American International University-Bangladesh (AIUB)

Faculty of Science and Technology (FST)
Department of Computer Science (CS)
Undergraduate Program

I. Course Code and Title:
COE 3206: Computer Networks

II. Credit:
3 credits

III. Nature:
Core Course for CS, CSE, CSSE, SE, CIS

Lab Manual

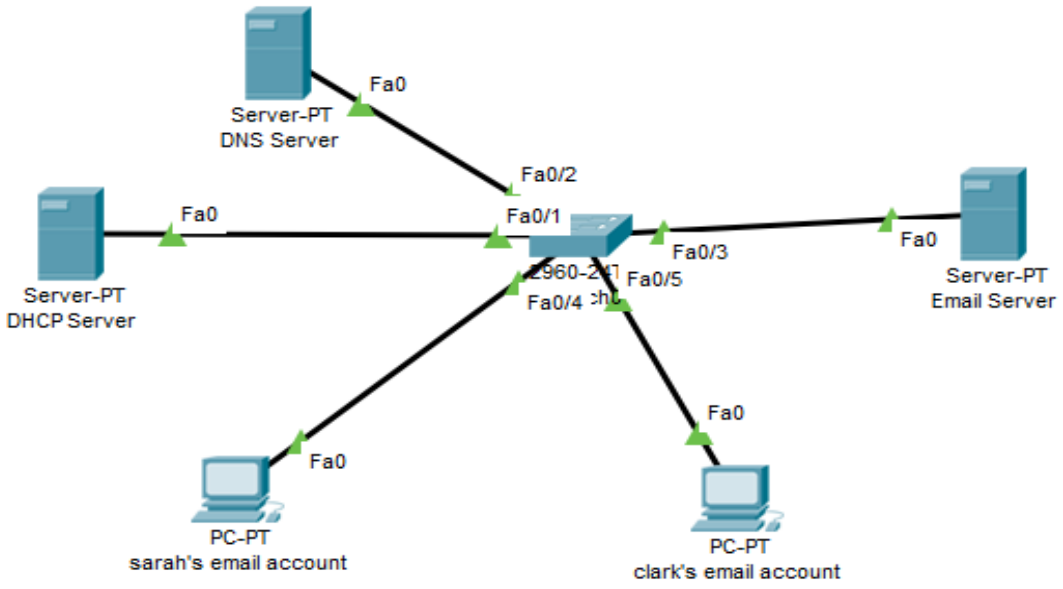
Title: Configuration of DNS, DHCP and Email servers

Abstract: This experiment is designed to introduce

1. DNS server configuration
2. DHCP server configuration
3. Email server configuration

Software: cisco packet tracer (version 7.3.0)

Network Design

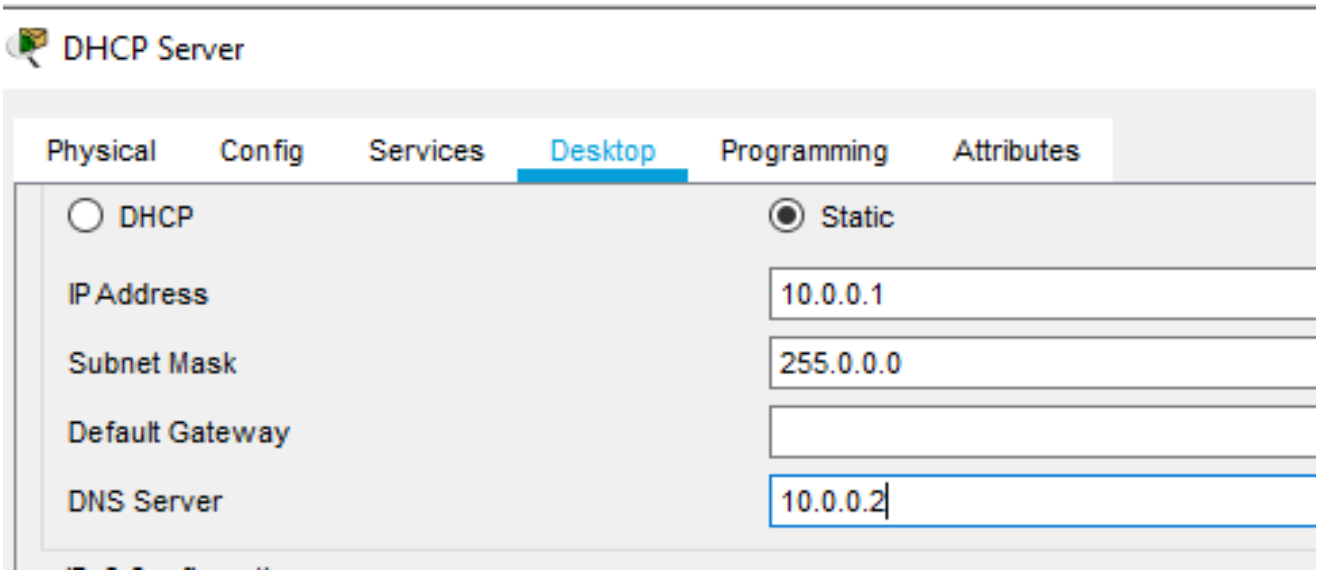


1st server: DHCP server

Desktop tab

→ IP configuration: Configure it manually

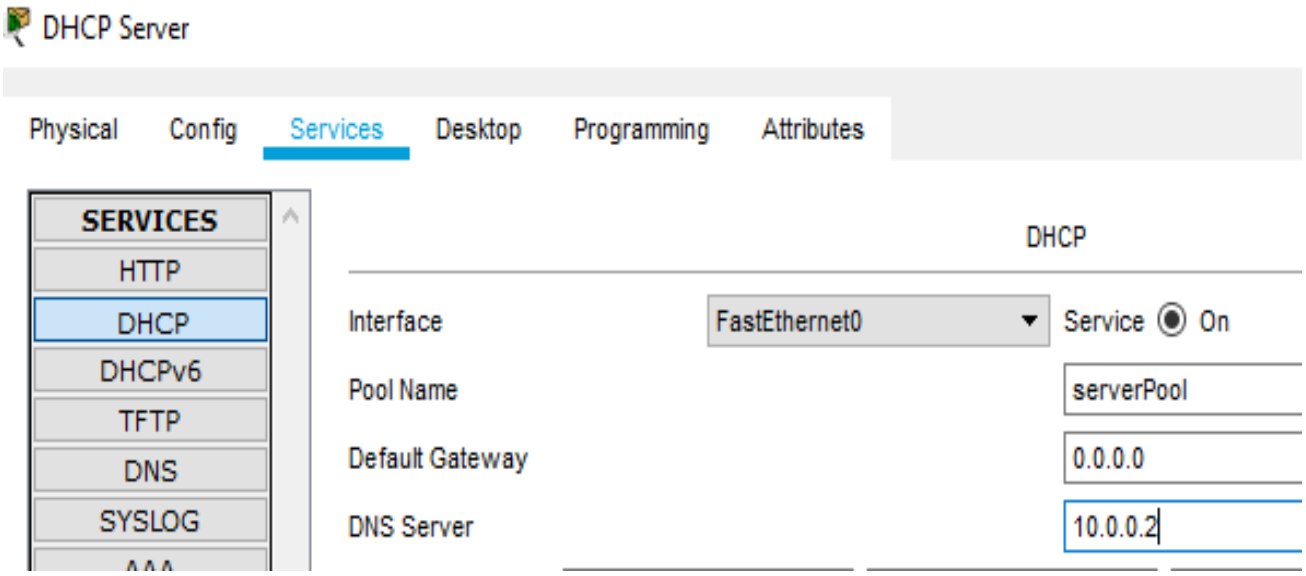
- Configure IP address,
- Configure subnet mask and
- Configure DNS server



Service tab

Activate service by clicking ’on’

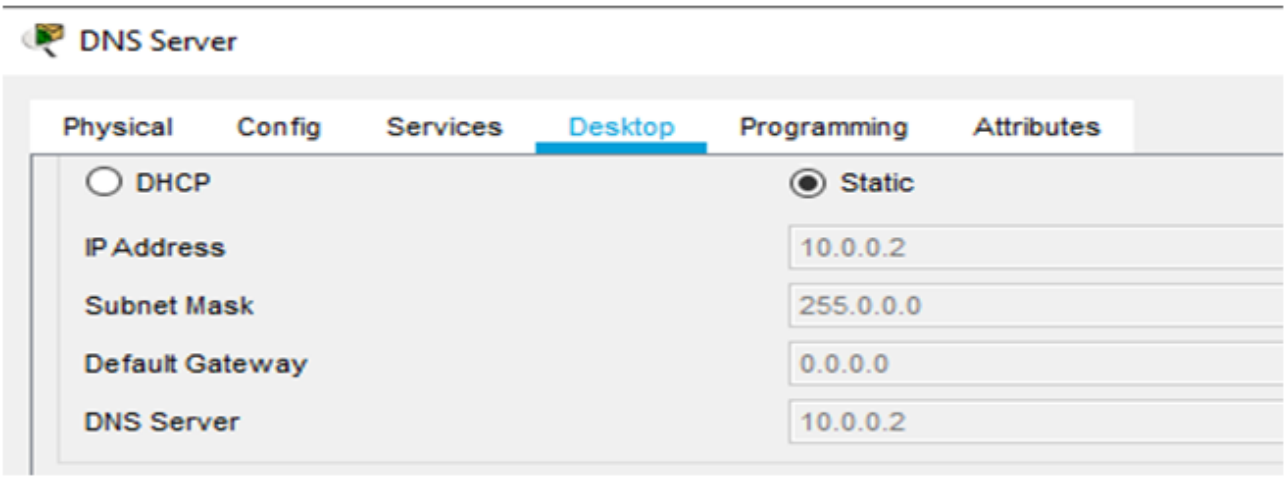
Assign 10.0.0.2 as DNS server



2nd Server: DNS server

Desktop tab

→ Ip configuration: Since this is a server, we will set a static IP configuration.

