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Leaky Feeder as A VoIP Transmission Medium

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ABSTRACT

VoIP (Voice over Internet Protocol) is a technology that allows its user to transmit voices using an internet network, although the technology uses the internet as its transmission medium VoIP still uses cable for most of its applications resulting in complicated cable management if not managed properly, this method can be optimized via wireless transmission for more efficient mobility and system configuration. This research aims to find out the capabilities of Leaky Feeder cable as a medium for VoIP transmission. A leaky feeder system consists of a single cable that runs along its designated space. This cable has gaps that allow the radio signal to leak into or out of the cable along its entire length meaning it can cover a larger area than the usual point-to-point transmission using cable. The parameters observed in particular are Signal Strength, Bit Rate, Packet Loss, Delay, and Throughput, the data obtained is taken quantitatively and its average value is calculated to ensure the system efficiency. Signal Strength trial shows an average value of -60.25 dBm, while also having an uplink and downlink of each 14.86 Mbps and 12.79 Mbps, Bit Rate trial shows that the more clients are served the less bandwidth each client will have , The Packet Loss trial shows an outstanding 0.71% loss, the delay trial shows an average of 20.5ms delay with -40dbm signal quality, and finally Throughput trial shows the highest value at 388Kbps when performing one call with -65dbm signal quality . This shows that the application of Leaky Feeder cable use on VoIP transmission is in a good category. Using Leaky Feeders in buildings can also reduce the number of Access Point installations required to cover the same area.

Keywords: *Leaky Feeder, Wireless LAN, VoIP, Signal Strength*

1. INTRODUCTION

The ability to communicate, coordinate quickly and easily is something that must be possessed by an agency, this is where the use of VoIP technology becomes popular [1], a technology that allows its users to connect with any client when connected to the internet network, this technology generally uses a Local Area Network (LAN), where each client is connected using an Ethernet cable as a transmission medium [2]. However, over time the use of cables as a local transmission medium is considered less efficient because of the large number of cables used, causing a financial burden on institutions that still use this method, with this problem the use of Wireless technology is the solution,

In its application, Wireless Local Area Network technology still has several shortcomings, including range, although this technology is increasingly practical, it has a limited effective range to be able to provide optimal service, the propagation of radio waves produced has Line of Sight (LOS), so that the presence of walls or other obstructing materials is a disadvantage for its propagation [3], WLAN networks, especially inside buildings, will require the installation of several radio devices (access points) to be able to reach all parts of the building [4].

Reviewing current communication technology, there is one technology that is rarely implemented in public institutions, namely leaky feeder, leaky feeder is a communication system that is often used in mining areas, consisting of cables that can transmit radio signals throughout the installation, reducing the amount of hardware needed for communication while increasing

efficiency, with the transmission system using leaky feeder WLAN technology can spread signals more effectively, creating a more efficient VoIP communication system for use.

2. LITERATURE REVIEW

2.1 Previous Research

The research conducted by VPA Santos entitled "Indoor Signal Coverage of a Leaky Feeder Cable". Explains the use of leaky feeder cables for communication in emergency stairs by studying the behavior of signals in corridors / hallways throughout the building examining the signal strength under the cable and outside the cable [5].

Previous research was conducted by Abdellah Chehri, Hussein Mouftah entitled "Radio Channel Characterization Through Leaky Feeder for Different Frequency Bands". The research resulted in the received signal level in the radial direction of the cable decreasing slowly (less than 12 dB/100 m), the leaky feeder has a wide coherent bandwidth and can support data rates up to 2.08 Mb/s [3].

Further research was conducted by Fernando Pereira et al., entitled "Multi-technology RF fingerprinting with leaky-feeder in underground tunnels". The research resulted in an experimental environment, as illustrated by APs installed 150 m from each other and antennas placed parallel to the leaky feeder at a distance between 5 and 10 cm. This configuration promoted the injection and propagation of WLAN signals through the cable in a direct LOS connection. Furthermore, the LOS between transmitter and receiver was reduced by installing a reflective shield, made of aluminum foil, near the AP. RSS measurements for WLAN were performed using a USB WLAN adapter, also based on the Realtek 8187L chipset featuring a 9 dBi antenna [6].

