CHAPTER 5

THE VoIP TECHNOLOGY

5 THE VOIP TECHNOLOGY

5.1 Introduction to the VoIP Technology

VoIP (Voice over Internet Protocol) technology is a technique for transmitting speech over data communication links using the IP protocol (packet switching).

The main advantages of **VoIP** over traditional telephony are:

- low cost of cabling (a working IP network is sufficient),
- free calls on the internal network,
- integration with services such as data or video transmission.

The main disadvantages **VoIP** over traditional telephony are:

- greater unreliability of services,
- need for dedicated hardware and software,
- communications are more exposed to the possibility of eavesdropping.

5.2 IP Phone End Device

An IP phone (IP Phone) is a terminal device with the ability to communicate via voice and the existing IP network. Therefore, the IP Phone has an Ethernet port marked **Switch**. In addition, it must be connected to a power supply.

There is only one model of IP Phone available in Packet Tracer, namely the 7960. In order to start building a telephone network, we must first insert the phone into the program's main board.

Figure 5.1 Choice of IP phone model 7960

In the bottom left corner of the program, find the "**End Devices**" device group, click on it and then select "**IP Phone**" and move the device to the board. The IP Phone will be represented as the following icon:

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Figure 5.2 IP phone model 7960

Before we move on to describing how to prepare the phone for operation, it is worthwhile for us to be able to simulate the dialing and busy tones.

To enable this, go to the Packet Tracer main menu and select **Options → Preferences**, then under "**Interface**" select "**Play Telephony Sound**".
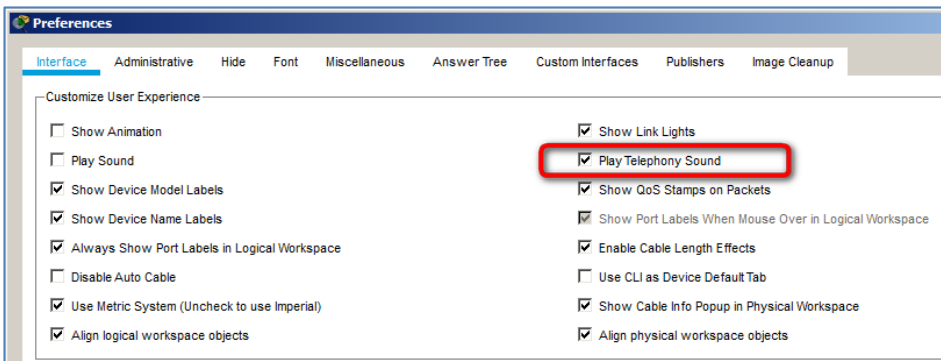

Figure 5.3 Option Play Telephony Sound

Now we can move on to the section describing how to prepare the IP phone for operation.