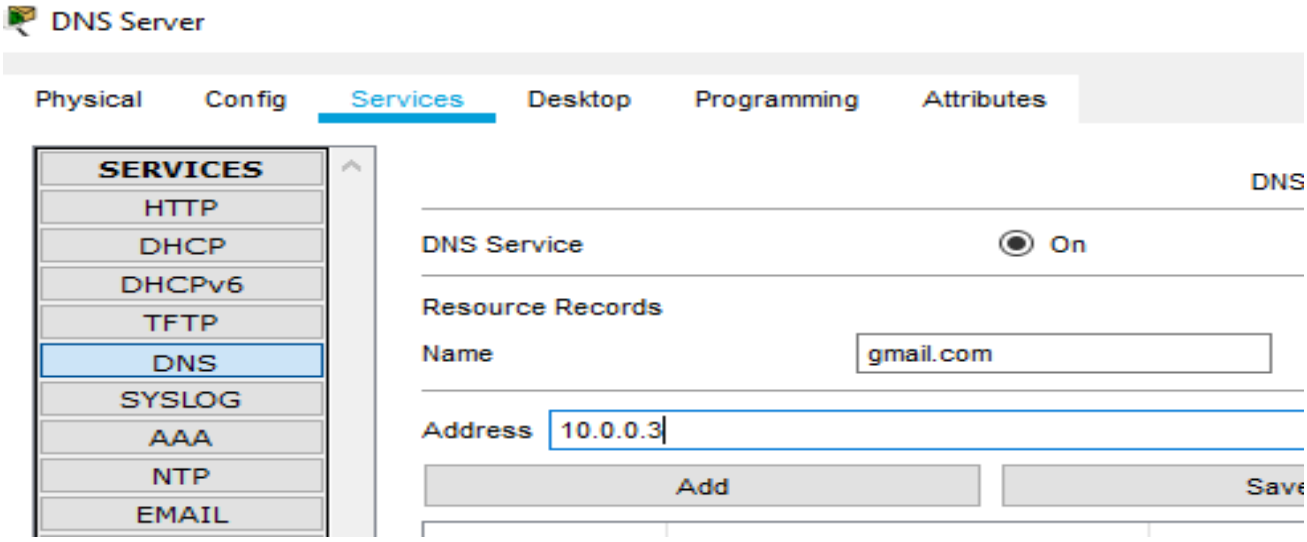


Service tab

Activate service by clicking ’on’

Write down ‘gmail.com’ in ‘Name’ box and ‘10.0.0.3’ in the ‘Address’ box

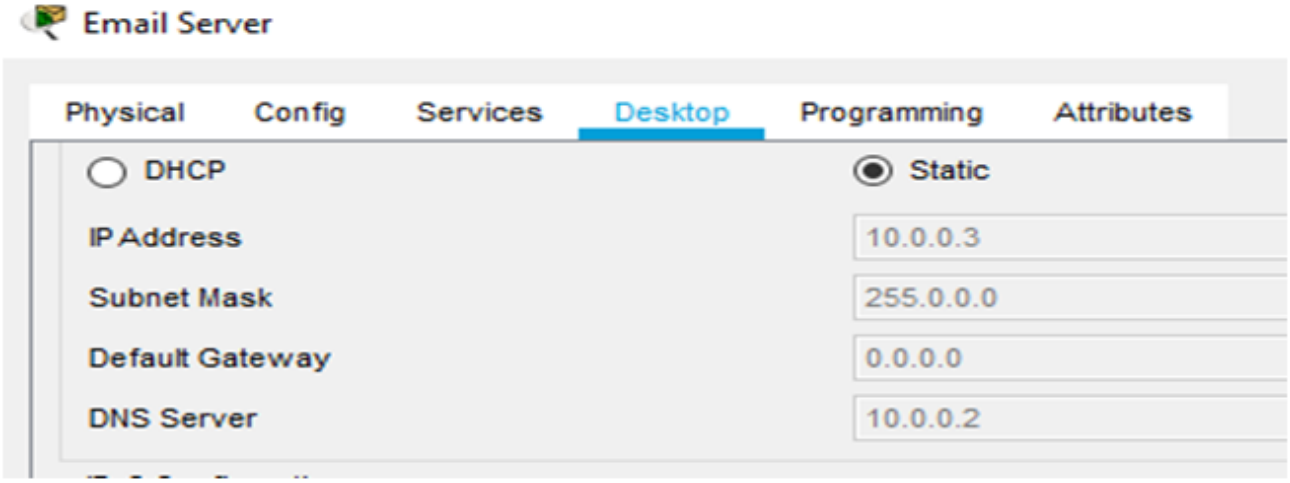
Then, click “Add” to store the record.



3rd Server: Email server

Desktop tab

→ IP configuration: Since this is a server, we will set a static IP configuration.