Further research conducted by U. Grossmann, S. Gansemer, O. Suttorp, entitled "RSSI-Based WLAN Indoor Positioning Used Within a Digital Museum Guide". The research resulted in an analysis of the quality of the signal received in a closed room due to reflection. The quality of service is obtained from processing the results of parameters including delay, jitter, packet loss and throughput with reference to ETSI standardization values [7].

2.2 VoIP Technology

"Voice over Internet Protocol (VoIP) is a communication technology that is able to pass voice, video and data traffic with packages through an IP network. The IP network itself is a packet-switch based data communication network", making voice calls using VoIP offers many advantages including in terms of cost this technology is more affordable than traditional telephone rates, because the IP network is global. So that the cost of international connections can be reduced by up to 70%. In addition, maintenance costs can be reduced because voice and data networks are separate, so that IP Phones can be added, moved and changed. This can be achieved because VoIP can be installed on various ethernet networks and IP addresses, unlike conventional telephones that use separate ports at the Central or PBX. The communication network that has been widely deployed in Indonesia is the PSTN network as managed by PT Telkom. To build an efficient communication network, it is necessary to determine the position of the

Network Operation Center (NOC), Point Of Presence (POP), Router, Gateway or the construction of a strategic inter-city connecting network [8].

2.3 Leaky Feeder Cable

Leaky Feeder Cable, is a modification of the coaxial cable that is deliberately given a gap/hole on the outside so that it can transmit signals, the use of this cable is a traditional solution to provide RF (Radio Frequency) coverage [4]. In limited areas using a single-hole coaxial cable that functions as a long antenna. This can be described as a coaxial cable with a periodic slot pattern on its outer conductor. In coaxial cables electromagnetic waves propagate in TEM mode confined between the inner and outer conductors. However, in leaky radiating cables, part of the wave energy leaks from the slots in the outer conductor and vice versa. The construction of a coaxial cable with leakage can be described briefly as follows:

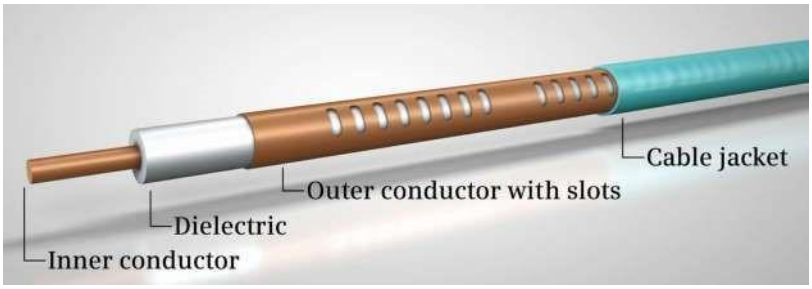

Figure 1. Leaky Feeder Cable Construction

One of its main advantages is its low EIRP (Effective Isotropic Radiated Power) because the slot in the outer conductor allows some of the controlled internal RF energy to be radiated into the conductor's surrounding environment [9]. This feature minimizes Return Loss on the transmitted signal [10], reduces interference and reaches the desired area better. The following is an illustration of a leaky feeder cable installation in a mining area.

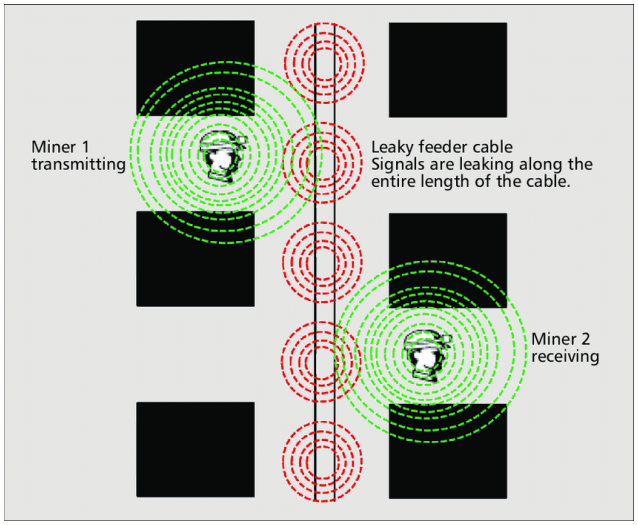

Figure 2. Illustration of Leaky Feeder Cable Signal Propagation

Figure 2 shows how a leaky feeder cable can transmit signals, where the signal is transmitted through a modified gap/hole in the cable, thus the effect of obstructions such as walls on the strength of the received signal is no longer significant.