5.3   Preparing the IP Telephone for Operation

The IP Phone must be connected to an external voltage source. To do this, click on the **IP Phone**. A window appears with the **Physical** tab, where you use the mouse to connect (drag) the power supply (VoIP power adapter) to the socket indicated by the arrow in the figure.
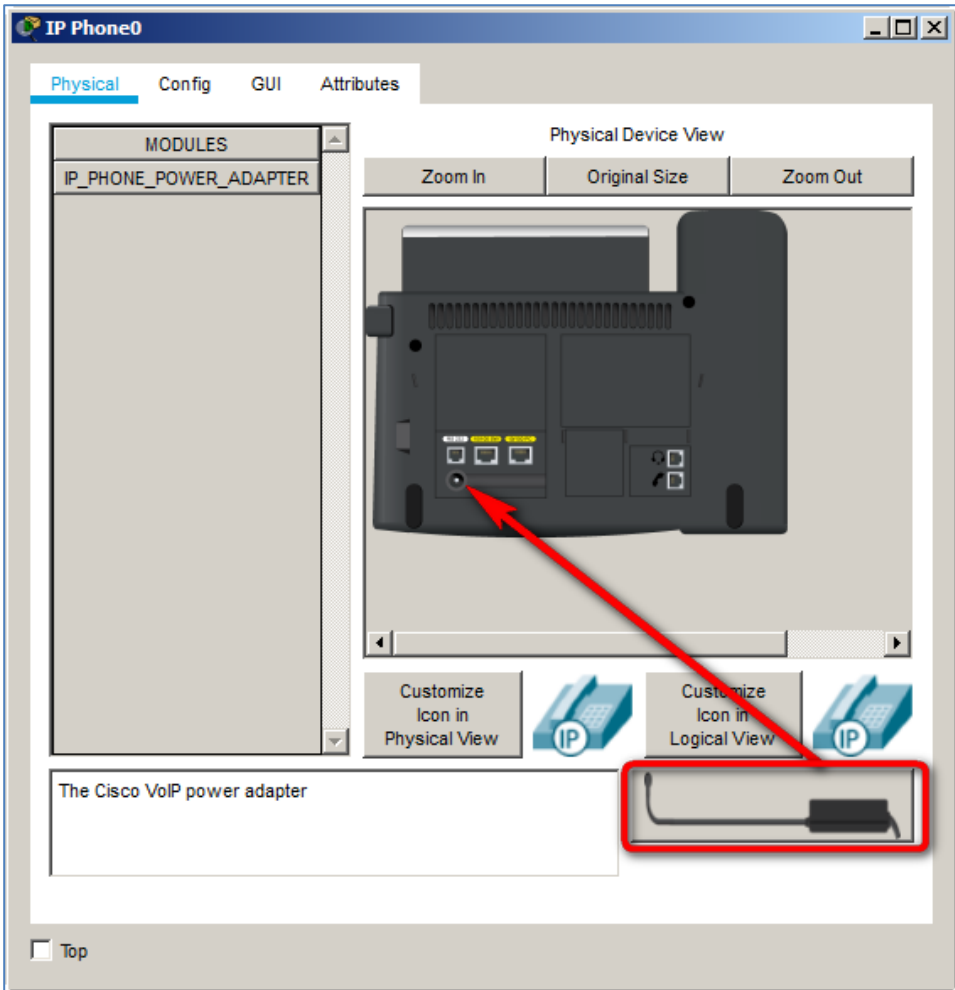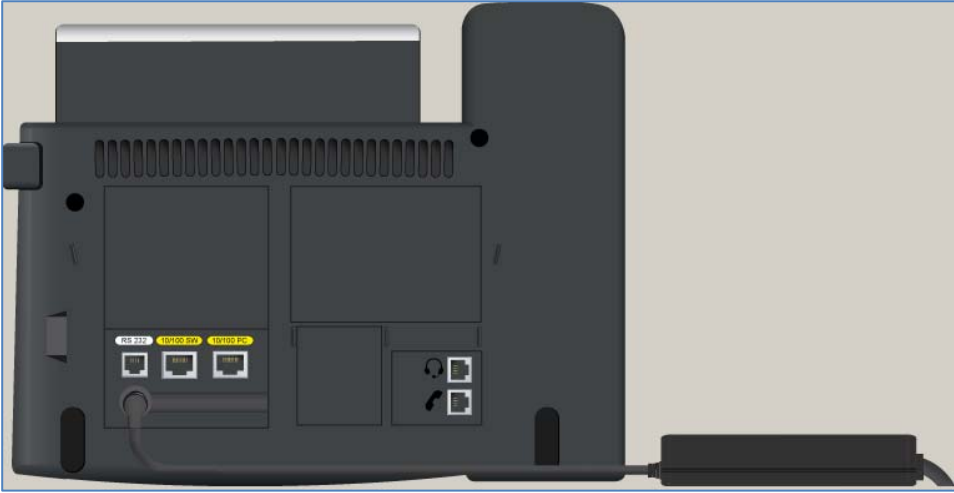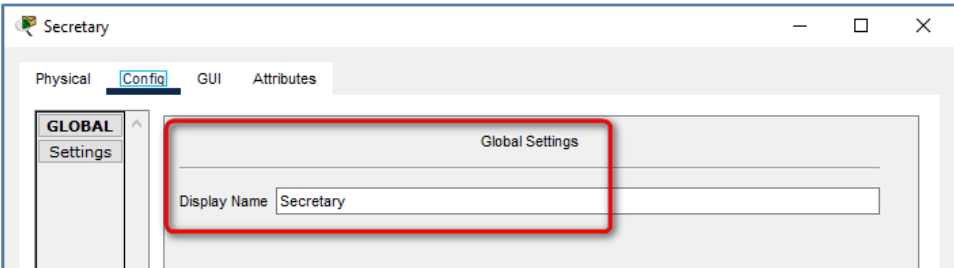
Figure 5.4 Connecting power to an IP phone.