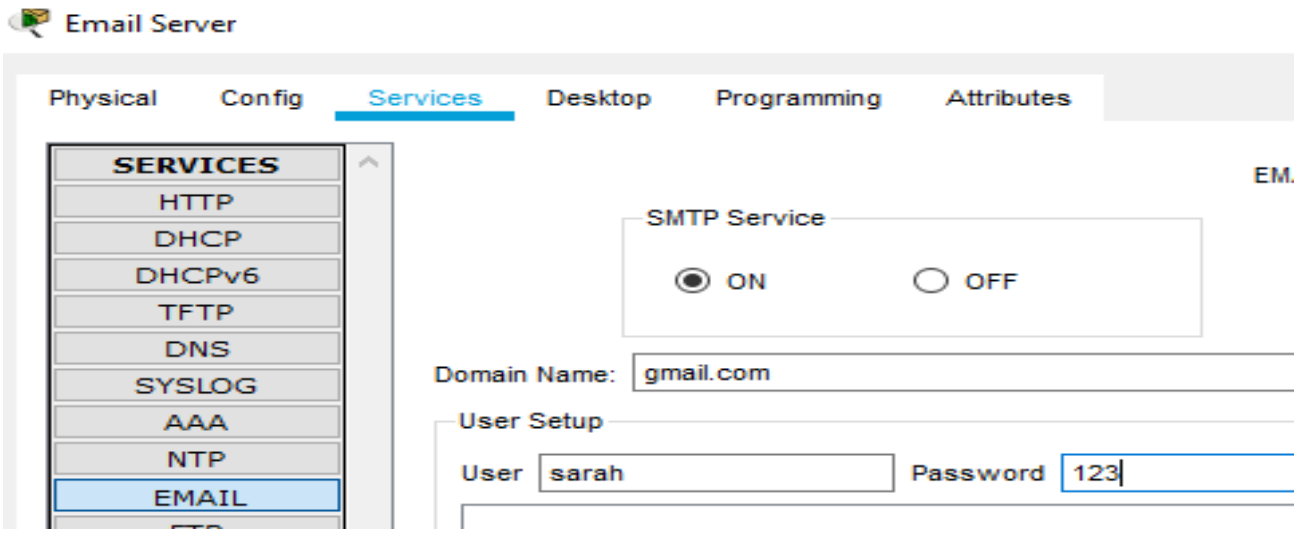
Service tab

Write down ‘gmail.com’ in ‘Domain name’ box

Press ‘set’ button

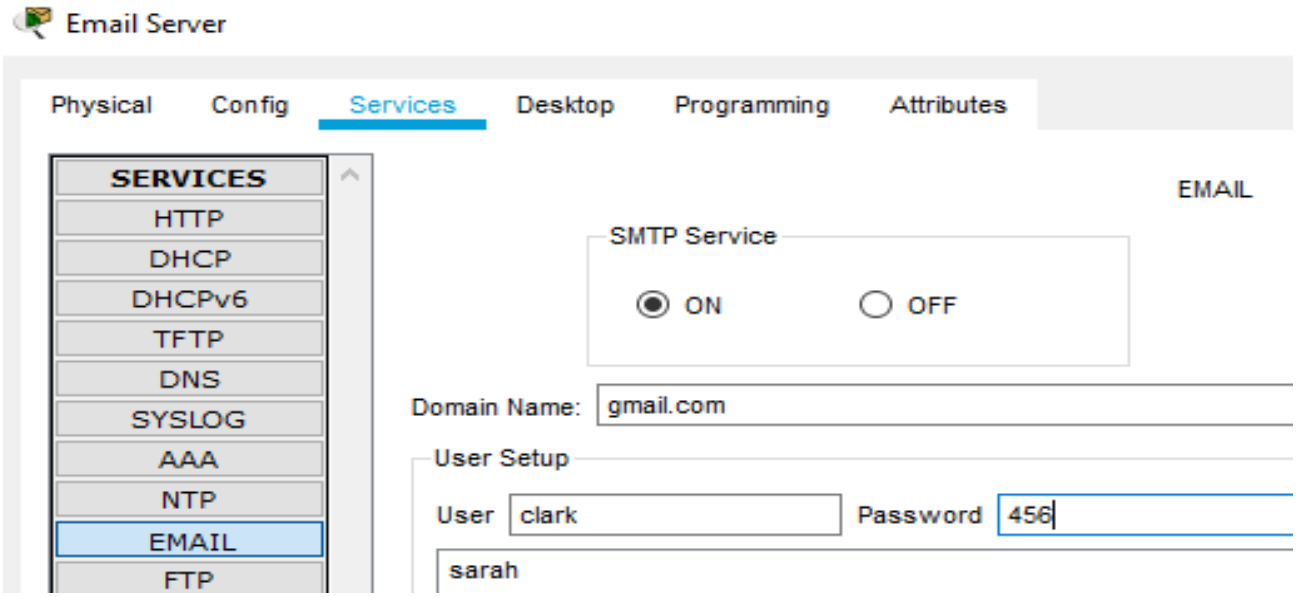
Write down ‘sarah’ in ‘user’ box and ‘123’ in ‘password’ box

Press ‘+’ button



Write down ‘clark’ in ‘user’ box and ‘456’ in ‘password’ box

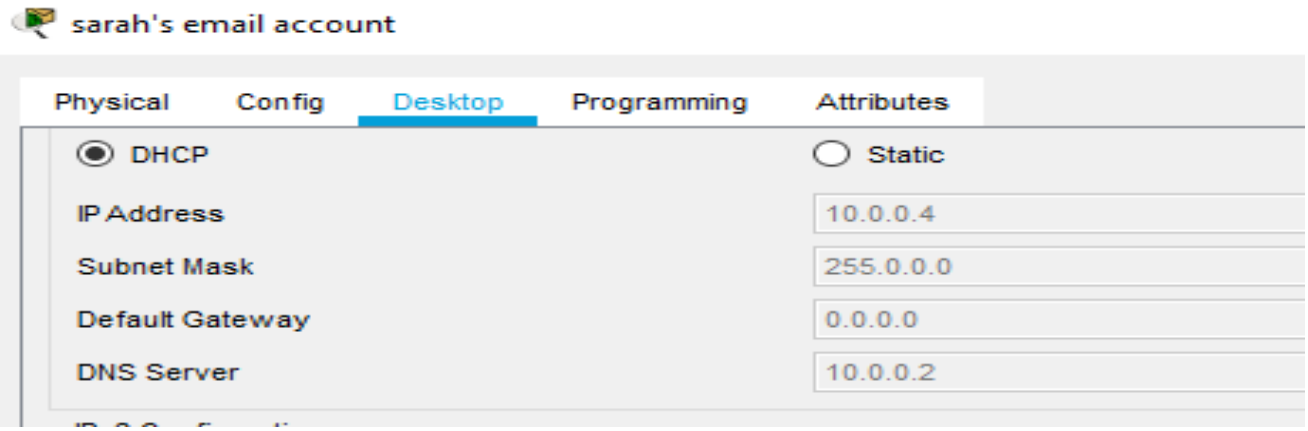
Press ‘+’ button



Pc0

Desktop tab

→ IP configuration: by clicking the DHCP option



Desktop tab

→ Email tab: configure mail

Write down ‘sarah’ in ‘Your name’ box

Write down ‘sarah@gmail.com’ in ‘Email address’ box

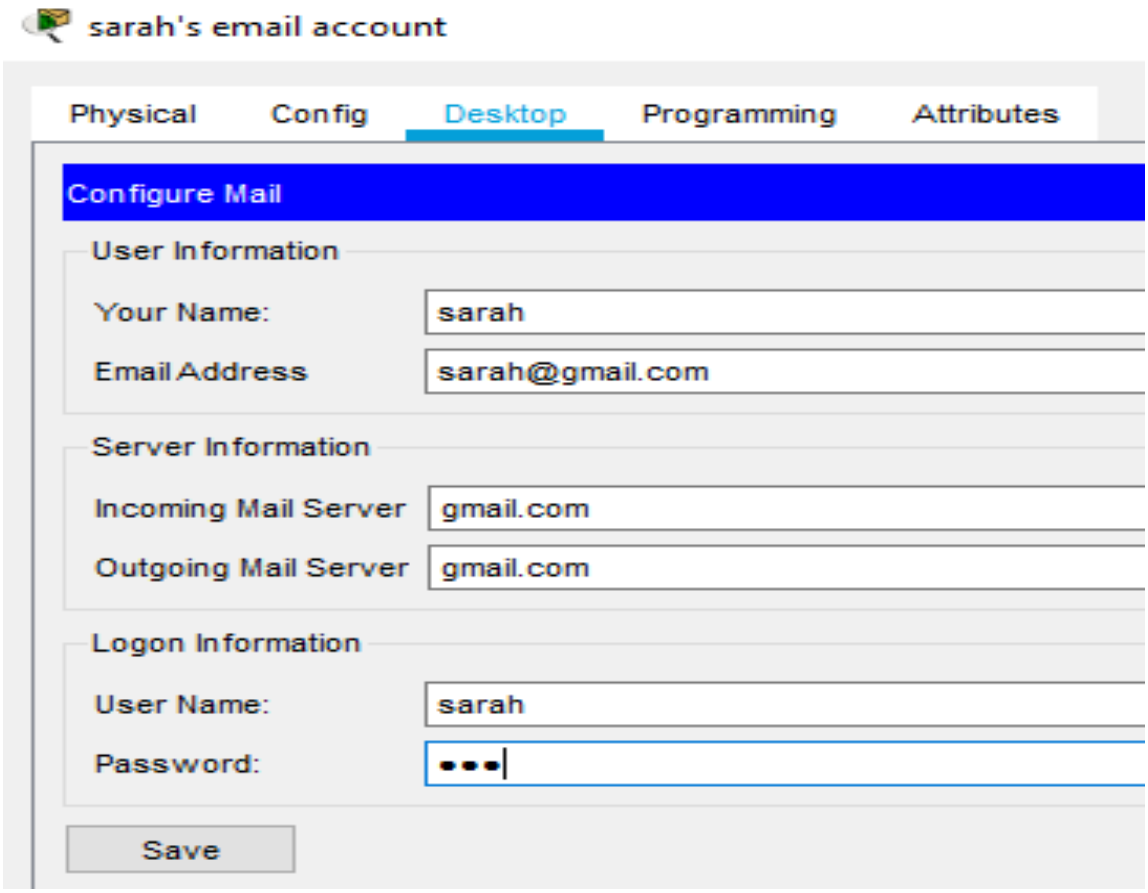
Write down ‘gmail.com’ in ‘Incoming mail server’ box

