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Implementation of Two-Way Voice and Text Communication System Using Fiber Optic Media

Hendro Darmono[1], Simon Calvin Pribadi [2], Yoyok Heru Prasetyo Isnomo[3]

[1,2,3] Program Study of Digital Telecommunication Networks
Department of Electrical Engineering, State Polytechnic of Malang, Malang, Indonesia

[1]hendrodarmonoo@gmail.com, [2]simoncalvinpma@gmail.com, [3]yoyok.heru@polinema.ac.id

Abstract— **In this technology age, people's need for communication systems is growing. In various places and conditions, communication must be maintained to meet various needs. One of the solutions required in these circumstances is an optical fiber communication system. Fiber optic cable is a light-based data transmission technique. The advantages of optical transmission include the fact that the light spectrum does not spread like radio frequencies, making it impossible to intercept, the fact that it propagates at a very high speed, allowing it to go very large distances, and the ease with which it may be installed. To tackle this problem, we proposed to innovate by realizing and developing a two-way voice and text communication system using fiber optic cable media. The voice and text communication system created and deployed in this study is based on an Android application. This communication system does not require a server and internet network. Only Android smartphones, access points, fiber media converters, and fiber optic cables are required. The greatest throughput value measured by the system is 2708 bytes/second, while the lowest is 1020 bytes/second. The longest delay is 2.314 seconds, while the shortest is 1.99 seconds. In terms of packet loss, the value is 0%.**

Keywords— **Communication System, Fiber Optic, Fiber Media Converter, Bending, Quality of Service.**

I. INTRODUCTION

People's need for a communication system is increasing in this technological era. In various places and conditions, communication must be maintained to meet various needs [1]. Communication services are a basic need for people in the current era of globalization [2][3]. Today's communication services are growing and sophisticated. However, the limitations of the development of high-tech communication systems have caused regional inequality and the people who can enjoy these services. Technology that can be used in areas that high-tech communication services have not reached can use radio technology [4][5][6].

Radio is a technology used to transmit signals using modulation and electromagnetic waves. These waves pass and propagate through the free air. However, radio technology has limitations to reach certain areas such as mountainous and hilly areas. In addition, the available radio frequency spectrum is also very limited [7]-[10].

An optical fiber communication system is one of the solutions needed in these conditions. Fiber optic cable is a technology for transmitting data using light. The data sent can be in the form of voice, text, video, and others. The light sources that are widely used are Lasers and Light Emitting Diodes (LED) [11]-[14]. The advantages of optical transmission are that the light spectrum does not spread like radio frequencies, so it cannot be intercepted and propagates at a very high speed to travel very long distances, and its installation is easy [15][16]. Given the several weaknesses of these radio waves, the researcher wants to innovate by realizing and developing a two-way voice and text communication system using fiber optic cable media that can be implemented for portable communication devices in remote areas that cannot be accessed by communication access.

A. Fiber Optic

Optical fiber is a transmission line or a kind of cable made of glass or plastic that is very smooth and smaller than a hair and can be used to transmit light signals from one place to another can be shown in Figure 1.

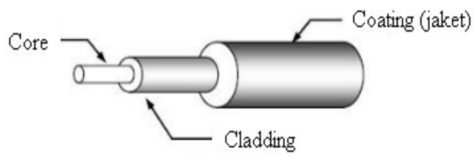

Figure 1. Basic structure of fiber optic

The structure of the optical fiber consists of:

1. Core.
   The most important part is called the core, where the light waves sent will propagate and have a refractive index greater than the second layer—made of glass with a diameter between 2µm-125µm, in this case depending on the type of optical fiber.
2. Cladding.
   The cladding function is like a mirror, which reflects light so that it can propagate to the other end. With this cladding, light can propagate in the fiber optic core. The cladding is made of glass with a lower refractive index than the core. Cladding is the sheath of the core. The cladding diameter is between 5µm-250µm, the refractive index relationship between the core and the cladding will affect the light propagation in the core (that is, it affects the critical angle).
3. Coating.
   The coating serves as mechanical protection on optical fiber, and color coded identity is made of plastic material. It serves to protect the optical fiber from damage.