Figure 5.5 Appearance of the bottom part of the IP phone after connecting the power supply

In the "**Config**" tab, we can change the **Display Name** for the telephone.

Figure 5.6 Changing the IP phone name

The "**GUI**" tab contains the view of the IP telephone (handset, display panel and keypad). We will use this tab only after configuring the IP network, telephone numbers and when testing connectivity.
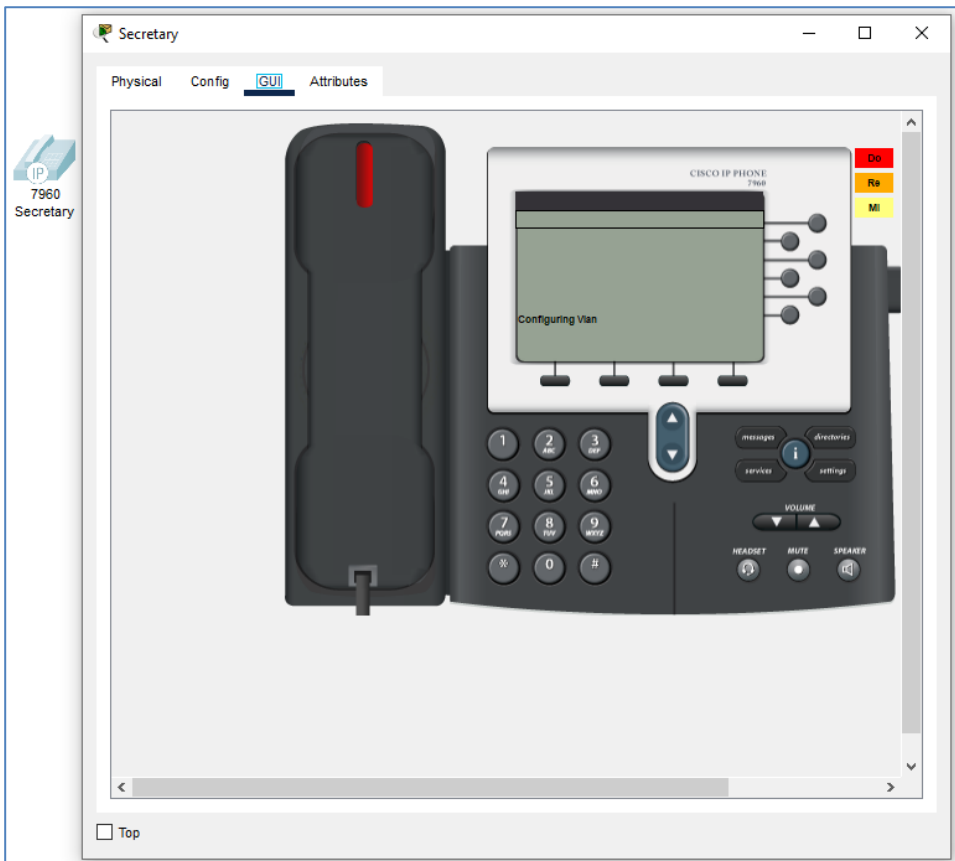
Figure 5.7 View of the IP phone on the GUI tab

To run a simple IP-based telephone network, you need a minimum of one router, one switch and two IP phones.

However, not every router has the necessary software to become a telephone exchange. In Packet Tracer, the **2811** meets this requirement. The VoIP PBX management software for Cisco routers is called **Call Manager Express**.

5.4   Call Manager Express

Call Manager Express (CME) software runs on Cisco routers and acts as a virtual PBX for IP telephony. For the description of **Voice over IP** technology in this chapter, the **2811** was chosen because in Packet Tracer only this model supports IP telephony.

5.5 Configuring a Simple VoIP Network

In order to set up and configure a simple VOIP network, we will select the following devices:

- router model **2811** (works as Call Manager Express),
- a switch model **2960** (works as a switch),
- and two IP telephones (model **7960**).
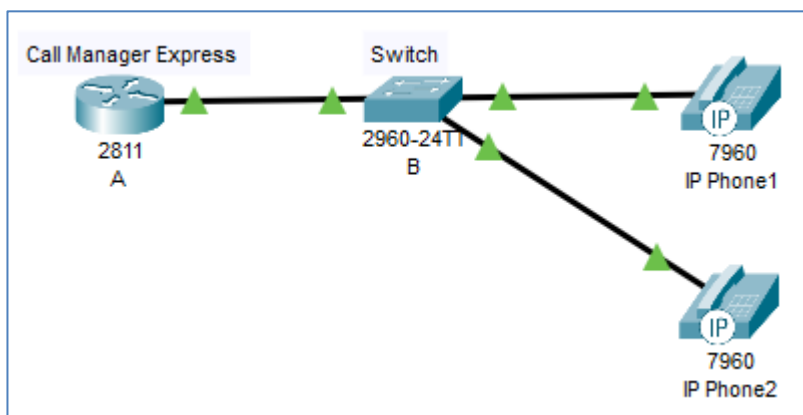
Figure 5.8 Simple VOIP network topology