Write down ‘gmail.com’ in ‘Outgoing mail server’ box

Write down ‘sarah’ in ‘User Name’ box

Write down ‘123’ in ‘password’ box

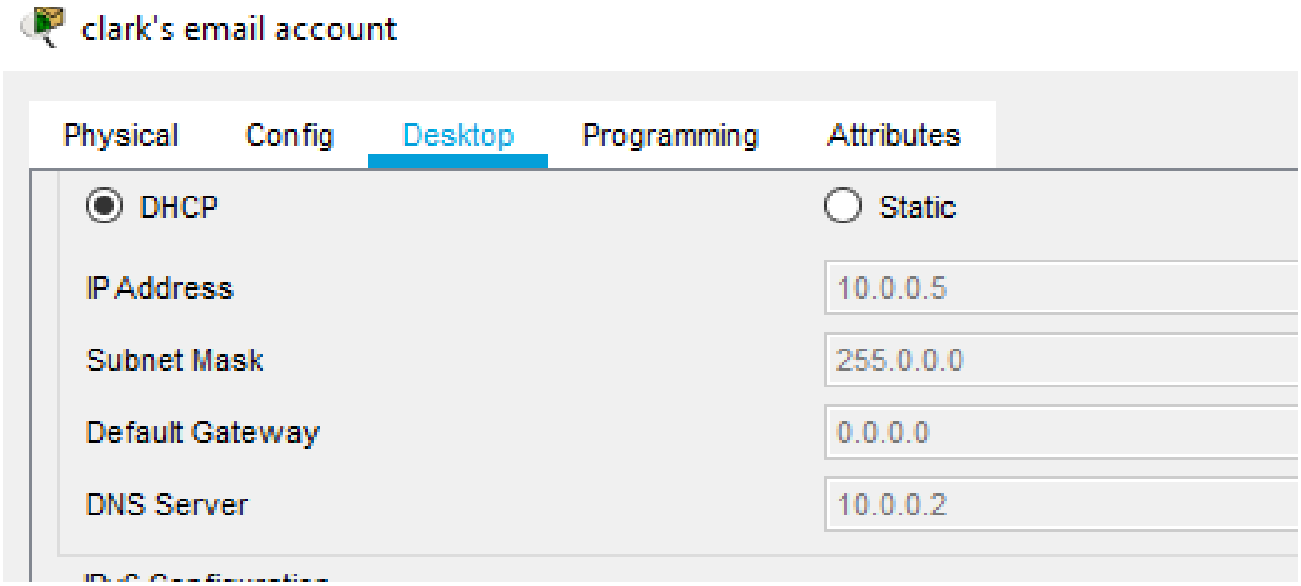
Press ‘save’ button



Pc1

Desktop tab

→ IP configuration: by clicking the DHCP option



Desktop tab

→ Email tab: Configure mail

Write down ‘clark’ in ‘Your name’ box

Write down ‘clark@gmail.com’ in ‘Email address’ box

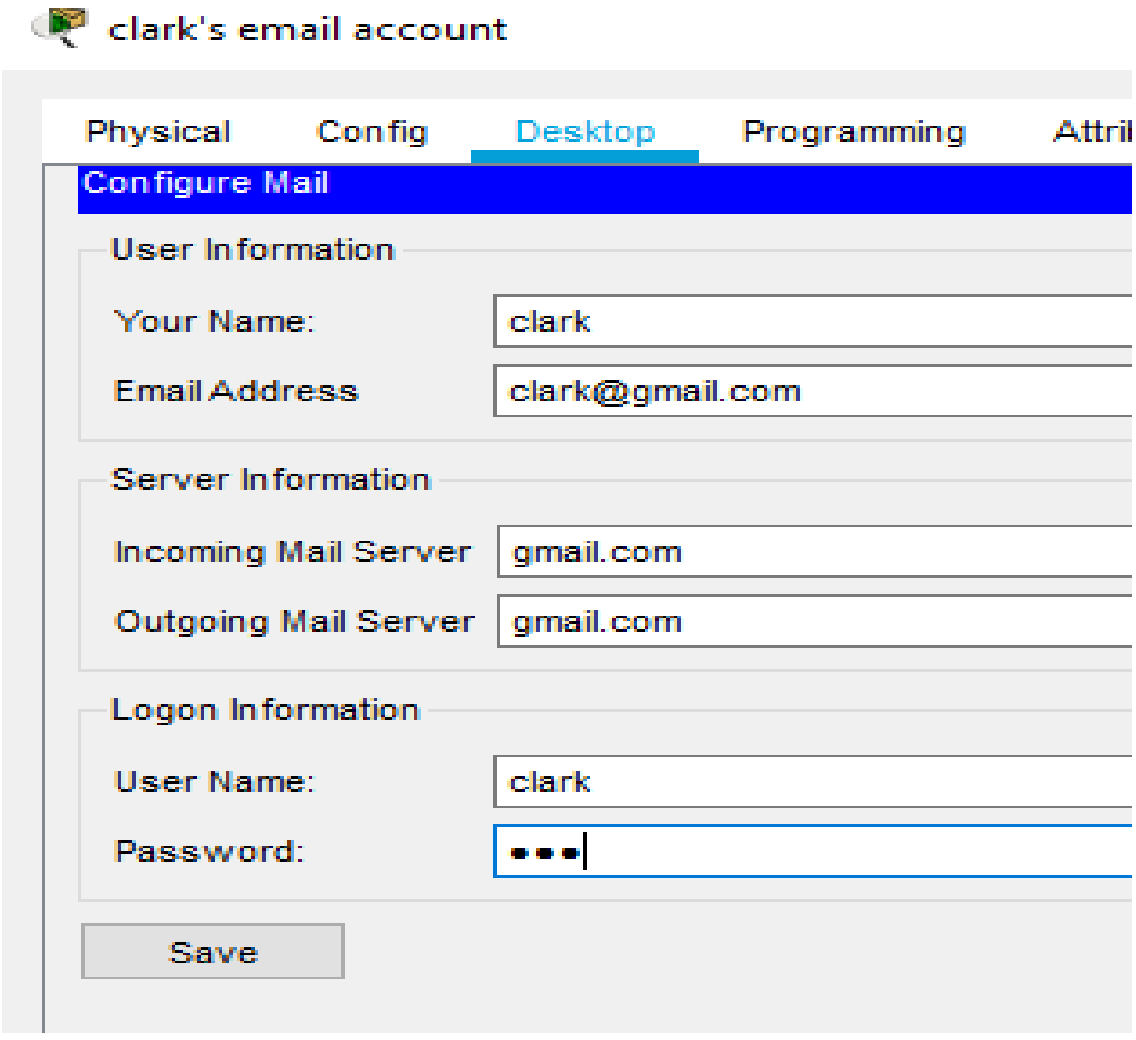
Write down ‘gmail.com’ in ‘Incoming mail server’ box