2.4 Wireless Local Area Network

WLAN is a technology that utilizes radio waves as a transmission medium in limited areas such as homes, schools, and offices. Basically, a WLAN network consists of a router and access point that are used to distribute signals. A very striking characteristic of this technology is user mobility, where users can access the internet freely without being connected by cables [11].

In WLAN, Propagation Loss on a WI-FI network is important because it can affect the performance of the WI-FI network [1]. Wi-Fi itself is short for Wireless Fidelity, which can be concluded as a set of standards used for Wireless Local Area Networks (WLAN) based on the IEEE 802.11 specification. At the beginning of its introduction, Wi-Fi was intended as a connection between wireless devices and Local Area Networks (LAN), but currently WI-FI networks are more widely used to access the internet. This technology allows computer users with wireless cards or personal digital assistants (PDAs) to connect to the Internet using a nearby access point (also known as a hotspot) [12]. Wi-Fi is designed based on the IEEE 802.11 specification. Currently there are four variations of 802.11, namely: 802.11a, 802.11b, 802.11g, and 802.11n. The b specification is the first Wi-Fi product.

3. METHODS

This research is a model for developing science and technology, with the aim of producing a more efficient IP-based telephone network, utilizing Leaky Feeder cables as transmitting antennas with the Wireless Local Area Network method.

3.1 Research Design

Figure 3 shows the layout of the building used as the testing site, with a length of 18m and a width of 44m, there is a corridor as wide as the building as a place to install leaky feeder cables and 16 rooms with various sizes that will be used as test point.

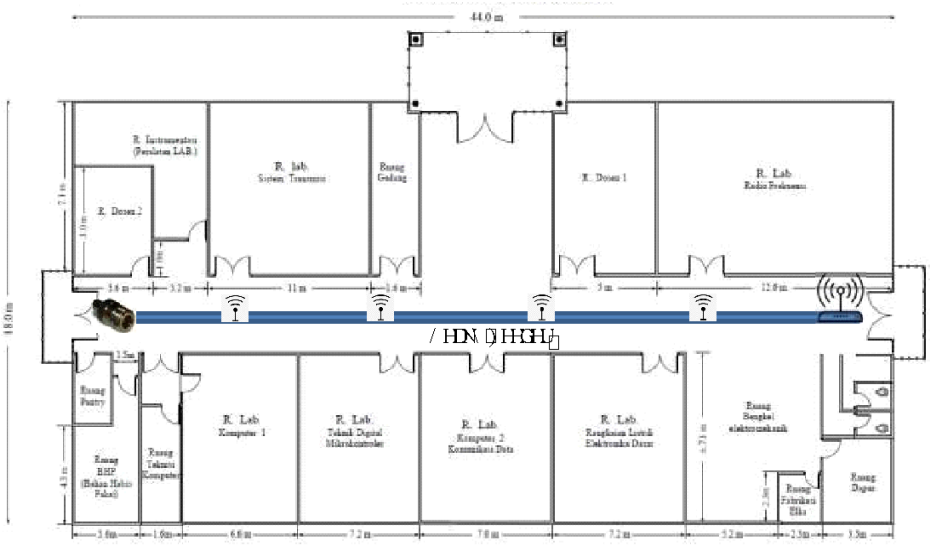

Figure 3. Leaky Feeder Installation Plan in Building Hallways

4. RESULTS AND DISCUSSION

4.1 Implementation Plan

Figure 4. Test Circuit with Leaky Feeder Antenna

Figure 5. Antenna and Terminator50Ω

Figure 4 shows a leaky feeder antenna connected to a coaxial transmission line for every 5 meters with an access point connected at the beginning of the cable, Figure 5 shows the end of the cable with a 50Ω terminator.

4.2 Signal Strength Test

This test aim to find out the received signal by the client in various room, the testing includes Signal Strength testing, as well as uplink and downlink, this test is carried out to determine the system's ability to distribute signals effectively in buildings.