B. Fiber Optic Working Principle

The working principle of optical fiber is shown in Figure 2 with the following explanation:

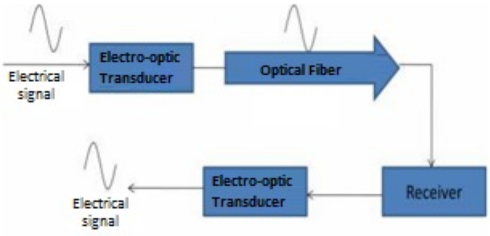

Figure 2. Fiber optic working principle

1. The initial signal/source in the form of an electrical signal at the transmitter is converted by an electrooptic transducer (Diode/ Laser Diode) into light waves.
2. The light wave is then transmitted through the fiber optic cable to the receiver, located at the other end of the optical fiber.
3. At the receiver/receiver, this optical signal is converted by an optoelectronic transducer (Photodiode/ Phototransistor) into an electrical signal again.

In the optical signal from the transmitter to the receiver, there will usually be light attenuation along the optical cable, cable connections, and connectors in the device. Therefore, if the transmission distance is far, one or more repeaters are needed to amplify light waves that have experienced attenuation along their journey.

C. Fiber Media Converter

A fiber media converter is a network device that can connect two different types of networks through media such as twisted pair with fiber optic cable. This technology was introduced to the industry almost three decades ago and had an important role in the interconnection process between fiber optic and copper-based networks in structured cabling systems. The fiber optic media converter supports various data communication protocols, including ethernet to fiber converter, fast ethernet, gigabit ethernet media converter T1 / E1 / J1, DS3 / E3, as well as several cable types such as twisted pair, multi-mode, and single-mode fiber optics.

Fiber optic media converter is a small device and PC card converter with a chassis system that offers advanced features for network management. Fiber optic media converter works by using the SNMP system (Simple Network Management Protocol) and then connecting to the LAN (Local Area Network) by modifying different media. While extending the LAN coverage to multiple locations, this optical media converter that connects spans to multiple locations up to 165 km with 1660 nanometer optics. The fiber media converter is shown in Figure 3.

Figure 3. Converter fiber optic

II. METHOD

A. System Description

The design that will be made in this research will be shown in Figure 4.

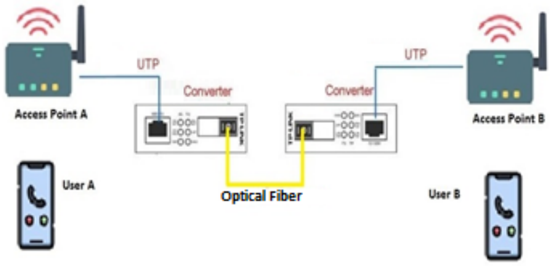

Figure 4. Proposed system design

The block diagram of the system design will explain the flow carried out during the research, including the following:

1. They are installing the Voice and Text application on each user's cellphone. Next, the user connects the cellphone to the local network already available (the user is connected via an access point) to run the Voice and Text application. Mobile phones that are already connected to the local network can run applications that have been made to communicate.
2. The local network or access point is connected using a fiber optic cable through a fiber media converter. Users send voice or text to other users point-to-point. For example, user A connected to access point A wants to communicate with user B, who is connected to access point B. Access points A and B are connected via fiber media converter using fiber optic cable media.

B. Application Design

The following is the design of the application display that will be made in this study. Figure 5 shows the initial appearance of the Voice and Text application, where there is a column to fill in the user name.

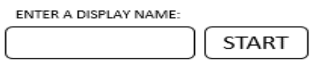

Figure 5. First page application

Furthermore, Figure 6 shows the design of the application display after the user enters a name and presses the start button. The design of this display will display 3 buttons, namely the update, call, and message buttons.

Figure 6. Second page application

Figure 7 shows the design of the application display after the user presses the update button.

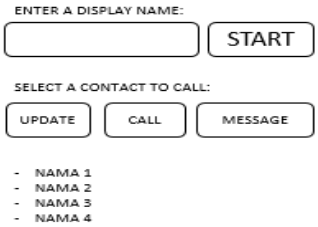

Figure 7. Update page

Then Figure 8 shows the design of the application display when the user has pressed the call button to connect to another intended user to make a voice call.