Write down ‘gmail.com’ in ‘Outgoing mail server’ box

Write down ‘clark’ in ‘User Name’ box

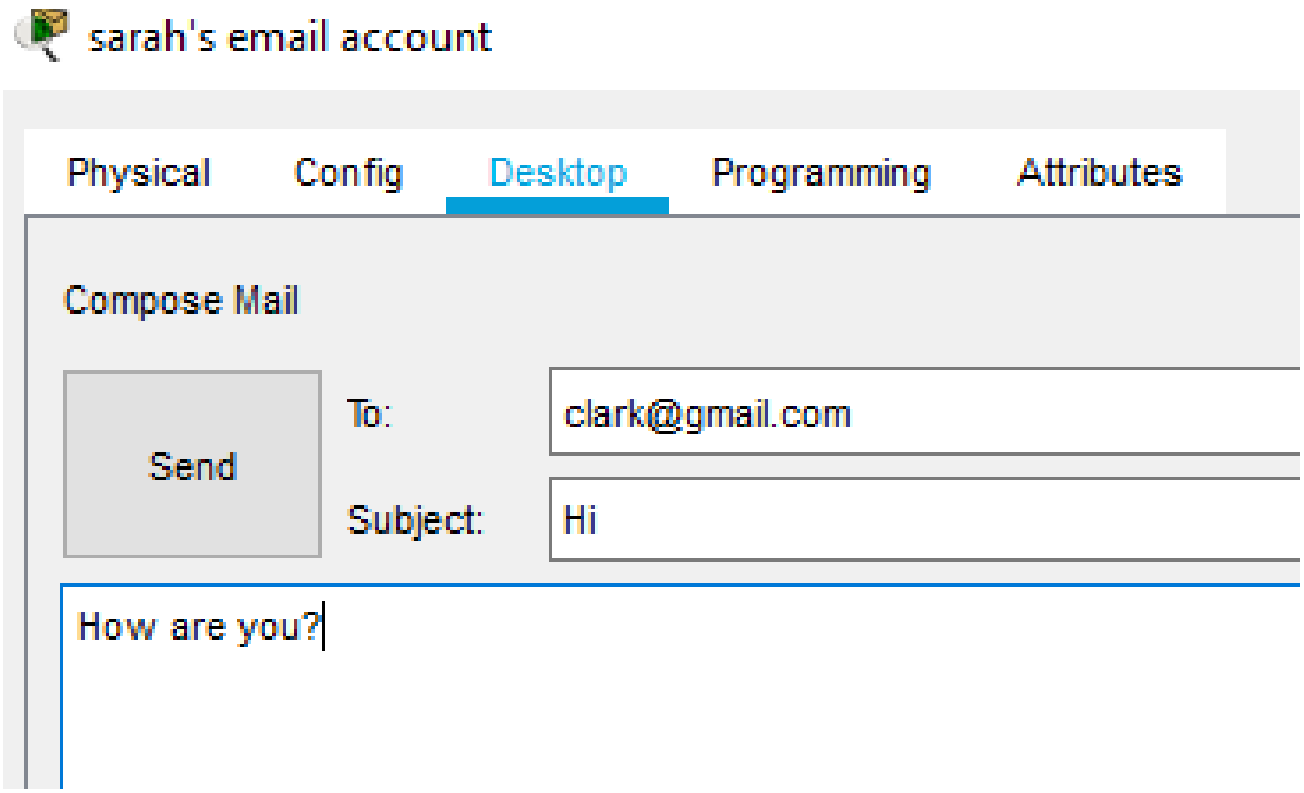
Write down ‘456’ in ‘password’ box

Press ‘save’ button

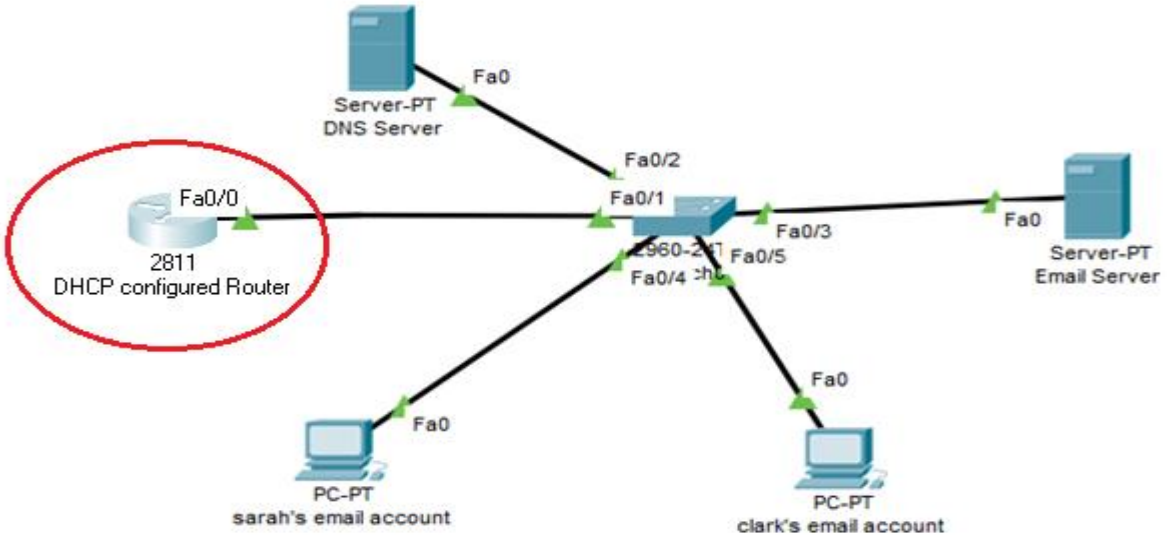


Now you can compose and send mail

Open Desktop tab of PC0 and click Email. Then compose send email to Clark.



You can configure DHCP in a router as well. Consider the following network,



Router configuration

```
Router>en

Router#conf t

Router(config)#int f0/0

Router(config-if)#ip address 10.0.0.1 255.0.0.0

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#ip dhcp pool dpool

Router(dhcp-config)#network 10.0.0.0 255.0.0.0

Router(dhcp-config)#default-router 10.0.0.1

Router(dhcp-config)#dns-server 10.0.0.2

Router(dhcp-config)#exit
```

Note: All the other configuration remains the same.

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Course Code and Title: CSC 3116: Computer Networks

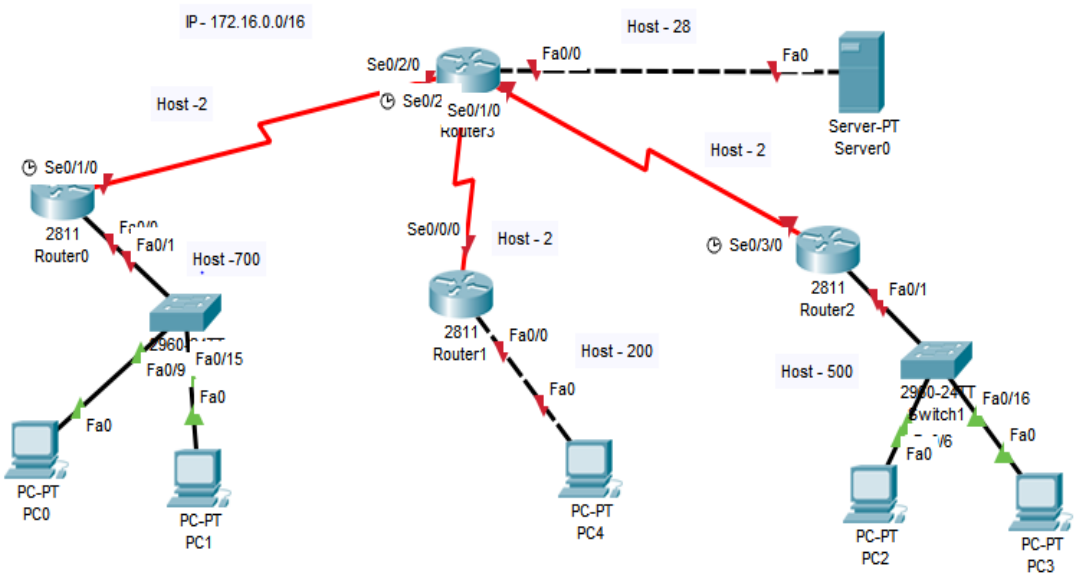
Credit: 3

Lab Manual: 06

Title: Configuration of EIGRP routing protocol with VLSM

Software: cisco packet tracer (version 7.3)

Network Design



Question:

IP address: 172.16.0.0/16

Default gateway – last valid IP of the range

Routing algorithm: EIGRP, autonomous no -170

Router 0: Host 700

Router 1: Host 100

Router 2: Host 500

Router 3: Host – 28

Serial:

router 0 to router 3 -1st subnet

router 1 to router 3 -2nd subnet

router 2 to router 3 -3rd subnet

Solution:

Configuration:

Router 0

```
Router>en
Router#conf t

Router(config)#int f0/0
Router(config-if)#ip address 172.16.3.254 255.255.252.0
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#int s0/1/0
Router(config-if)#ip address 172.16.7.33 255.255.255.252
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#router eigrp 170
Router(config-router)#network 172.16.0.0 0.0.3.255
Router(config-router)#network 172.16.7.32 0.0.0.3
Router(config-router)#exit
```

Router 1

```
Router>en
Router#conf t

Router(config)#int f0/0
Router(config-if)#ip address 172.16.6.254 255.255.255.0
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#int s0/0/0
Router(config-if)#ip address 172.16.7.37 255.255.255.252
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#router eigrp 170
Router(config-router)#network 172.16.6.0 0.0.0.255
Router(config-router)#network 172.16.7.36 0.0.0.3
```

Router 2

```
Router>en
Router#conf t

Router(config)#int f0/0
Router(config-if)#ip address 172.16.5.254 255.255.254.0
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#int s0/3/0
Router(config-if)#ip address 172.16.7.41 255.255.255.252
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#router eigrp 170
Router(config-router)#network 172.16.4.0 0.0.1.255
Router(config-router)#network 172.16.7.40 0.0.0.3
```

Router 3

```
Router>en
Router#conf t

Router(config)#int f0/0
Router(config-if)#ip address 172.16.7.30 255.255.255.224
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#int s0/2/0
Router(config-if)#ip address 172.16.7.34 255.255.255.252
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#int s0/2/1
Router(config-if)#ip address 172.16.7.38 255.255.255.252
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#int s0/1/0
Router(config-if)#ip address 172.16.7.42 255.255.255.252
Router(config-if)#no shut
Router(config-if)#exit

Router(config)#router eigrp 170
Router(config-router)#network 172.16.7.0 0.0.0.31
Router(config-router)#network 172.16.7.32 0.0.0.3
Router(config-router)#network 172.16.7.36 0.0.0.3
Router(config-router)#network 172.16.7.40 0.0.0.3
```

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Course Code and Title: CSC 3116: Computer Networks

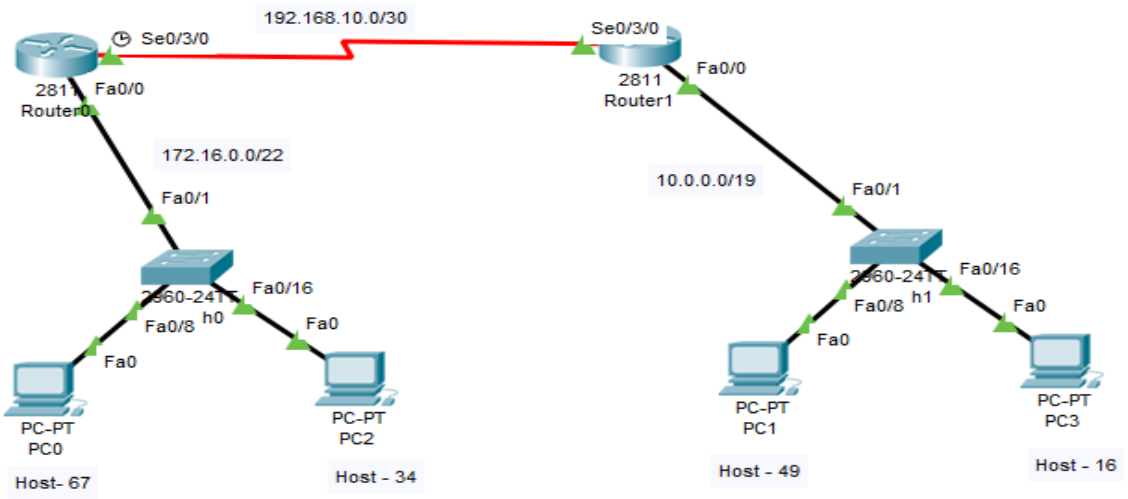
Credit: 3

Lab Manual:

