Research Article

Simulation of Local Area Network (LAN) System Based on VoIP at XYZ Office Building

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Abstract: This research discusses the simulation of a Voice Over Internet Protocol (VoIP) communication network within the scope of a Local Area Network (LAN). Nowadays, the use of computer networks as a means of communication to support operations has become widespread as an enhancement of an organization's performance, with the hope of reducing operational costs and making communication facilities more practical. This research aims to design a VoIP network that can be implemented in office buildings. The method used is the Top-Down Network Design method with research stages including needs analysis, network design, implementation, and testing through the design of integrated network architecture, including IP Phone, Analog Telephone Adapter, Switch, Softphone, and others. Furthermore, the use of Cisco Packet Tracer for simulation and testing of the VoIP network will take into account several aspects consisting of network topology selection, network scale, infrastructure, and the VoIP devices used.

Keywords:; Cisco Packet Tracer; LAN; Simulation; Top-Down Network Design; VoIP

1. Introduction

The integration of Information and Communication Technology (ICT) has become a primary necessity in managing activities within the office environment, yet in several cases, the communication process between employees, customers, and business relations isn't optimally conducted face-to-face [1]–[3]. In response to this background, ICT services such as Voice over Internet Protocol (VoIP) can transmit voice through data networks, making it easier for users to communicate via the internet. VoIP enables communication to take place anywhere and anytime, even from great distances, as long as there is an internet connection [4], [5]. Therefore, VoIP becomes an additional element that can help organizations maintain their competitive edge [6]–[8].

However, the implementation of VoIP networks is a topic that is being researched to meet the requirements according to the needs of the relevant institutions or companies. In addition, the model of the VoIP network that will be implemented must also be considered [9], so that the suitability of the applied infrastructure aligns with the related needs.

The solution for VoIP network planning through the Top-Down Network Design method has provided a structured approach through four stages: business needs analysis, providing a design description to ensure the network meets needs and can be used in future technological developments. Then, the technical issues include determining the network design, selecting the network topology and its devices. The final stage involves implementation and testing of the network design [10].
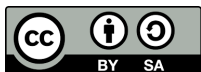
Previous research results related to network architecture models and the methods used based on article [11] have designed a VoIP network with integration among wireless network devices such as Wireless Fidelity (WiFi), Router, IP-Phone, Switch, and other devices. It was found that the implementation of VoIP networks has been proven to minimize operational costs and increase flexibility.

Furthermore, based on article [12], the design is carried out using the Top-Down Network Design method. This method takes a structured approach with a focus on flexible design, and helps researchers understand traffic flow and protocol behavior.

Based on the literature review conducted, VoIP is able to provide communication flexibility that supports the needs of educational organizations and companies at a lower cost. Furthermore, VoIP also enhances the operational efficiency of institutions by significantly reducing communication costs [12]–[14].

Furthermore, this research focuses on the planning of VoIP-based communication network design in the XYZ office building through the application of the Top-Down Network Design method. Therefore, for future prospect development, it is hoped to provide recommendations for the development of VoIP technology and open new opportunities so that it can be applied in several agencies or companies in building a fast, practical, cost-effective, and efficient communication environment that can support the communication process within the office environment.

The purpose of this research are:

1. Design a VoIP network simulation on a LAN network as practical, flexible, and economical communication.
2. Test the system design and provide improvement suggestions for enhancing communication quality.

The contribution of this research is to introduce ICT that supports the goals of the SDGs, particularly Industry, Innovation, and Infrastructure (SDG 9), Sustainable Cities and Communities (SDG 11), as well as Partnerships for the Goals (SDG 17).

2. Proposed Method

This research conducts a simulation of VoIP network design with the simulation object being an office environment using the Top-Down Network Design method as shown in the following figure 1 [15].