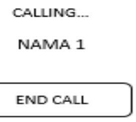

Figure 8. Calling page

Furthermore, Figure 9 shows the design of the application display when there is an incoming call. In this display, there are several buttons, namely the accept, reject, and end call buttons.

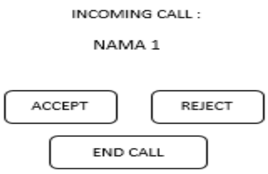

Figure 9. Login Page

Figure 10 shows the display design when one user with another user sends text messages to each other.

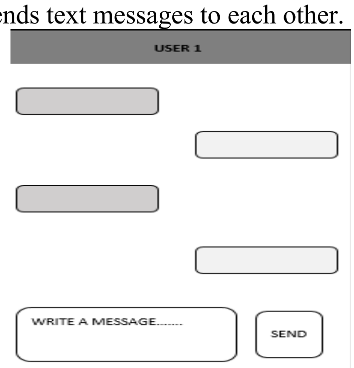

Figure 10. Chat page

C. Research Procedure

The research procedure is a series of activities carried out during research regularly and systematically. The whole system procedure can be explained through a flowchart to clarify the procedure process of the whole system when it runs. The flowchart of the system will be explained in the procedure to be made, which is shown in Figure 11.

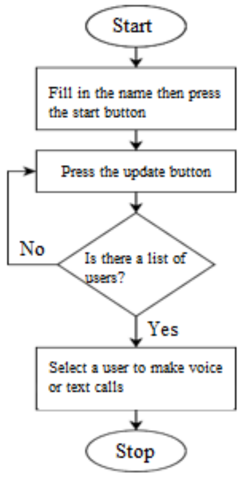

Figure 11. Flowchart Application

Based on the flow chart of the operating procedure in Figure 11, it can be explained as follows:

1. First, the user must enter the application that has been designed, then fill in the name column that is already available.
2. After the user enters the name, the user then presses the start button so that the entered name can be saved.
3. Then the user presses the update button to see a list of other users that have been saved. Names that have been saved will be broadcast once every one minute.
4. If the user list has appeared, the user will choose one other user name to communicate.
5. To communicate by voice, the user presses the call button, while to communicate by text, the user presses the message button.

D. Experiment Testing Method

The data collection design is presented in Figure 12. The data to be taken include the success of voice and text communication, the quality of network performance based on Quality of Service, the effect of bending fiber-optic cables on the quality of network performance. The flow of data collection shown in the block diagram in Figure 12 can be explained as follows:

1. The first procedure is to install the Voice and Text application on each user's android smartphone. After the installation process is complete, each user connects the Android smartphone to an existing network through a different access point.
2. After connecting to a different access point, each user can make calls by voice or text. User 1 will make the first call to user 2. The network performance quality will be calculated for each voice call and communication via text, namely delay, throughput, and packet loss.

Furthermore, the fiber optic cable will be bent using a bending module with a diameter of 5 cm, 4.5 cm, 4 cm, 3.5 cm, 3 cm, 2.5 cm, 2 cm, 1.5 cm, 1 cm, and 0.5 cm for 10 turns. Every time you bend with different diameters, network performance data will be taken based on Quality of

Service, then the data will be compared, analyzed, and concluded.

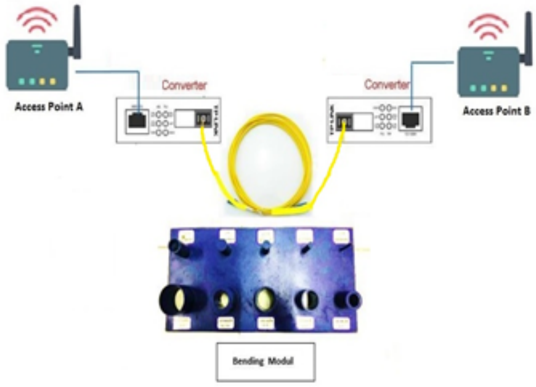

Figure 12. Measurement experiment

III. RESULTS AND DISCUSSION

The results of the system planning consist of the results of the implementation of software and hardware. Furthermore, to test the tools that have been implemented, we need to test and measure several predetermined parameters.

