 12th, 1990, (email: meilia.safitri@vokasi.umy.ac.id).