Title: Configuration of Virtual Local Area Network (VLAN) with VLSM

Software: cisco packet tracer (version 7.3.0)

Network Design:



Question:

*Default gateway (IP before the broadcast ip), IP of Pc's (First IP of the range)

Router0

Switch0

Vlan 10- name Faculty (Range f0/2-f0/15)

Vlan -20- name Student (Range f0/16-f0/24)

Trunk port –f0/1

Hostname –AIUB

Router1

Switch1

Vlan 10- name Faculty (Range f0/2-f0/15)

Vlan -20- name Student (Range f0/16-f0/24)

Trunk port –f0/1

Hostname –NSU

Solution:

Configuration:

Switch0

➔ Creating vlans and assigning names to the vlans

```
Switch>en
Switch#config t
Switch(config)#vlan 10
Switch(config-vlan)#name Faculty
Switch(config-vlan)#exit

Switch(config)#vlan 20
Switch(config-vlan)#name Student
Switch(config-vlan)#exit
```

➔ Assigning ports to the vlans and trunking f0/1

```
Switch(config)#int range f0/2- f0/15
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#exit

Switch(config)#int range f0/16- f0/24
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#exit
```

Switch(config)#int f0/1

Switch(config-if)#switchport mode trunk

Switch(config-if)#switchport trunk allowed vlan all

Router0

Router>en

Router#conf t

➔ Assigning hostname AIUB to Router0

Router(config)#hostname AIUB

➔ Applying encapsulation and assigning ip to sub-interfaces

AIUB(config)#int f0/0

AIUB(config-if)#no shut

AIUB(config)#int f0/0.10

AIUB(config-subif)#encapsulation dot1q 10

AIUB(config-subif)#ip address 172.16.0.126 255.255.255.128

AIUB(config-subif)#exit

AIUB(config)#int f0/0.20

AIUB(config-subif)#encapsulation dot1q 20

AIUB(config-subif)#ip address 172.16.0.190 255.255.255.192

AIUB(config-subif)#exit

AIUB(config-if)#exit

➔ Assigning ip to serial interface

```
AIUB(config)#int s0/3/0
AIUB(config-if)#ip address 192.168.10.1 255.255.255.252
AIUB(config-if)#clock rate 64000
AIUB(config-if)#no shut
```

➔ Assigning routing protocol (OSPF with autonomous number 55)

```
AIUB(config)#router ospf 55
AIUB(config-router)#network 192.168.10.0 0.0.0.3 area 0
AIUB(config-router)#network 172.16.0.0 0.0.0.127 area 0
AIUB(config-router)#network 172.16.0.128 0.0.0.63 area 0
```

Switch1

```
Switch>en
Switch#conf t
```

➔ Creating vlans and assigning names to the vlans

```
Switch(config)#vlan 10
Switch(config-vlan)#name Faculty
Switch(config-vlan)#exit
Switch(config)#vlan 20
Switch(config-vlan)#name Student
Switch(config-vlan)#exit
```

➔ Assigning ports to the vlans and trunking f0/1

```
Switch(config)#int range f0/2-f0/15
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#exit

Switch(config)#int range f0/16-f0/24
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#exit

Switch(config)#int f0/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk allowed vlan all
```

Router1

```
Router>en
Router#conf t
Router(config)#int f0/0
Router(config-if)#no shut
```

➔ Assigning hostname NSU to Router1

```
NSU(config)#hostname NSU
```

➔ Applying encapsulation and assigning ip to sub-interfaces

```
NSU(config-if)#int f0/0.10
NSU(config-subif)#encapsulation dot1q 10
NSU(config-subif)#ip address 10.0.0.62 255.255.255.192
NSU(config-subif)#exit

NSU(config)#int f0/0.20
NSU(config-subif)#encapsulation dot1q 20
NSU(config-subif)#ip address 10.0.0.94 255.255.255.224
NSU(config-subif)#exit
```

➔ Assigning ip to serial interface

```
NSU(config)#int s0/3/0
NSU(config-if)#ip address 192.168.10.2 255.255.255.252
NSU(config-if)#no shut
NSU(config-if)#exit
```

➔ Assigning routing protocol (OSPF with autonomous number 80)

```
NSU(config)#router ospf 80
NSU(config-router)#network 192.168.10.0 0.0.0.3 area 0
NSU(config-router)#network 10.0.0.0 0.0.0.63 area 0
NSU(config-router)#network 10.0.0.64 0.0.0.31 area 0
```

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Course Code and Title: CSC 3116: Computer Networks

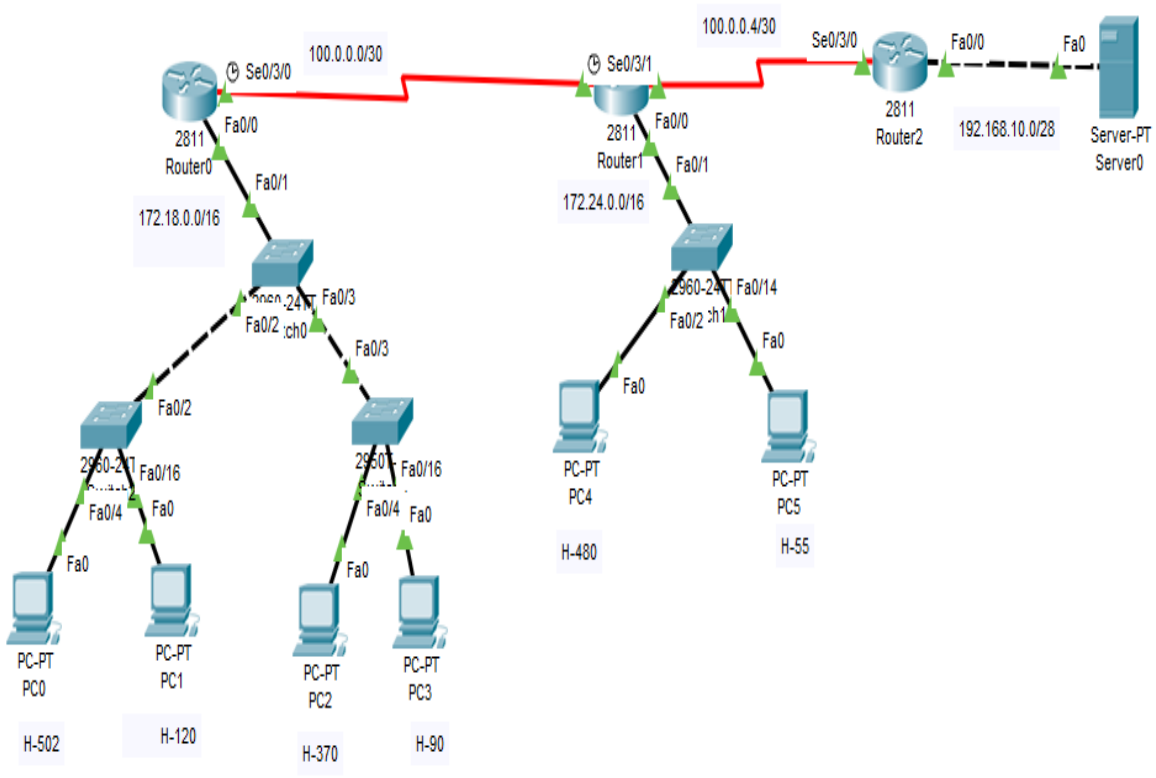
Credit: 3

Lab Manual: 10

Title: Configuration of VLAN, VLAN-VTP and NAT with DHCP

Software: cisco packet tracer (version 7.3.0)

Network Design:



Question:

Switch 0:

It is the server switch with the domain name AIUB

Two vlans are there CSE (vlan 2) and EEE (vlan 4)

Trunk port f0/1, f0/2 and f0/3

Switch 2:

It's the client switch

Range for vlan 2 is from f0/4 to f0/15 (Host -502)

Range for vlan 4 is from f0/16 to f0/24 (Host-120)

Switch 3:

It's the client switch

Range for vlan 2 is from f0/4 to f0/15 (Host -370)

Range for vlan 4 is from f0/16 to f0/24 (Host-90)

Switch 1:

Two vlans are there IT (vlan 3) and MKT (vlan 6)

Trunk port f0/1

Range for vlan 3 is from f0/2 to f0/13 (Host-480)

Range for vlan 6 is from f0/14 to f0/24 (Host-55)

Router 0:

Ip address is 172.18.0.0/16

Default gateway should be the last ip (ip before the broadcast)

DHCP pool name is dpool2 and dpool4

Ospf autonomous no is 40

Router 1:

Ip address is 172.24.0.0/16

Default gateway should be the last ip (ip before the broadcast)

DHCP pool name is dpool3 and dpool6

Ospf autonomous no is 80

Router 2:

Network ip address for Fast Ethrenet is 192.168.10.0/28

Default gateway should be the last ip (ip before the broadcast)

DHCP pool name is svr

Ospf autonomous no is 100

Apply Nat: Nat access-list should have the same number as vlan number.