Table 1. Leaky Feeder Installation Test Results on Signal Strength

Coverage Area	Signal Strength (dBm)	Internet	
		Uplink Mbit/s	Downlink Mbit/s
Lab Room. Transmission System	-61	13.09	10.26
Lecturer Room 2	-58	12.04	15.38
Instrumentation Room	-57	17.13	11.36
Warehouse Space	-59	26.98	19.01
Radio Frequency Lab Room	-57	23.89	21.45
Kitchen space	-56	16.55	9.20
Fabrication Room	-54	18.45	12.10
Mechanic Workshop Room	-58	14.02	7.40
Computer Lab Room 1	-66	4.54	4.20
Pantry Room	-64	17.23	16.38
BHP Room	-65	16.03	14.18
Technician Room	-54	18.71	17.20

Lab Room. Digital Engineering and Microprocessor	-62	13.85	21.07
Data Communication Lab.	-68	6.07	8.40
Lab. Elka and Electrical Circuits	-62	10.04	9.67
Warehouse Space	-63	9.20	7.45

From the test results, the average signal strength at several test points in the building corridor is -60.25 dBm, while the average uplink and downlink speeds are 14.86 Mbps and 12.79 Mbps. This shows that for applications on computer networks and smartphones with a good category. The use of Leaky Feeder in buildings can reduce the number of Access Point installations needed for the same area coverage.

4.3 Bit Rate Testing

The system used will serve many clients, therefore this test is intended to determine the effect of the number of clients on the system's transmission capability when serving several clients at once.

Table 2. Relation between the number of clients and the size of the bit rate"

Number of Clients	Average client bit rate (kbps)
1	436.53
2	195.5215
3	131.1407
4	99.88125
5	81.0928

From the data results above, it shows that the more clients there are, the lower the average bit rate value received by the client. The bit rate value will be divided according to the number of clients. The maximum bit rate value reaches half the bandwidth available on the network, which is 1Mb. With Thus the system works normally and can be applied.

4.4 Packet Loss Testing

Packet loss is the number of packets lost or damaged during packet delivery compared to the total number of packets received on the client side. Packet loss greatly affects system efficiency, ensuring smooth communication when used. The unit used is percent (%), in calculating the Packet Loss parameter value, the equation can be used:

$$PacketLoss = \frac{package\ sent - package\ received}{package\ sent} \times 100\%$$

Table 3. Packet Loss Parameter Measurement with 1 Call

Codecs	Signal strength (dBm)	Packet loss (%)
G.711	-40	0.44
	-65	0.00
	-85	0.06
GSM	-40	0.00
	-65	0.00
	-85	0.00
G.729	-40	0.00
	-65	0.00
	-85	0.00

Table 4. Packet Loss Parameter Measurement with 2 Calls

Codecs	Signal strength (dBm)	Packet loss (%)
G.711	-40	0.00
	-65	0.13
	-85	0.71
GSM	-40	0.00
	-65	0.00
	-85	0.13
G.729	-40	0.00
	-65	0.00
	-85	0.00

Based on the packet loss value above using Call or 4 clients (1 call is 2 clients) for testing audio call packet loss by G.711, GSM and G.729 codecs. For the smallest packet loss value on 1 call and 2 calls of 0% as well as on 2 calls of 0%. The largest packet loss value on 1 call is on the G.711 codec with a value of 0.44%. While the largest packet loss value for 2 calls occurs on the G.711 codec with a value of 0.71%.

The average packet loss value for the G.711 codec is higher than the GSM codec and the G.729 codec. This is because the coding speed on the G.711 codec is greater, which is 64 Kbps, compared to the GSM codec which is only 13Kbps and G.729 which is 8Kbps.

According to the TIPHON (Telecommunications and Internet Protocol Harmonization Over Networks) standardization, the packet loss value is still quite good because the largest is only 0.71%.

4.5 Delay Testing

Delay is the delay time between packets on the receiving side, the unit used is milliseconds (ms). The purpose of delay analysis is to find out how fast the network is.