A. Hardware Implementation

The result of hardware implementation is the result of hardware design used for two-way voice and text communication systems. The hardware used functions as a transmission medium and an interface to connect two users at two different points. If there is no hardware, the software or android application cannot be used to communicate. The results of the hardware implementation are shown in Figure 13.

The result of hardware implementation consists of two access points and two fiber converters. The android application/software created cannot be used without hardware. To communicate, Android phones must be connected via an access point network.

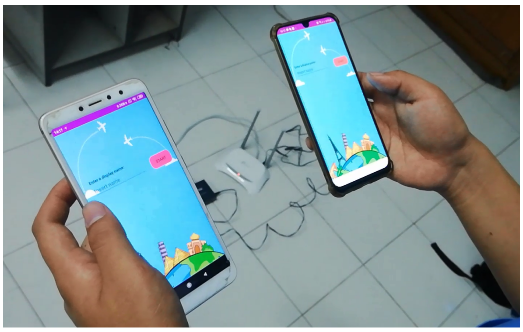

Figure 13. Hardware and software implementation.

Then the access point is connected to the fiber media converter. Fiber media converter converts electrical signals into light signals and converts light signals back into electrical signals. The optical fiber used as the transmission medium is a single-mode optical fiber with a length of five meters and uses an SC-SC connector. There are two fiber optic cables used. One cable connected to the transmitter port of fiber media converter A is connected to the receiver port of fiber media converter B. Furthermore, vice versa, the cable connected to the transmitter port of fiber media converter B is connected to the receiver port of fiber media converter A.

B. Software Implementation

The result of the software implementation is the result of designing an android application for a two-way voice and text communication system. Applications made on Android phones are applications that can communicate by voice and text. This application facilitates communication between users without using pulses or paid internet networks anywhere as long as the communication location is connected to an available access point. This application does not use a server to make the communication process more practical. The results of the implementation of the android application are shown in figure 14 to figure 20.

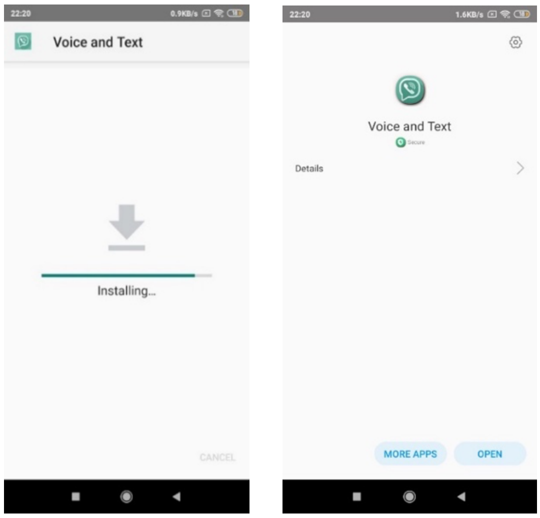

Figure 14. Installation result on android smartphone

Figure 15. Initial screen before the user enters a name and presses the start button.

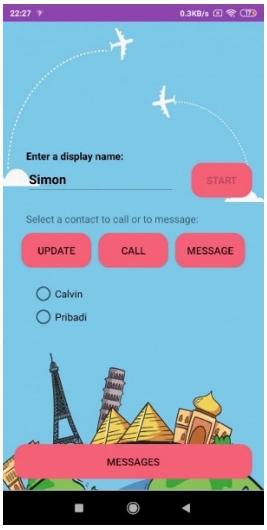

Figure 16. The display after the user fills in the name and presses the start button, then presses the update button to find out a list of other users that connected to the same network

