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IP-Phone Communication Network System for College of Engineering and Architecture: A Working Model

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Abstract – *Voice over Internet Protocol (VoIP) is now commonly used to send voice, multimedia content, and other types of data over packet-switched connections over the internet protocol. Calls can fly as data packets on shared lines over the internet, eliminating the tolls of a public switched telephone network (PSTN). Audio is encapsulated into packets of data and sent over an IP network, then de-encapsulated back to audio at the other end of the link using a hardware interface or a software-based method. This study aimed to develop an "IP Telephony System" to show that a full-duplex private way of communication between the departments of the College of Engineering and Architecture of Pangasinan State University, Urdaneta City Campus, and the College Dean is possible without wasting time and effort, and without paying telephone bills by using VoIP technology, manageable router and switches, and IP phones.*

Keywords – *Voice over Internet Protocol (VoIP), public switched telephone network (PSTN), IP Telephony System, Full-duplex*

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INTRODUCTION

Communication is the most critical factor to be considered inside an organization [1, 2]. Good communication could strengthen their foundation and avoid misunderstanding [1, 3]. A Paging System is a one-way communication used when important announcements like class suspensions, general assembly, meetings, and other meetings spread immediately [4, 5]. The researchers' goal is to develop an IP Telephony system to provide communication without wasting time and effort more securely and privately. Because they were announcing the names of the individuals and summoning them through the speakers located throughout the campus and there are times when the announcement is not delivered clearly or when the different name of the person has mistakenly announced, causing the paging system to repeat it until the message has successfully delivered.

The Internet's global evolution and overall network creation have become embedded in our everyday lives [2, 3], which causes the interest and demand for various applications have increased [6]. The increase in demand has resulted in numerous new applications [7]. VoIP technology has emerged as a viable alternative to and complement conventional telephony systems over the Public Switched Telephone Network (PSTN) [8, 9], offering a versatile, scalable, and cost-effective solution for speech communications [7, 10]. VoIP is a game-changing technology that has emerged as a hot topic in both the rising Internet and existing telecommunications industries [11-13]. IP technology allows telephone calls over computer networks such as the Internet, where packet switching is used instead of circuit switching, and analog signals are converted to digital signals for real-time two-way communication [14-17]. Due to the lower cost of VoIP, it has become a viable alternative to the current PSTN technology. Despite its lower cost, it faces significant barriers to adoption [11, 14, 18].

As a result, VoIP has become widespread in corporate implementations [3, 11, 19-21]. VoIP system provides communication without wasting time and effort more securely and privately [5, 19, 21-23]. The researchers have begun to investigate developing an IP Telephony system within the network to replace the paging scheme. This system would allow individuals to connect directly with their colleagues by dialing the same phone numbers as they would from their office's IP phones [8, 24]. There is no need for a separate contact list. Additionally, the gateway can connect users of publicly accessible VoIP services (such as Skype) and users of the university and other organization-owned VoIP networks [25]. Deploying such a system provides users with full-duplex communication and a

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broader range of communication options to enhance their collaboration experience across the campus.

OBJECTIVES OF THE STUDY

This study aimed to develop an "IP Telephony System" to show that a full-duplex private way of communication between the departments of the College of Engineering and Architecture of Pangasinan State University, Urdaneta City Campus, and the College Dean is possible without wasting time and effort, and without paying telephone bills by using VoIP technology, manageable router and switches, and IP phones.

MATERIALS AND METHODS

The research design employed in this study is the qualitative and experimental development method, often referred to as "expansionist design." It is defined as "an online resource which advocates the premise that problems can be solved and practices improved by observation, analysis, and presentation of results" [29]. It was employed because of its more straightforward methodology, and for that reason, the researchers classified it as the fourth generation. They are considered "modifiable by design," meaning they were meant to be changeable from the beginning [30].

In Table 1, the first phase is data gathering, in which planning and researching were used to gather enough data to design the system's network topology to acquire the data for the system. The researchers used the internet. Additional resources (such as Google and Cisco) were also used as a search engine, and they were used in tandem to obtain data for use in research studies by various organizations. The average collection of data in this study is based on the surveys on the staff's views on contact practices and experiences in Pangasinan State University, Urdaneta City Campus via frequency and percentage (%) distribution. The second phase is where the network topology of the system was created and simulated; the researchers used a software called packet tracer, an innovative and powerful networking simulation tool used for practice, discovery, and troubleshooting [31], to simulate the IP telephony system. In this simulator, the researchers connected the manageable switch and router to the IP phones and configured it using the CISCO IOS configurations inside the simulator. The third phase is to build the system, this is where the pieces of equipment used in the simulation were canvassed and purchased. Once the pieces of equipment were complete, these were connected and configured. This helped to test the capability of the system. During the building stage, the types of equipment needed were canvassed, bought, and had been set up. Testing and implementation was the last stage of the system where the initial and final testing were done and the researchers gathered the feedback from the users.