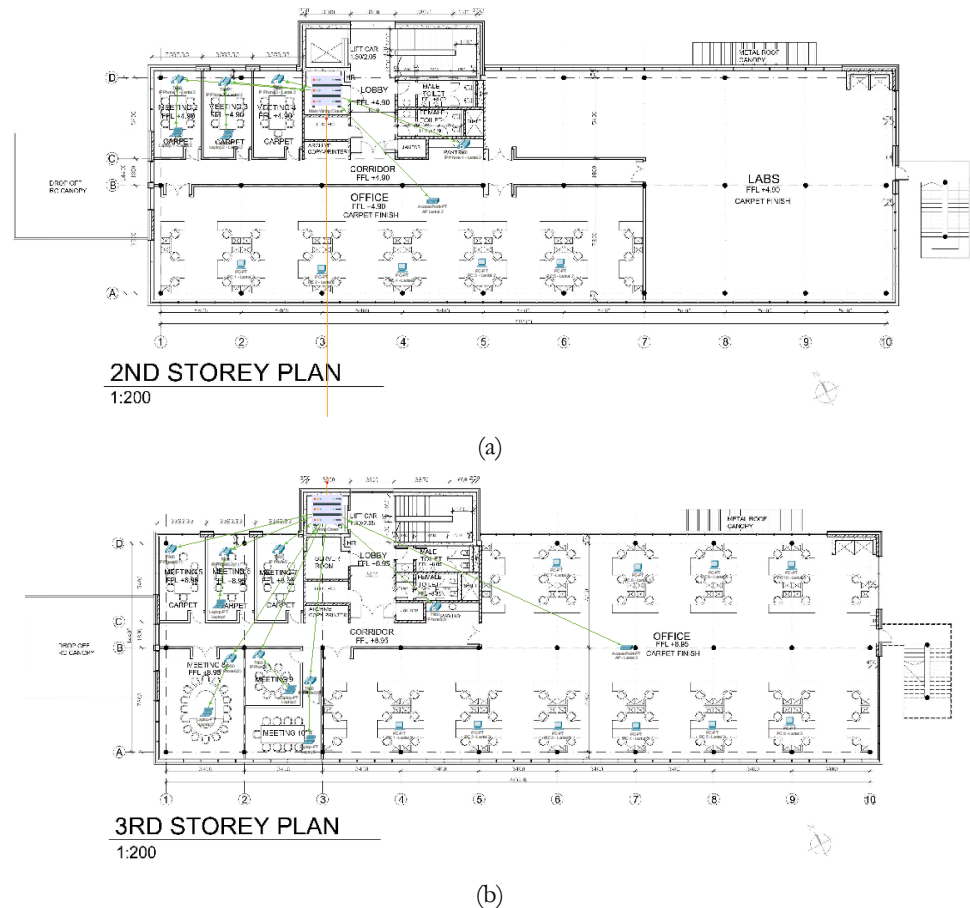**Figure 1.** Research method flowchart [16]

(a)

(b)

Figure 3. Device mapping; (a) 2nd floor; (b) 3rd floor

2.1. Identification of Institutional Requirements

Identification is the initial stage to understand needs. This stage involves several aspects including problem identification, and infrastructure identification through data collection using the Top-Down Network Design method [17]. The description of the need identification are as follows:

1. Problem Identification

   Present VoIP-based communication with practical, flexible, and easy implementation.
2. Analyze physical infrastructure

   Based on the analysis of the building layout shown in Figure 2, the building has 2 floors with a not too large building area, and the floor plan is almost identical on the 2nd and 3rd floors, hence a star topology and a bus topology (hybrid) are applied. Furthermore, the placement of Access Points (AP) will be arranged by considering signal strength and interference at the placement points. Table 1 shows the network distribution so that the entire area in the office can provide access to the network for each user.

Table 1. Network distribution

2nd Floor	3rd Floor
Office Room	Office Room
Labs Room	Meeting Room 6
Meeting Room 3	Meeting Room 9

2.2 Determination of Network Design

The next stage is the determination of the network design, including logical networks and physical networks, with the following explanations:

1. Logical network design

   Logical network design includes network topology and the selection of network protocols used by planning a logical layer that encompasses addressing and choosing the switching and routing protocols used. Furthermore, the design includes network management capable of meeting the requirements for LAN and remote access. The resulting model includes logical topology, IP address mapping, routing, and security planning. The applied topology is a hybrid topology.

2. Physical network design

   This stage produces a physical network design that includes the specifications for computer network infrastructure and technology selection.

2.3 Selection of Network Technology and Its Devices

The next step is the selection of network technology and devices based on the following description.