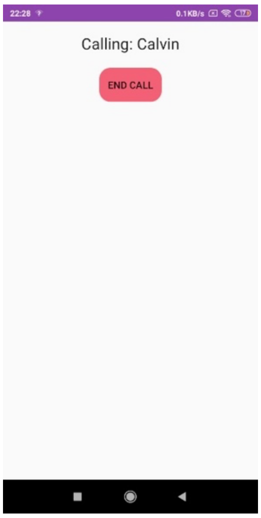

Figure 17. Display when the user makes a call

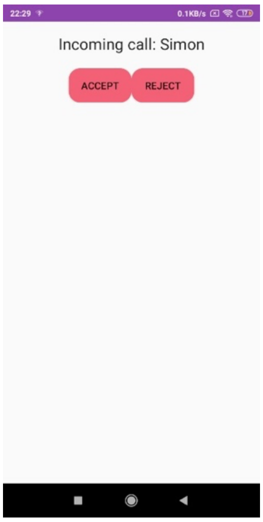

Figure 18. Display when the user is receiving an incoming call

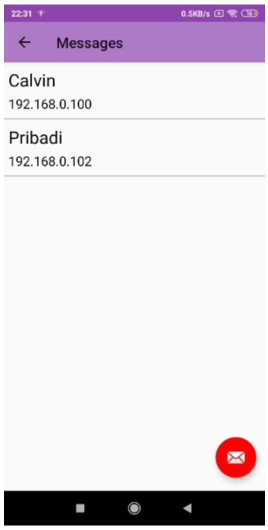

Figure 19. Display a list of incoming messages from various connected users

Figure 20. Display when one user with another user sends text messages to each other

C. *Fiber Media Converter Test*

The table I below shows the results of the output power measurement based on the test results.

TABLE I. FIBER MEDIA CONVERTER OUTPUT POWER MEASUREMENT RESULTS

Bending Diameter	Fiber Media Converter Output Power A	Fiber Media Converter Output Power B
without Bending	-11.43 dBm	-12.26 dBm
5 cm	-11.46 dBm	-12.27 dBm
4.5 cm	-11.54 dBm	-12.35 dBm
4 cm	-11.63 dBm	-12.50 dBm
3.5 cm	-11.66 dBm	-12.51 dBm
3 cm	-11.69 dBm	-13.03 dBm
2.5 cm	-11.75 dBm	-13.14 dBm
2 cm	-11.98 dBm	-13.26 dBm
1.5 cm	-13.70 dBm	-14.98 dBm
1 cm	-14.83 dBm	-15.79 dBm
0.5 cm	-46.34 dBm	-50.00 dBm

Based on Table I, a graph can be made to determine the relationship or effect of bending optical fiber cable on the power transmitted by the fiber media converter. The following is a graph illustrating the effect of bending on the output power shown in Figure 21.

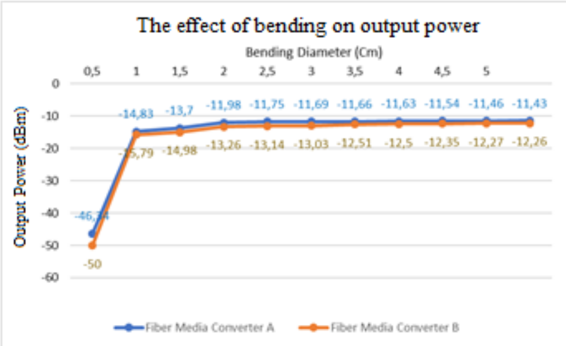

Figure 21. Bending vs power

Based on Figure 21, it can be seen in the graph that the x-axis shows the bending diameter, and the y-axis shows the output power. The smaller the bending diameter of the cable, the output power transmitted by the fiber media converter decreases both the output power on media converter A and the output power on media converter B. When the cable is bent with a diameter of 1 cm, 1.5 cm, 2 cm, 2.5 cm. , 3 cm, 3.5 cm, 4 cm, 4.5 cm, and 5 cm, the output power transmitted by the fiber media converter is only slightly reduced and not drastically reduced. The power transmitted by media converter B is smaller than media converter A. This may be due to losses in the cables and media converter devices. In the datasheet of the media converter, it is not stated how much power the device can transmit and receive.