Table 1. Program of Work

Project Phase	Activity
Data Gathering	• Planning • Research
Designing the System	• Designing the network topology • Simulation using packet tracer
Development	• Canvass and purchase of materials and equipment. • Setting up the equipment. • Programming and coding.
Testing and Implementation	• Initial testing of the system using different lengths of cables to be used in the IP phones • Reliability test by running the system 24/7 • Feedback of the users about the system.

RESULTS AND DISCUSSION

The IP Telephony system is built in a star topology, as shown in Figure 1. Cisco 2811 router and Cisco 7960 IP phones were wired to a Cisco 2960 POE switch [26-28, 30], while the cable mapping is shown in Figure 2. Using Dynamic Host Configuration Protocol, the router assigns IP addresses to IP phones (DHCP). The router has been configured manually with the IP phones' MAC addresses and directory numbers. Additionally, it is responsible for the system's voice-over IP communication.

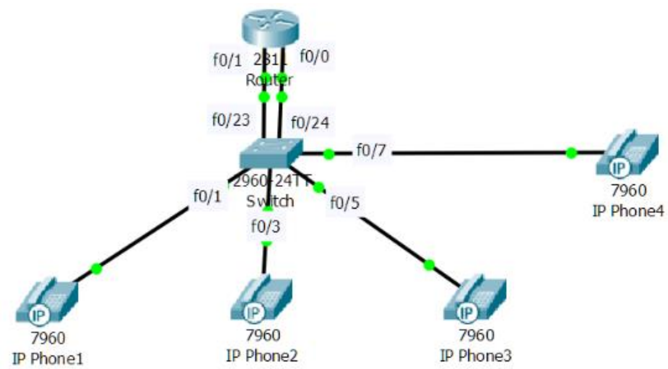

Figure 1. Network Topology

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It was connected to the switch through two (2) straight-through cables, one for the VLAN trunk and another for Telnet. For the VLAN network, Fast-Ethernet 0/1 of the 2811 router was connected to Fast-Ethernet 0/23 of the 2960 Power over Ethernet (POE) switch Fast-Ethernet 0/0 of the router was connected to Fast-Ethernet 0/24 of the 2960 switch for Telnet. The router's VLAN and Telnet port were divided to provide distinct paths for data when accessing the router's and switch's Telnet and a distinct data path for speech. The switch supplied 6.3 watts of power to the IP phones. Additionally, it allocated the Fast-Ethernet port used by the IP Phones to its voice VLAN.