1. Network Technology

   Based on identification through the network design process, the technology applied is Wi-Fi technology.
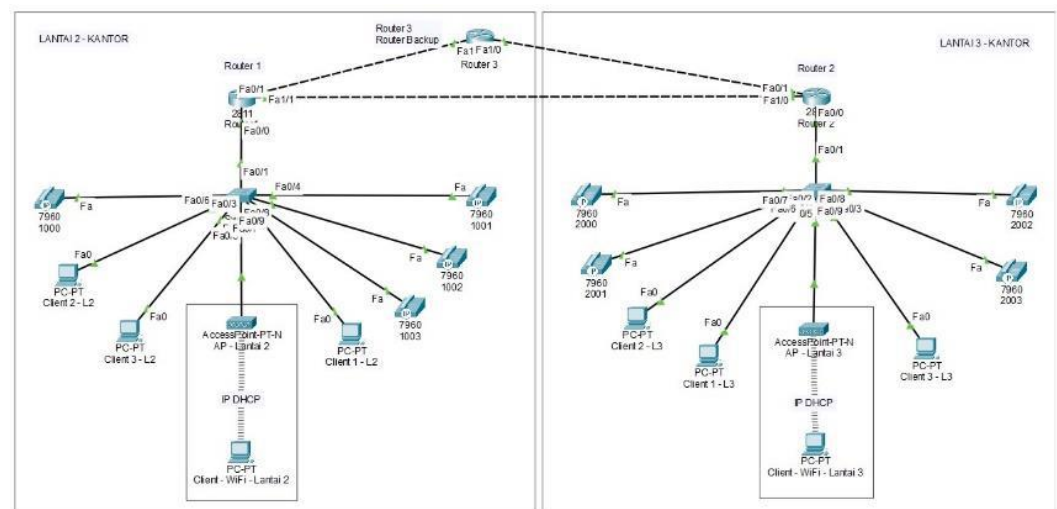
2. Device

   The devices used can be seen in Table 2. Table 2.

Table 2. Devices to be used

Hardware	Software
Router	Softphone
Access Point	Cisco PacketTracer
Switch	Wireshark
PBX Server	

2.4 Prototyping and Testing

Prototyping is an initial model used as an experiment to test the concepts, features, and functions of a design or draft that is applied comprehensively. This stage ensures that the design can meet all the established requirements. In this case, testing includes performance tests and failure tests on connections between devices and networks. The testing uses Cisco Packet Tracer software.

Figure 3. Network topology

3. Results and Discussion

3.1 Network System Design

Based on the needs analysis, the VoIP network design includes the use of devices such as IP phones, PCs, laptops, switches, and routers within the XYZ office environment. This design is integrated using a LAN network and a hybrid network topology. Furthermore, the call routes are designed for each VoIP device path using VoIP Dial-Peer configuration. VoIP Dial-Peer is a static route configuration for voice or VoIP networks that identifies call endpoints and determines the characteristics of each call path through a router. The network administrator can control calls in the VoIP and PSTN systems and ensure smooth communication between each VoIP device.

3.2 Simulation and Configuration of Network Mapping

The testing simulation conducted is to ensure that each device that has been configured can operate according to the established rules. Based on the test results, it shows success that all devices can connect to each other as shown in Figure 3. Furthermore, a hybrid topology is used based on user needs and the placement of devices according to the existing office layout. Table 3 shows the results of the simulation analysis.

Table 3. System analysis

Device	Function	Testing Method	Result	Status
Router	Routing and VoIP path settings	Dial-Peer Configuration, testing calls	The communication path has been successfully configured and tested.	Success
Switch	Network distribution to LAN devices	Test connectivity between devices	All LAN devices are successfully connected.	Success
Access Point	Wi-Fi network provider	Testing signals and wireless connections	The signal is stable, all WiFi devices are connected.	Success
Server PBX	VoIP call management	VoIP call simulation	Calls between devices are successful.	Success
IP-Phone/Softphone	Voice communication between users	Test calls between VoIP devices	Voice quality was good	Success
PC/Laptop	Network simulation and configuration	Ping and traceroute	All hosts are responsive, and there is no data loss.	Success
Software Simulation	Simulation environment for configuration and testing	Full network scenario simulation	The configuration runs according to the hybrid topology design.	Success

4. Conclusions

This research successfully simulated a VoIP network system based on LAN using a Top-Down Network Design approach. The design process starts with identifying needs, mapping the network, and selecting devices. The simulation results show that the system functions well, all network devices are connected, and VoIP communication runs smoothly with Dial-Peer configuration. The implemented hybrid topology proved effective in distributing connectivity. The implementation of this system is able to enhance internal communication efficiency in a practical and flexible manner, and also reduces the need for conventional communication devices. Thus, this system can be a cost-effective and adaptive solution to the development of communication technology in office environments.

Conflicts of Interest: We certify that the submitted work was performed with no conflict of interest.

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