Solution

Configuration:

Switch0

Switch>en

Switch#conf t

- **Assigning the name of VTP domain**

Switch(config)#vtp domain AIUB

- **Creating vlans and assigning names to the vlans**

Switch(config)#vlan 2

Switch(config-vlan)#name CSE

Switch(config-vlan)#exit

Switch(config)#vlan 4

Switch(config-vlan)#name EEE

Switch(config-vlan)#exit

- **Assigning trunk ports**

Switch(config)#int f0/1

Switch(config-if)#switchport mode trunk

Switch(config-if)#switchport trunk allowed vlan all

Switch(config-if)#exit

Switch(config)#int f0/2

Switch(config-if)#switchport mode trunk

Switch(config-if)#switchport trunk allowed vlan all

Switch(config-if)#exit

Switch(config)#int f0/3

Switch(config-if)#switchport mode trunk

Switch(config-if)#switchport trunk allowed vlan all

Switch1

Switch>en

Switch#conf t

- **Changing VTP mode**

Switch(config)#vtp mode client

- **Assigning ports to the vlans**

Switch(config)#int range f0/4-f0/15

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 2

Switch(config-if-range)#exit

Switch(config)#int range f0/16-f0/24

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 4

Switch2

Switch>en

Switch#conf t

- **Changing VTP mode**

Switch(config)#vtp mode client

- **Assigning ports to the vlans**

Switch(config)#int range f0/4-f0/15

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 2

Switch(config-if-range)#exit

Switch(config)#int range f0/16-f0/24

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 4

Router0

Router>en

Router#conf t

- **Applying encapsulation and assigning ip to sub-interfaces**

Router(config)#int f0/0

Router(config-if)#no shut

Router(config-if)#int f0/0.2

Router(config-subif)#encapsulation dot1q 2

Router(config-subif)#ip address 172.18.3.254 255.255.252.0

Router(config)#int f0/0.4

Router(config-subif)#encapsulation dot1q 4

Router(config-subif)#ip address 172.18.4.254 255.255.255.0

Router(config-subif)#exit

- **Creating DHCP pool**

Router(config)#ip dhcp pool dpool2

Router(dhcp-config)#network 172.18.0.0 255.255.252.0

Router(dhcp-config)#default 172.18.3.254

Router(dhcp-config)#exit

Router(config)#ip dhcp pool dpool4

Router(dhcp-config)#network 172.18.4.0 255.255.255.0

Router(dhcp-config)#default 172.18.4.254

- **Assigning ip to serial interface**

Router(config)#int s0/3/0

Router(config-if)#ip address 100.0.0.1 255.255.255.252

Router(config-if)#clock rate 64000

Router(config-if)#no shut

Router(config-if)#exit

- **Assigning routing protocol (OSPF with autonomous number 40)**

Router(config)#router ospf 40

Router(config-router)#network 172.18.0.0 0.0.3.255 area 0

Router(config-router)#network 172.18.4.0 0.0.0.255 area 0

Router(config-router)#network 100.0.0.0 0.0.0.3 area 0

Switch3

Switch>en

Switch#conf t

- **Creating vlans and assigning names to the vlans**

Switch(config)#vlan 3

Switch(config-vlan)#name HR

Switch(config-vlan)#exit

Switch(config)#vlan 6

Switch(config-vlan)#name MKT

Switch(config-vlan)#exit

- **Assigning trunk ports**

Switch(config)#int f0/1

Switch(config-if)#switchport mode trunk

Switch(config-if)#switchport trunk allow vlan all

Switch(config-if)#exit

- **Assigning ports to the vlans**

Switch(config)#int range f0/2-f0/13

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 3

Switch(config-if-range)#exit

Switch(config)#int range f0/14-f0/24

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 6

Router1

Router>en

Router#conf t

- **Assigning ip to serial interface**

Router(config)#int s0/3/0

Router(config-if)#ip address 100.0.0.2 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int s0/3/1

Router(config-if)#ip address 100.0.0.5 255.255.255.252

Router(config-if)#clock rate 64000

Router(config-if)#no shut

Router(config)#int f0/0

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int f0/0

Router(config-if)#no shut

- **Applying encapsulation and assigning ip to sub-interfaces**

Router(config-if)#int f0/0.3

Router(config-subif)#encapsulation dot1q 3

Router(config-subif)#ip address 172.24.1.254 255.255.254.0

Router(config-subif)#exit

Router(config)#int f0/0.6

Router(config-subif)#encapsulation dot1q 6

Router(config-subif)#ip address 172.24.2.62 255.255.255.192

Router(config-subif)#exit

- **Creating DHCP pool**

Router(config)#ip dhcp pool dpool3

Router(dhcp-config)#network 172.24.0.0 255.255.254.0

Router(dhcp-config)#default 172.24.1.254

Router(dhcp-config)#exit

Router(config)#ip dhcp pool dpool6

Router(dhcp-config)#network 172.24.2.0 255.255.255.192

Router(dhcp-config)#default 172.24.2.62

Router(dhcp-config)#exit

- **Assigning routing protocol (OSPF with autonomous number 80)**

Router(config)#router ospf 80

Router(config-router)#network 172.24.0.0 0.0.1.255 area 0

Router(config-router)#network 172.24.2.0 0.0.0.63 area 0

Router(config-router)#network 100.0.0.0 0.0.0.3 area 0

Router(config-router)#network 100.0.0.4 0.0.0.3 area 0

Router2

Router>en

Router#conf t

- **Assigning ip to serial interface**

Router(config)#int s0/3/0

Router(config-if)#ip address 100.0.0.5 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

- **Assigning ip to fast-ethernet interface**

Router(config)#int f0/0

Router(config-if)#ip address 192.168.10.14 255.255.255.240

Router(config-if)#no shut

Router(config-if)#exit

- **Creating DHCP pool**

Router(config)#ip dhcp pool svr

Router(dhcp-config)#network 192.168.10.0 255.255.255.240

Router(dhcp-config)#default 192.168.10.14

Router(dhcp-config)#exit

- **Assigning routing protocol (OSPF with autonomous number 100)**

Router(config)#router ospf 100

Router(config-router)#network 100.0.0.4 0.0.0.3 area 0

Router(config-router)#network 192.168.10.0 0.0.0.15 area 0

- **Natting in Router 0**

Router(config)#access-list 2 permit 172.18.0.0 0.0.3.255

Router(config)#access-list 4 permit 172.18.4.0 0.0.0.255

Router(config)#ip nat inside source list 2 interface s0/3/0 overload

Router(config)#ip nat inside source list 4 interface s0/3/0 overload

Router(config)#int s0/3/0

Router(config-if)#ip nat outside

Router(config-if)#exit

Router(config)#int f0/0

Router(config-if)#ip nat inside

- **Natting in Router 1**

Router(config)#access-list 3 permit 172.24.0.0 0.0.1.255

Router(config)#access-list 6 permit 172.24.2.0 0.0.0.63

Router(config)#ip nat inside source list 3 interface s0/3/1 overload

Router(config)#ip nat inside source list 6 interface s0/3/1 overload

Router(config)#int s0/3/1

Router(config-if)#ip nat outside

Router(config-if)#exit

Router(config)#int f0/0

Router(config-if)#ip nat inside

- **Natting in Router 2**

Router(config)#ip nat inside source static 192.168.10.1 100.0.0.6

Router(config)#int f0/0

Router(config-if)#ip nat inside

Router(config-if)#exit

Router(config)#int s0/3/0

Router(config-if)#ip nat outside

RIP

Course Code: CSC 3116 Course Title: Computer Networks

Dept. of Computer Science
Faculty of Science and Technology

Lecturer No:	**Lab 5**	**Week No:**	**5**	**Semester:**	**Summer 22-23**
Lecturer:	*Shakila Rahman; Shakila.Rahman@aiub.edu*				

Lecture Outline

1. Introduction
2. Static routing vs dynamic routing
3. Dynamic routing
4. Routing information protocol (RIP)

Introduction

- Routing
  - routing is the act of forwarding network packets from a source network to a destination networks by a router based on its routing table [2].

CODE	NETWORK, MASK	AD/METRIC	NEXT HOP	INTERFACE
O	10.0.0.0 /8	110/20	200.1.1.1	S0
O	172.16.0.0 /16	110/15	200.1.1.1	S0
O	192.168.1.0 /24	110/20	200.2.2.2	S1
C	210.1.1.4 /30	0/0	Directly connected	E0

Fig. A simplified routing table [2]

Introduction

- How is the routing table created?
  - Static routing
    - If it is done manually by inputting information for each destination network by a network engineer,
    - Suitable for very small network
  - Dynamic routing
    - If the table is created and modified automatically depending on the network condition by a routing protocol
    - Dynamic routing can be deployed on small to large size network.