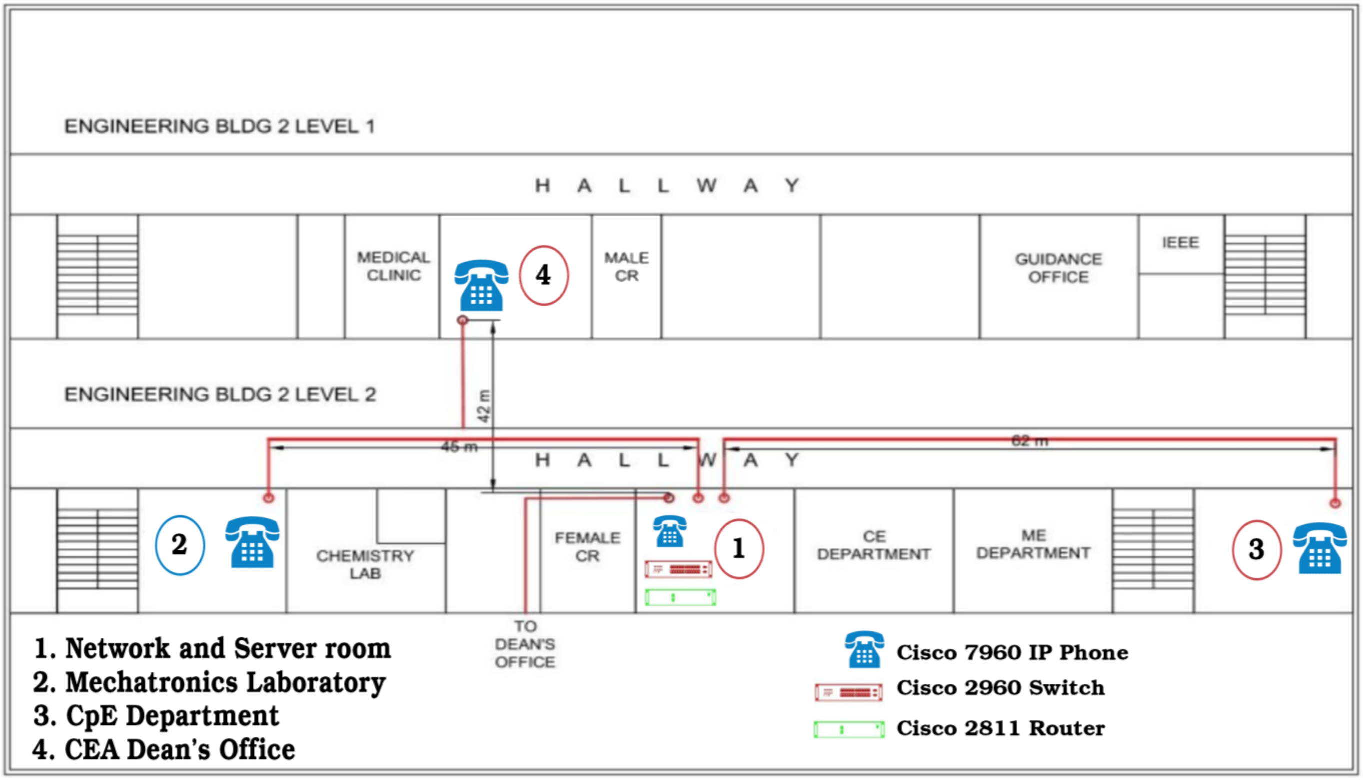

Figure 2. Cable Map

The source code for configuring router 2811:

```
Router(config)#telephony-service
Router(config-telephony)#max-ephones 4
Router(config-telephony)#max-dn 8
Router(config-telephony)#ip source-address
192.168.20.1 port 2000
Router(config-telephony)#exit
Router(config)#ephone-dn 1 dual-line
Router(config-ephone-dn)#number 1010
Router(config-ephone-dn)#name department 1
Router(config-ephone-dn)#ephone-dn 2 dual-line
Router(config-ephone-dn)#number 1020
Router(config-ephone-dn)#name department 2
Router(config-ephone-dn)#ephone-dn 3 dual-line
Router(config-ephone-dn)#number 1030
Router(config-ephone-dn)#name department 3
Router(config-ephone-dn)#ephone-dn 4 dual-line
Router(config-ephone-dn)#number 1040
Router(config-ephone-dn)#name department 4
Router(config-ephone-dn)#exit
```

The commands above were used in registering the IP phones that are connected to the switch. "Telephony-service" was used to set and configure the maximum number of phones (max-ephone) and the maximum number of simultaneous call (max-dn). "IP source address" was used in the IP phones to automatically obtain their IP addresses using User Datagram Protocol (UDP) port 2000. "ephone-dn |IP phone number| dual-line" was used to configure the IP phones to handle two simultaneous calls, making it capable of three-way

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conferencing. “Number” is the directory number assigned to the IP phones and the “Name” is the directory number name that shows up on the screen of the phones when there is a call. Then manually register the IP phones by entering their mac-address, phone type, and which directory number it belongs to, using the command below:

```
Router(config)#ephone 1
Router(config-ephone)#mac-address 001A.A1C6.C80C
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:1
Router(config-ephone)#ephone 2
Router(config-ephone)#mac-address 001A.A1C6.C3AB
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:2
Router(config-ephone)#ephone 3
Router(config-ephone)#mac-address 0030.94C2.A14D
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:3
Router(config-ephone)#ephone 4
Router(config-ephone)#mac-address 0018.18D7.5D2F
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:4
Router(config-ephone)#end
Router# copy running-config startup-config
```

The switch has 24 Power over Ethernet (POE) Fast-Ethernet ports. The ports 1, 3, 5, and 7 of the 2960 POE switch were used for the IP phones. The following ports were chosen to avoid crowding the cables and make them look organized. Port 23 is used for the telnet access of the router while port 24 is used for the trunking connection going to the router. The positions and port choices were aesthetically based. The four ports mentioned above (1, 3, 5, and 7) are connected to the four (4) IP phones SW10/100 port which provides the phones with 6.3watts of power. The other port, 10/100 PC can optionally be connected to a Personal Computer for data access.