Furthermore, when the cable is bent with a diameter of 0.5 cm, the output power transmitted by the fiber media converter is drastically reduced, even to the point of loss. This causes the fiber media converter A cannot be connected to the fiber media converter B. So the communication line is cut off and cannot communicate using voice or text.

D. Throughput Measurement Results

The table II below shows the results of the throughput measurement based on the test results.

TABLE II. THROUGHPUT MEASUREMENT RESULTS

Bending Diameter	Throughput (Byte/Second)		
	Side Bending A	Side Bending B	Side Bending A and B
without Bending	1920	1920	1920
5 cm	1680	1500	1260
4.5 cm	2040	1980	1080
4 cm	1440	1175	1020
3.5 cm	2400	1786	1680
3 cm	1380	1150	1081
2.5 cm	1860	1800	1800
2 cm	2708	2280	1920
1.5 cm	1850	1380	1260
1 cm	2460	2160	1800
0.5 cm	Not detected	Not detected	Not detected

Based on Table II, a graph can determine the relationship or effect of bending optical fiber cable on the throughput value. The following is a graph illustrating the effect of bending on throughput shown in Figure 22.

Based on Figure 22, it can be seen that the x-axis shows the bending diameter, and the y-axis shows throughput in bytes per second. When the cable is not bent or bent with diameters of 1 cm, 1.5 cm, 2 cm, 2.5 cm, 3 cm, 3.5 cm, 4 cm, 4.5 cm, and 5 cm, the highest throughput value is obtained when bending 2 cm. and the lowest value is obtained when bending 3 cm. Overall, bending with a diameter of 1 cm to 5 cm does not affect the amount of throughput. Performance quality for voice and text communication is quite good.

When given three different treatments, namely bending on side A, bending on side B, and bending on sides A and B, the throughput value will differ for each treatment. When bending on side B, the throughput value decreases compared to bending on side A and sides A and B. The throughput value decreases compared to bending on side B. So the throughput value when bending side A > bending side B > bending sides A and B.

Furthermore, when the cable is bent with a diameter of 0.5 cm, the throughput parameter is not detected or cannot be measured because when the cable is bent with a diameter of 0.5 cm, the communication line is cut off so that no voice or text information is sent.

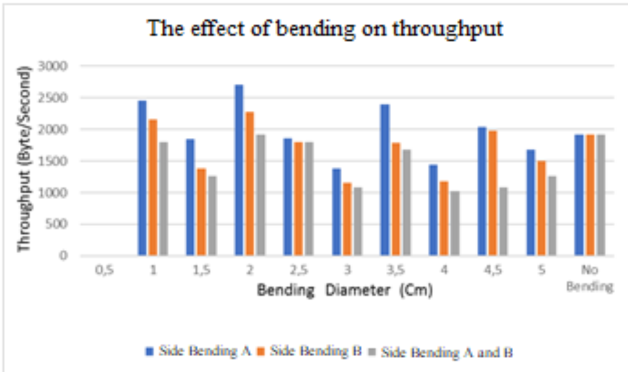

Figure 22. Bending vs Throughput

E. Delay Measurement Results

The table III below shows the findings of the delay measurement based on the test results.

TABLE III. DELAY MEASUREMENT RESULTS

Bending Diameter	Delay		
	Side Bending A	Side Bending B	Side Bending A
without Bending	2,001 second	2,001 second	2,001 second
5 cm	1,996 second	2,001 second	2,101 second
4.5 cm	2,00 second	2,001 second	2,122 second
4 cm	1,997 second	2,085 second	2,121 second
3.5 cm	2,052 second	2,106 second	2,145 second
3 cm	1,998 second	2,09 second	2,314 second
2.5 cm	2,002 second	2,002 second	2,003 second
2 cm	2,00 second	2,001 second	2,002 second
1.5 cm	1,99 second	2,001 second	2,002 second
1 cm	1,99 second	2,05 second	2,11 second
0.5 cm	Not detected	Not detected	Not detected

Based on Table III, a graph can determine the relationship or effect of bending optical fiber cable on delay. The following is a graph illustrating the effect of bending on delay shown in Figure 23.