Configuring a simple VOIP network takes place in the following steps:

Step 1. Connect the power supplies to both phones.

In addition, we change the names of the phones to: **IP Phone1, IP Phone2**.

Step 2. Connect router A to switch B.

We connect the router interface **Fa0/0** to the **Fa0/24** interface of the switch with an Ethernet cable.

Step 3. Connect IP Phone 1 to switch B.

Connect the phone's **Fa** interface (**note**: two ports will appear on the screen, one named **Switch** and the other **PC** - choose either one) to the switch's **Fa0/1** interface using an Ethernet cable.

Step 4. We configure the IP address for interface Fa0/0 of router A.

To do this, we execute the following commands:

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```
conf t
hostname A
int Fa0/0
ip address 192.168.1.1 255.255.255.0
no shutdown
```

Step 5. We configure the DHCP service on router A.

To do this, we run the following commands:

```
conf t
ip dhcp pool POOL
network 192.168.1.0 255.255.255.0
default-router 192.168.1.1
option 150 ip 192.168.1.1
```

Note: in order for the router to use VoIP technology, it is necessary to use option 150 in the DHCP configuration.

Step 6. We configure the Call Manager Express telephony service on the router

To do this, we enter global configuration mode (execute the following commands):

```
en
conf t
```

Assuming that a maximum of 5 phones will be supported on our network. We enter the telephone service configuration mode using the command:

```
telephony-service
```

In the telephone service configuration mode, the following options are set:

```
max-dn 5
max-ephones 5
ip source-address 192.168.1.1 port 2000
```

Below we can read a brief description of the purpose of the commands:

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- **max-dn** – is used to set the maximum number of directory entries (so-called **directory names)** that will store information about telephone numbers,
- **max-ephones** – is used to set the maximum number of IP phones,
- **ip source-address <source_address> port <port_no> - defines IP address** and the source port number for telephone services,

Step 7. We configure the VLAN on switch B.

Since we established in the previous step that we will support a maximum of 5 phones, we need 5 ports on the switch.

need to configure them to carry voice on **VLAN 1**. To do this, we run the commands:

```
conf t
hostname B
interface range fa0/1-fa0/5
switchport mode access
switchport voice vlan 1
```

Step 8. On router A, we assign telephone numbers to both phones.

Now we create directory entries (called **directory names**). To perform this step we will use the commands:

```
en
conf t
ephone-dn 1
number 101
exit
ephone-dn 2
number 102
end
```

```
A(config)#ephone-dn  1
A(config-ephone-dn)#number  101
A(config-ephone-dn)#exit
A(config)#ephone-dn  2
A(config-ephone-dn)#number  102
A(config-ephone-dn)#end
```

Figure 5.9 Configuring phone numbers in Call Manager Express

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Step 9. We check that IP Phone1 has received an IP address and number.

Note: the process of receiving the line number address can take up to several minutes. **Call Manager Express** needs to register the configured phones. Correct registration manifests itself in the form of messages in the router. This is shown in the following figure.

```
%IPPHONE-6-REGISTER: ephone-2 IP:192.168.1.2 Socket:2
DeviceType:Phone has registered.

%IPPHONE-6-REGISTER: ephone-1 IP:192.168.1.3 Socket:2
DeviceType:Phone has registered.
```
Figure 5.10 Correct registration of telephone numbers in Call Manager Express

To check whether **IP Phone1** has been given the correct IP address and line number, move the mouse pointer over the phone and check the data that appears.