A survey was conducted during the implementation and the respondents, who are faculty members, were asked regarding their experiences and thoughts about the current way of communication inside the campus. Based on the survey results, they have found out that the IP telephony system is a much suitable way of communication between the departments and offices inside the campus. Furthermore, IP phones provide a more private way of communication without wasting time and effort. They also said that it is easy to use the IP phone on making calls and that the voice was delivered clearly. The command “sh call history voice compact” displays the compact history of calls in the router in a table form. It displays through which phone the calls originated and which phone answered the calls in the “A/O” column. The other columns, “T<sec>,” shows the length of the call and the User Datagram Protocol (UDP) port that is used as depicted in Figure 3.

```
Router#sh call history voice compact
<callID>  A/O FAX T<sec>     type  Peer Address IP R<ip>:<udp>
disc-cause
    34      ORG      T0         TELE  P1030             D10
    33      ANS      T0         TELE  P1020             D10
    35      ANS      T28        TELE  P1020             D10
    36      ORG      T28        TELE  P1030             D10
    37      ANS      T0         TELE  P1010             D1C
    39      ORG      T20        TELE  P1020             D10
    38      ANS      T20        TELE  P1010             D10
    40      ANS      T209       TELE  P1010             D10
    41      ORG      T209       TELE  P1020             D10
```

Figure 3. Call History Voice Compact

The researchers conducted a one (1) week test for the IP Phones inside the system and manually recoded the data because the router deletes the call log (Figure 3) every 15 minutes. Four (4) calls per day were conducted to test the communication between the IP Phones. Two (2) calls in the morning, and two (2) calls in the afternoon. The result shows a 100% success rate. The test involves knowing which room the call originated, the destination of the call, the date and time the calls were conducted, the length of calls, and most importantly the quality of the voice transmitted and received.

CONCLUSION AND RECOMMENDATION

The implemented system answered the main problem: improving the communication method between offices and fulfilled the provision of a full-duplex communication between the departments involved using the IP telephony system. The system helped the faculty members of the Computer Engineering department to have private communication without wasting time and effort. Although there are some setbacks encountered that were solved by researching and understanding how does VoIP technology work. The voice can be heard clearly, either using the handset or the speaker of the phone, and there was no downtime during the implementation of the system. Thus the system was said to be reliable.

To maximize the conference calls in the IP phones inside the system, the router must be updated to Cisco Unified Call Manager Express (CUCME) version 4.3 or later versions. To provide communication across the whole campus, 23 more IP phones should be installed for the following offices and departments: Accounting