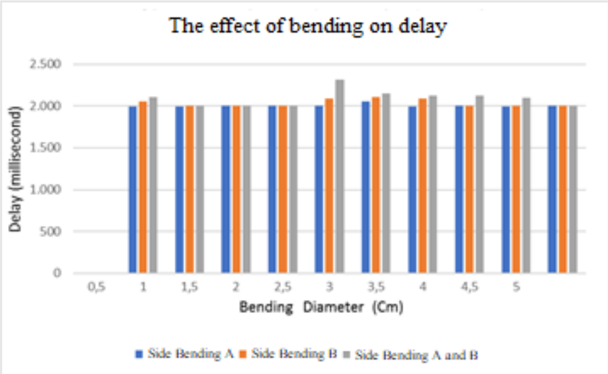

Figure 23. Bending vs Delay

Based on Figure 23, it can be seen that when the cable is not bent or bent with diameters of 1 cm, 1.5 cm, 2 cm, 2.5 cm, 3 cm, 3.5 cm, 4 cm, 4.5 cm, and 5 cm, the delay value The results obtained tend to be stable and almost the same so that there is no significant difference. Overall, bending with a diameter of 1 cm to 5 cm does not affect the amount of delay. Performance quality for voice and text communication is quite good.

When given three different treatments, namely bending on side A, bending on side B, and bending on sides A and B, the delay value will differ for each treatment. When bending on side B, the delay value increased compared to bending on side A, and when bending on sides A and B, the delay value increased compared to bending on side B. So the value of delay when bending side A < bending side B < bending sides A and B.

Furthermore, when the cable is bent with a diameter of 0.5 cm, the delay parameter is not detected or cannot be measured because when the cable is bent with a diameter of 0.5 cm, the communication line is cut off so that no voice or text information is sent.

E. Packet Loss Measurement

The following is a table of packet loss measurement results based on the test results shown in Table IV.

TABLE IV. PACKET LOSS MEASUREMENT RESULTS

Bending Diameter	Packet Loss		
	Side Bending A	Side Bending B	Side Bending A
without Bending	0%	0%	0%
5 cm	0%	0%	0%
4.5 cm	0%	0%	0%
4 cm	0%	0%	0%
3.5 cm	0%	0%	0%
3 cm	0%	0%	0%
2.5 cm	0%	0%	0%
2 cm	0%	0%	0%
1.5 cm	0%	0%	0%
1 cm	0%	0%	0%
0.5 cm	Not detected	Not detected	Not detected

Based on Table IV, when the cable is not bent or bent with diameters of 5 cm, 4.5 cm, 4 cm, 3.5 cm, 3 cm, 2.5 cm, 2 cm, 1.5 cm, and 1 cm, the packet loss values obtained are is 0% or no packets are lost at all. This is because the data packets sent are small packets. After all, they only contain voice and text information in contrast to information signals in videos or other files that require large data packets to wrap the information to be sent.

Furthermore, when the cable is bent with a diameter of 0.5 cm, the packet loss value is not detected or cannot be measured because when the cable is bent with a diameter of 0.5 cm, the communication line is cut off so that no voice or text packets are sent.

IV. CONCLUSION

A two-way voice and text communication system using fiber optic media is implemented using an android application to send and receive voice and text. Android devices are connected via an access point. Then from the access point connected to the fiber media converter to be transmitted using fiber optic cable transmission media. The quality of network performance based on Quality of Service on voice and text communication systems is measured using throughput, delay, and packet loss parameters. Based on the test results, the highest throughput value is 2708 bytes/second, and the lowest is 1020 bytes/second. Then the highest delay value is 2.314 seconds, and the lowest is 1.99 seconds. Next, the value of packet loss is 0%. The effect of optical fiber bending on the quality of network performance in voice and text communication systems does not significantly affect the bending diameter of 5 cm, 4.5 cm, 4 cm, 3.5 cm, 3 cm, 2.5 cm, 2 cm, 1.5 cm and 1 cm. However, bending with a diameter of 0.5 cm is very influential on network performance quality because the Quality of Service parameter is not detected. After all, the power transmitted by the fiber media converter is lost so that the communication line is lost.

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