```
Port      Link    IP Address          MAC Address
Vlan1     Up      192.168.1.3/24      0009.7C34.D69D
Switch    Up      <not set>           0050.0FB9.7501
PC        Down    <not set>           0050.0FB9.7502

Gateway: 192.168.1.1
Line Number: 101
```
Figure 5.11 Current configuration of IP Phone1.

Step 10. Connect IP Phone 2 to switch B.

We connect the **Fa** interface of the phone to the **Fa0/2** interface of the switch using an Ethernet cable. Check that the **IP Phone2** has obtained the correct IP address and line number. To do this, move the mouse pointer to the phone and check the data that appears.

```
Port      Link    IP Address          MAC Address
Vlan1     Up      192.168.1.2/24      0001.4379.5EA3
Switch    Down    <not set>           0001.96A5.CE6D
PC        Up      <not set>           0001.6343.A1D7

Gateway: 192.168.1.1
Line Number: 102
```
Figure 5.12 Current configuration of IP Phone2.

In addition, on the console of router **A** using the command: `show ip dhcp binding`, we can check the status of the assigned IP addresses.

```
A#show ip dhcp binding
IP address      Client-ID/              Lease expiration      Type
                Hardware address
192.168.1.2     0001.4379.5EA3          --                    Automatic
192.168.1.3     0009.7C34.D69D          --                    Automatic
```

Figure 5.13 Status of dynamically assigned IP addresses

Step 11. We check the connectivity between the IP phones.

We have reached the last step, which is to check if it is possible to call number 102 from number 101 and vice versa. To do this, we click **IP Phone1**. The phone number (**101**) appears in the top right corner on the display panel.
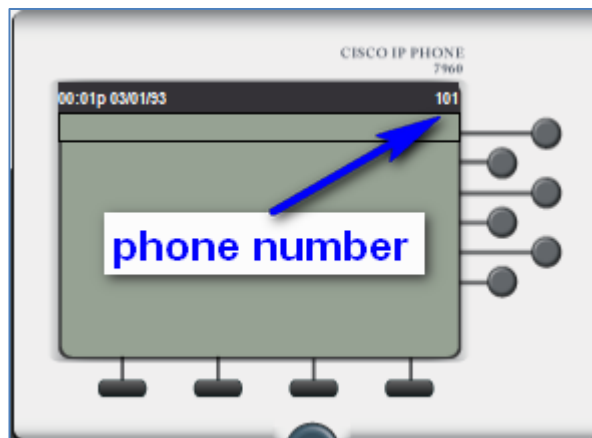

Figure 5.14 Display panel on phone number 101

If we want to call the number of the second telephone 102, we remove the handset (simply click it). You will hear a continuous tone confirming the call to the telephone exchange.

Figure 5.15 The phone is now ready for dialing.

The display will show "**Enter number**". We proceed to dial the number. On **IP Phone1** you dial **102**, on **IP Phone2** you hear a ring tone.
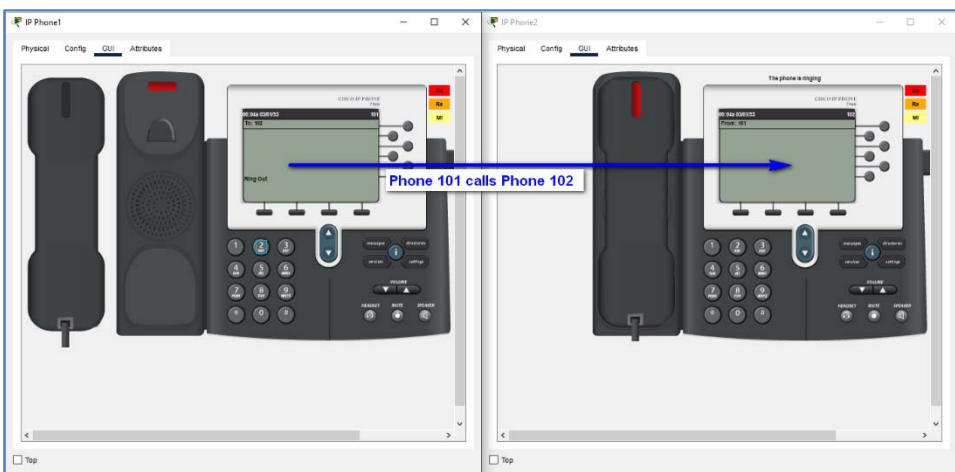

Figure 5.16 Phone 101 calls Phone 102.

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Now we can hang up and call from the second phone (number **102**) to the number of the first phone, i.e. **101**. At the same time, on display of **Phone 102** we can observe that the message **"From: 101"**. This message informs us that this is an incoming call from the number 101.

5.6 Communication between Two VoIP Exchanges

In order to set up and configure two VOIP networks (exchanges), connected between each other, we will first perform the following topology:
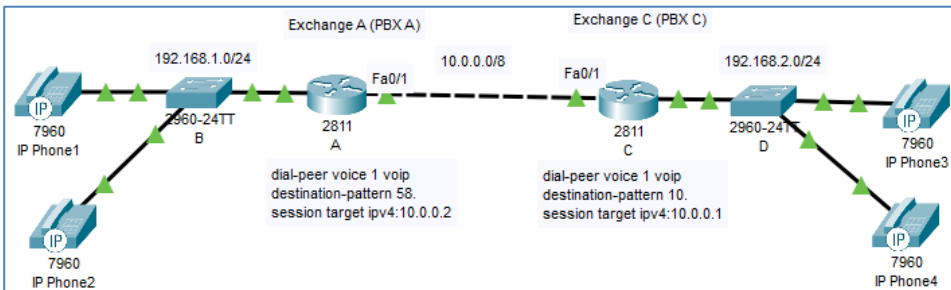

Figure 5.17 VoIP network topology with two exchanges A and C.

To create the topology, we choose:

- two routers (model **2811**),
- two switches (model **2960**),
- four IP telephones (model **7960**).

Assumptions for the configuration:

The assumptions for this example are shown in the table below**.**

PBX A	Internal network 192.168.1.0/24	Exchange network 10.0.0.0/8	IP of destination network : 10.0.0.2
PBX A	IP Phone 1	Prefix number 10	Number **101**
PBX A	IP Phone 2	Prefix number 10	Number **102**
PBX C	Internal network 192.168.2.0/24	Exchange network 10.0.0.0/8	IP of destination network 10.0.0.1
PBX C	IP Phone 3	Prefix number 58	Number **581**
PBX C	IP Phone 4	Prefix number 58	Number **582**

Table 5.1 Assumptions for the configuration of a VoIP network with two PBXs.

We will configure two VoIP PBXs in two stages :

- Stage 1 – internal (local) configuration of phones and exchanges.
- Stage 2 - configuring the link between the exchanges.

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Stage 1 - Configuring the phones and PBXs.

We will carry out Stage 1 using the following steps:

Step 1. We connect the power supplies to the telephones at PBXs A and C.

Step 2. We connect PBX A to switch B.

Step 3. Connect PBX C to switch D.

Step 4. Connect IP Phone 1 and IP Phone 2 to switch B.

Step 5. Connect IP Phone 3 and IP Phone 4 to switch D.

Step 6. We configure the IP address for interface Fa0/0 of PBX A.

To do this, perform the following commands:

```
conf t
hostname A
int Fa0/0
ip address 192.168.1.1 255.255.255.0
no shutdown
```

Step 7. We configure the IP address for interface Fa0/1 of PBX A.

To do this, we execute the following commands:

```
conf t
hostname A
int Fa0/1
ip address 10.0.0.1 255.0.0.0
no shutdown
```

Step 8. We configure the DHCP service on PBX A with option 150.

To do this, we execute the following commands:

```
conf t
ip dhcp pool VOICE1
network 192.168.1.0 255.255.255.0
default-router 192.168.1.1
```

```
option 150 ip 192.168.1.1
```

Step 9. We configure the IP address for interface Fa0/0 of panel C.

To do this, we execute the following commands:

```
conf t
hostname C
int Fa0/0
ip address 192.168.2.1 255.255.255.0
no shutdown
```

Step10. We configure the IP address for interface Fa0/1 of the C panel.

To do this, we execute the following commands:

```
conf t
hostname C
int Fa0/1
ip address 10.0.0.2 255.0.0.0
no shutdown
```

Step 11. We configure the DHCP service on PBX C with option 150.

To do this, we execute the following commands:

```
conf t
ip dhcp pool VOICE2
network 192.168.2.0 255.255.255.0
default-router 192.168.2.1
option 150 ip 192.168.2.1
```

Step 12. We configure the Call Manager Express telephony service on PBX A.

To do this, we enter global configuration mode and execute the following commands:

```
en
conf t
telephony-service
```

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```
max-dn 5
max-ephones 5
ip source-address 192.168.1.1 port 2000
```

Step 13. We configure the Call Manager Express telephony service on PBX C.