Office, Administrative Office, Architecture Department, Campus Executive Director's Office, Cashier's Office, College of Arts and Education Dean's Office, College of Computing Dean's Office, Electrical Engineering Department, English Language Department, Guidance and Counselling Office, Health Office/ Clinic, Information Technology Department, Library, Maintenance, Management Information System Office, Math, and Natural Sciences Department, President's Office, Records Office, Registrar's Office, Senior High School Principal's Office / General Education Department, Students account Office, Supply Office, Teacher Education Department. The router should have at least 64MB or higher amount of flash memory before installing a new IOS. Additional switches or POE extenders should be installed for every 100-meter distance of the cable from the switch to the IP phones. The Router configuration code is shown below:

```
Router(config)#telephony-service
Router(config-telephony)#max-ephones 27
Router(config-telephony)#max-dn 30
Router(config-telephony)#ip source-address
192.168.20.1 port 2000
Router(config-telephony)#exit
Router(config)#ephone-dn 1 dual-line
Router(config-ephone-dn)#number 1001
Router(config-ephone-dn)#name Accounting Office
Router(config-ephone-dn)#ephone-dn 2 dual-line
Router(config-ephone-dn)#number 1002
Router(config-ephone-dn)#name Administrative
OfficeRouter(config-ephone-dn)#ephone-dn 3 dual-line
Router(config-ephone-dn)#number 1003
Router(config-ephone-dn)#name Architecture
Department
Router(config-ephone-dn)#ephone-dn 4 dual-line
Router(config-ephone-dn)#number 1004
Router(config-ephone-dn)#name Campus Executive
Director's Office
Router(config)#ephone-dn 5 dual-line
Router(config-ephone-dn)#number 1005
Router(config-ephone-dn)#name Cashier's Office
Router(config)#ephone-dn 6 dual-line
Router(config-ephone-dn)#number 1006
Router(config-ephone-dn)#name CAE Dean's Office
Router(config)#ephone-dn 7 dual-line
Router(config-ephone-dn)#number 1007
Router(config-ephone-dn)#name COC Dean's Office
Router(config)#ephone-dn 8 dual-line
Router(config-ephone-dn)#number 1008
Router(config-ephone-dn)#name CEA Dean's Office
Router(config)#ephone-dn 9 dual-line
Router(config-ephone-dn)#number 1009
Router(config-ephone-dn)#name Civil Engineering
Department
Router(config)#ephone-dn 10 dual-lineRouter(config-
ephone-dn)#number 1010
Router(config-ephone-dn)#name Computer Engineering
Department
Router(config)#ephone-dn 11 dual-line
Router(config-ephone-dn)#number 1011
Router(config-ephone-dn)#name Electrical Engineering
Department
Router(config)#ephone-dn 12 dual-line
Router(config-ephone-dn)#number 1012
Router(config-ephone-dn)#name English Language
Department
Router(config)#ephone-dn 13 dual-line
Router(config-ephone-dn)#number 1013
Router(config-ephone-dn)#name Gen. Education
Department/ SHSRouter(config)#ephone-dn 14 dual-
line
Router(config-ephone-dn)#number 1014
Router(config-ephone-dn)#name Guidance Office
Router(config)#ephone-dn 15 dual-line
Router(config-ephone-dn)#number 1015
Router(config-ephone-dn)#name Health Office/Clinic
Router(config)#ephone-dn 16 dual-line
Router(config-ephone-dn)#number 1016
Router(config-ephone-dn)#name Information
Technology Department
Router(config)#ephone-dn 17 dual-line
Router(config-ephone-dn)#number 1017
Router(config-ephone-dn)#name Library
Router(config)#ephone-dn 18 dual-line
Router(config-ephone-dn)#number 1018
Router(config-ephone-dn)#name Maintenance
Router(config)#ephone-dn 19 dual-line
Router(config-ephone-dn)#number 1019
Router(config-ephone-dn)#name Mechanical
Engineering Department
Router(config)#ephone-dn 20 dual-line
Router(config-ephone-dn)#number 1020
Router(config-ephone-dn)#name MIS Office
Router(config)#ephone-dn 21 dual-line
Router(config-ephone-dn)#number 1021
Router(config-ephone-dn)#name Statistics Office/ Math
and Nat. Sci. Department
Router(config)#ephone-dn 22 dual-line
Router(config-ephone-dn)#number 1022
Router(config-ephone-dn)#name Records Office
Router(config)#ephone-dn 23 dual-line
Router(config-ephone-dn)#number 1023
Router(config-ephone-dn)#name Registrar's Office
```


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```
Router(config)#ephone-dn 24 dual-line
Router(config-ephone-dn)#number 1024
Router(config-ephone-dn)#name President's Office
Router(config)#ephone-dn 25 dual-line
Router(config-ephone-dn)#number 1025
Router(config-ephone-dn)#name Students Account
Office
Router(config)#ephone-dn 26 dual-line
Router(config-ephone-dn)#number 1026
Router(config-ephone-dn)#name Supply Office
Router(config)#ephone-dn 27 dual-line
Router(config-ephone-dn)#number 1027
Router(config-ephone-dn)#name Teacher Education
Department
Router(config-ephone-dn)#exit
Router(config)#ephone 1
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:1
Router(config-ephone)#ephone 2
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:2
Router(config-ephone)#ephone 3
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:3
Router(config-ephone)#ephone 4
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:4
Router(config-ephone)#ephone 5
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:5
Router(config-ephone)#ephone 6
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:6
Router(config-ephone)#ephone 7
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:7
Router(config-ephone)#ephone 8
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:8
Router(config-ephone)#ephone 9
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:9
Router(config-ephone)#ephone 10
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:10
Router(config-ephone)#ephone 11
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:11
Router(config-ephone)#ephone 12
Router(config-ephone)#mac-address
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:12
Router(config-ephone)#ephone 25
Router(config-ephone)#mac-address |0000.0000.0000|
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:25
Router(config-ephone)#ephone 26
Router(config-ephone)#mac-address |0000.0000.0000|
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:26
Router(config-ephone)#ephone 27
Router(config-ephone)#mac-address |0000.0000.0000|
Router(config-ephone)#type 7960
Router(config-ephone)#button 1:27
Router(config-ephone)#end
Router# copy running-config startup-con
```

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