In addition, it is also to determine the extent of the influence of the Network used on the quality of VoIP produced. Delay testing in this study was carried out when the initial call was established until the call was closed, the delay was obtained by calculating as follows:

$$Delay = \frac{transmission\ duration}{package\ sent}$$

Table 5. Delay Parameters with 1 Call

Codecs	Signal strength (dBm)	Delay (ms)
G.711	-40	20.4
	-65	9.8
	-85	10.6
GSM	-40	12.2
	-65	10.5
	-85	12.4
G.729	-40	15.4
	-65	7.1
	-85	10

Table 6. Delay parameters with 2 Calls

Codecs	Signal strength (dBm)	Delay (ms)
G.711	-40	20.5
	-65	12.2
	-85	11.8
GSM	-40	11.9
	-65	12.3
	-85	12.4

G.729	-40	10.4
	-65	11.8
	-85	17

Table 5 shows that the delay value for the G.729 codec is smaller than the GSM codec and G.711 codec because the G.279 codec has a frame size of 10 ms compared to the GSM and G.711 codecs which each have a frame size of 20 ms.

Based on table 4.6. in the delay parameter test, the smallest delay in the 2-call test is on the G.729 codec of 10.4 ms which is measured when the RSSI value is -40dBm. While the largest delay is on the G.711 codec of 20.5 ms when the RSSI value is -40dBm.

The delay value for the G.729 codec is smaller than the GSM codec and G.711 codec because the G.279 codec has a frame size of 10 ms compared to the GSM and G.711 codecs which each have a frame size of 20 ms. And the G.729 codec has a smaller coding speed of 8 Kbps compared to the GSM codec which has a coding speed of 13 Kbps and the G.711 codec which has a coding speed of 64 Kbps. Thus, making the delay value low on the G.729 codec.

According to the TIPHON (Telecommunications and Internet Protocol Harmonization Over Networks) standardization, the delay value is still quite good, because the largest is only 20.5 ms.

4.6 Throughput Testing

Throughput is the number of packets received in a certain time interval. The units used are Bytes/Second, throughput is obtained by the following calculation method:

$$Throughput = \frac{received\ data\ (Bytes)}{transmission\ duration}$$

Table 7. Throughput parameters with 1 call

Codecs	Signal strength (dBm)	Throughput (Kbps)
G.711	-40	117
	-65	175
	-85	162
GSM	-40	69
	-65	78
	-85	70
G.729	-40	95
	-65	388
	-85	102

Table 8. Throughput parameters with 2 calls

Codecs	Signal strength (dBm)	Throughput (Kbps)
G.711	-40	201
	-65	141
	-85	157
GSM	-40	70
	-65	69
	-85	69
G.729	-40	71
	-65	75
	-85	74

In table 7 of throughput parameter testing, the smallest throughput in testing using 1 call is on the GSM codec of 69 Kbps measured when the RSSI value is -40dBm. While the largest throughput is on the G.729 codec of 388Kbps when the RSSI value is -40dBm.

Table 4.7 shows the largest throughput occurs in the G.729 codec, this is because the G.729 codec has a lower coding speed compared to the GSM codec and the G.711 codec, the amount of throughput is also influenced by the bitrate and the size of the packet sent.

In table 4.8. throughput parameter testing, the smallest throughput in testing using 1 call is on the GSM codec of 69 Kbps which is measured when the RSSI value is -65dBm and -85dBm. While the largest throughput is on the G.711 codec of 201Kbps when the RSSI value is -40dBm.

Table 4.8 shows the highest throughput value is the G.711 codec, because its packet size is the largest among the others, so the number of bits passed is large during the packet sending process. The amount of throughput is also influenced by the bitrate and the size of the packet sent.

CONCLUSION

From the tests that have been carried out, the following conclusions can be drawn:

Unlike Access Points in general, the use of Leaky Feeder as a WLAN transmission antenna can drastically reduce the hardware needed for signal distribution, the installed Leaky Feeder cable can reach most rooms in the building optimally.

Leaky Feeder cables do not have to use special cables, Leaky Feeders can be made using coaxial cables that are modified in such a way that the conductor part of the cable can transmit signals, this signal can be further amplified by using an antenna.

The effect of using Leaky Feeder on signal strength in several places measured when compared to the installed Access Point has almost the same value, but the upload and download speeds experience a slight decrease, although the transmitted signal can be distributed optimally, there is still attenuation along the cable which can cause a decrease in performance.

The results of the test parameter measurements showed good results according to TIPHON standards, proving the capabilities of the Leaky Feeder cable for use as a VoIP transmission medium.

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