To do this, we enter global configuration mode and execute the following commands:

```
en
conf t
telephony-service
max-dn 5
max-ephones 5
ip source-address 192.168.2.1 port 2000
```

Step 14. On PBX A, we assign telephone numbers.

> **Note: In the event of misconfiguration of directory entries, when telephones cannot obtain line numbers, it is best to delete router A, then add it again, correctly connect to the devices in the topology and configure it.**

We now create directory entries (so-called **directory names**) for PBX **A**, using the commands: **ephone-dn** and **number**. We then create the phone line assignments for the directory entries.

We assign telephone line 1 of the first telephone found by DHCP to directory entry **ephone-dn 1** (i.e. number 101). We assign phone line 2 of the second phone found by DHCP to the **ephone-dn 2** directory entry (i.e. number 102).

We will use commands to perform this step:

```
en
conf t
ephone-dn 1
number 101
ephone-dn 2
number 102
end
```

Step 15. On PBX C we assign telephone numbers.

> **Note: in case of misconfiguration of directory entries, when phones cannot obtain line numbers, it is best to remove the C router, then add it again, correctly connect to the devices in the topology and configure it.**

As with PBX A, we now create directory entries (so-called **directory names**) for PBX **C,** using the **ephone-dn** and **number** commands. We then create the phone line assignments for the directory entries.

We assign telephone line number 1 of the first telephone found by DHCP to directory entry **ephone-dn 1** (i.e. number 581). We assign phone line 1 of the second phone found by DHCP to the **ephone-dn 2** directory entry (that is, number 582).

To perform this step we will use the commands:

```
en
conf t
ephone-dn 1
number 581
ephone-dn 2
number 582
end
```

Step 16. We configure the VLAN on switches B and D.

To do this, we execute the commands:

```
conf t
hostname B
interface range fa0/1-fa0/5
switchport mode access
switchport voice vlan 1

conf t
hostname D
interface range fa0/1-fa0/5
switchport mode access
switchport voice vlan 1
```
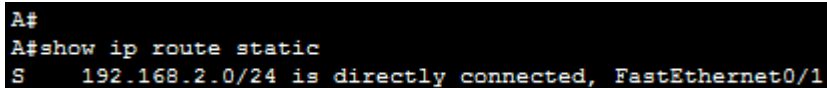
Stage 2 – configuring the link between A and C exchanges

We will carry out stage two, the configuration of the inter-panel link, using the following steps.

Step 1. At PBX A, we configure a static route to PBX C.

To do this, we execute the commands:

```
en
conf t
ip route 192.168.2.0 255.255.255.0 FastEthernet0/1
```

```
A#
A#show ip route static
S    192.168.2.0/24 is directly connected, FastEthernet0/1
```
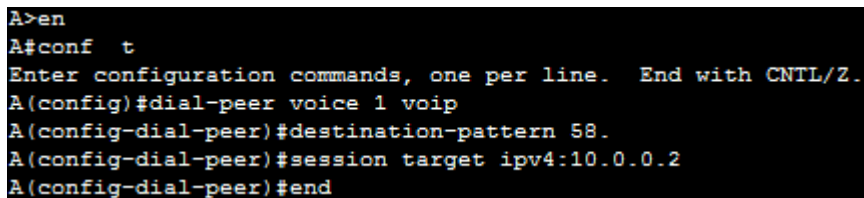
Figure 5.18 Static routes in router A.

Step 2. At PBX A, we configure the processing of VoIP traffic to PBX C.

To do this, we execute the commands:

```
en
conf t
dial-peer voice 1 voip
destination-pattern 58.
session target ipv4:10.0.0.2
end
```

Note: here we also configure the number prefix to PBX C (**58**). The **dot** that follows the prefix is important - it stands for a single digit from 0 to 9.
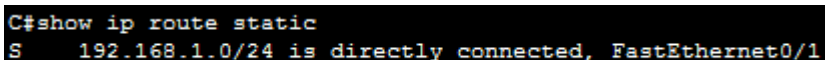
```
A>en
A#conf  t
Enter configuration commands, one per line.  End with CNTL/Z.
A(config)#dial-peer voice 1 voip
A(config-dial-peer)#destination-pattern 58.
A(config-dial-peer)#session target ipv4:10.0.0.2
A(config-dial-peer)#end
```

Figure 5.19 Configuring VoIP traffic from router A to router C.

Step 3. At PBX C, we configure a static route to PBX A.

To do this, we execute the commands:

```
en
conf t
ip route 192.168.1.0 255.255.255.0 FastEthernet0/1
```

```
C#show ip route static
S    192.168.1.0/24 is directly connected, FastEthernet0/1
```
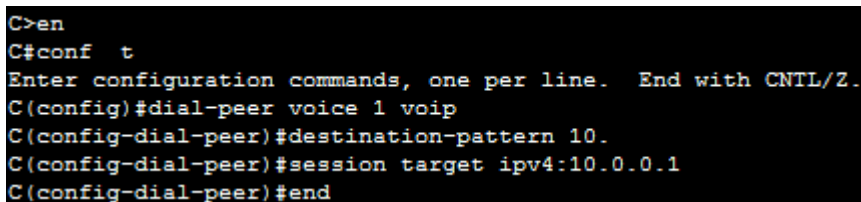
Figure 5.20 Static routes in router C .

Step 4. In PBX C, we configure the processing of VoIP traffic to PBX A.

To do this, we execute the commands:

```
en
conf t
dial-peer voice 1 voip
destination-pattern 10.
session target ipv4:10.0.0.1
end
```

Note: here we also configure the number prefix to PBX C (**10**). The **dot** that follows the prefix is important - it stands for a single digit from 0 to 9.

```
C>en
C#conf  t
Enter configuration commands, one per line.  End with CNTL/Z.
C(config)#dial-peer voice 1 voip
C(config-dial-peer)#destination-pattern 10.
C(config-dial-peer)#session target ipv4:10.0.0.1
C(config-dial-peer)#end
```

Figure 5.21 Configuring VoIP traffic from router C to router A.

Step 5. We check the communication between IP phones belonging to different exchanges.

We can now check whether phones located in different exchanges can call each other. To carry out a communication check of the phone located in PBX A (**101**) to the phone located in PBX C (**582**), we will dial the phone number **101**, which will call the phone number **582**.
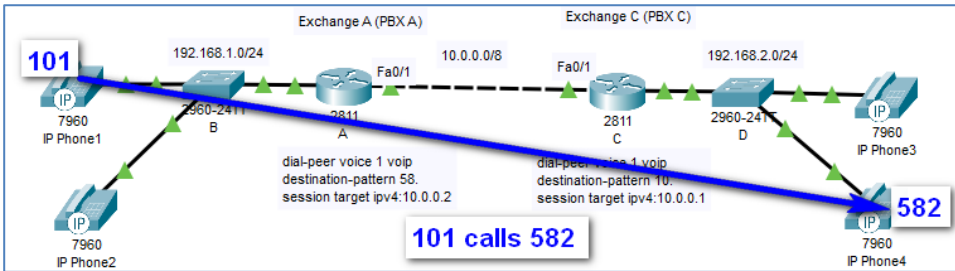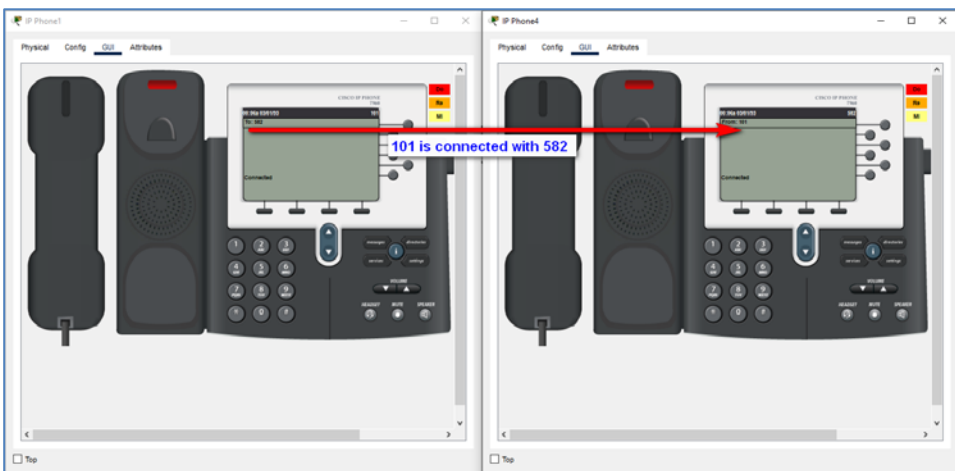
Figure 5.22 Phone 101 is calling Phone 582.

Figure 5.23 Phone 101 is connected with phone 582.

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