Dynamic Routing

Features

- Facilitates the exchange of routing information between routers
- Allow routers to dynamically learn information about remote networks and automatically add this information to their own routing tables
- Determines the best path to each network

Dynamic Routing....

Ways to classify routing protocols

- Interior Gateway Protocols or Exterior Gateway protocols
- Distance vector or Link state

Dynamic Routing….

IGP

- IGP
  - Routing inside an autonomous system (AS), where, AS is a collection of network under a common administrator
  - Example
    - Routing Information Protocol (RIP) version 1
    - Interior Gateway Routing Protocol (IGRP)
    - Enhanced IGRP (EIGRP)
    - Open Shortest Path First (OSPF)
    - Intermediate System (IS)-IS

Dynamic Routing….

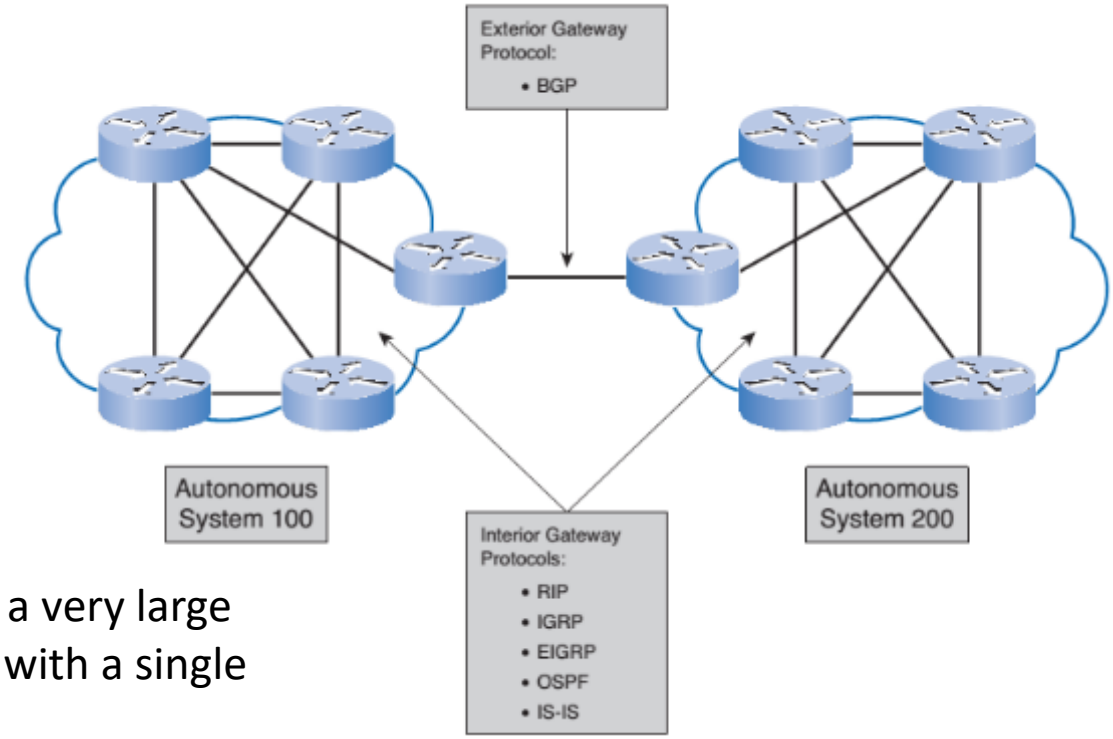
EGP

- EGP
  - Routing between autonomous systems(AS)
  - Example
    - Border Gateway Protocol (BGP)

Dynamic Routing....

Classification

Autonomous systems



An autonomous system (AS) is a very large network or group of networks with a single routing policy.

Dynamic Routing....

Distance vector routing

- A router communicates with its neighbors only for populating its routing table
- *Distance vector* means that routes are advertised as *vectors* of distance and direction
- Distance is defined in terms of a metric such as hop count, and direction is simply the next hop router or exit interface.
- Bellman-Ford algorithm is used for the best-path route determination.
- Some distance vector protocols periodically send complete routing tables to all connected neighbors.
- In large networks, these routing updates can become enormous, causing significant traffic on the links.
- Example

  RIP, EIGRP

Dynamic Routing....

Link state routing

- A router configured with a *linkstate* routing protocol can create a "complete view," or topology, of the network by gathering information from all the other routers.
- A router communicates with all other routers of the network
- Only send update (partial) when there is any change in the network topology
- Example

  OSPF

Dynamic Routing....

Administrative Distance

- The term *trustworthiness* is commonly used when defining administrative distance.
- Administrative distance (AD) defines the preference of a routing source.
- Administrative distance is an integer value from 0 to 255.
- The lower the value, the more preferred the route source.
- An administrative distance of 0 is the most preferred.
- Only a directly connected network has an administrative distance of 0, which cannot be changed.

Dynamic Routing....

Administrative distance

Route Source	AD
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

RIP

Features

- Distance vector routing protocol
- Hop count is used as the metric for path selection.
- If the hop count for a network is greater than 15, RIP cannot supply a route to that network.
- Routing updates are broadcast or multicast every 30 seconds, by default.
- If for some reason, an update for a particular route is not received within a period of 180 seconds then that specific route is declared as invalid and the router which identified that, informs all its neighbors about this invalid route.
- Has two versions: RIPv1 & RIPv2

RIP

RIP v1-vs-RIPv2

- **Uses Classless addressing**

  RIPv1 uses classful addressing, RIPv2 uses VLSM

- **Multicasting vs Broadcasting**

  Version 1 of RIP uses broadcasting (to 255.255.255.255) to send RIP messages to every neighbor. In this way, all the routers on the network receive the packets, as well as the hosts. RIP version 2, on the other hand, uses the all-router multicast address (224.0.0.9) to send the RIP messages only to RIP routers in the network.

- **Updates**

  RIPv2 sends and receives version 2 updates only. RIPv1 sends version 1 updates and receives both 1 and 2, however version 2 information is ignored.

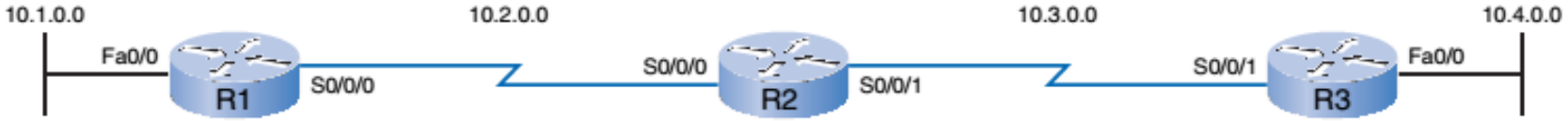
- **Authentication**

  RIPv2 ensure authentication, while RIPv1 does not

RIP

Routing table update

Cold Start



Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0

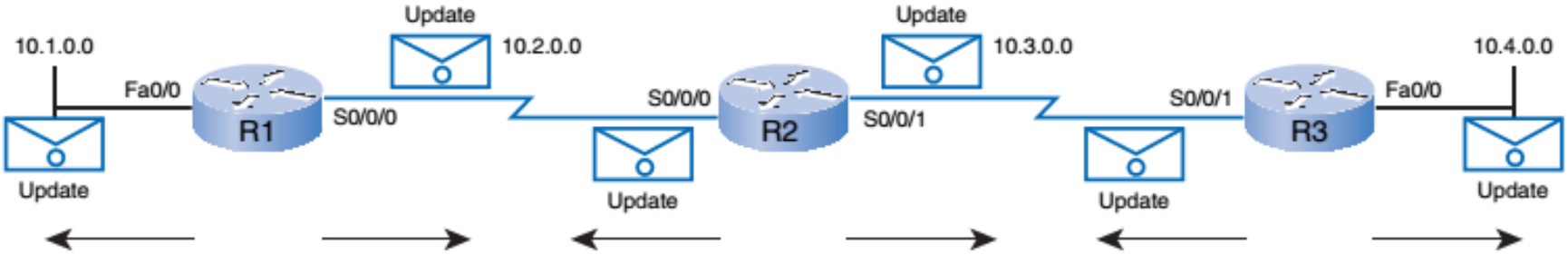
Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0

Network	Interface	Hop
10.3.0.0	S0/0/1	0
10.4.0.0	Fa0/0	0

Topic Heading..

Routing table update

❖Initial Exchange of Information



Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0

Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0

Network	Interface	Hop
10.3.0.0	S0/0/1	0
10.4.0.0	Fa0/0	0

Topic Heading..

Routing table update

❖Table Updating

Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/0	1

Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0
10.1.0.0	S0/0/0	1
10.4.0.0	S0/0/1	1

Network	Interface	Hop
10.3.0.0	S0/0/1	0
10.4.0.0	Fa0/0	0
10.2.0.0	S0/0/1	1

Topic Heading..

Routing table update

❖Next Update

No New Information

Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/0	1
10.4.0.0	S0/0/0	2

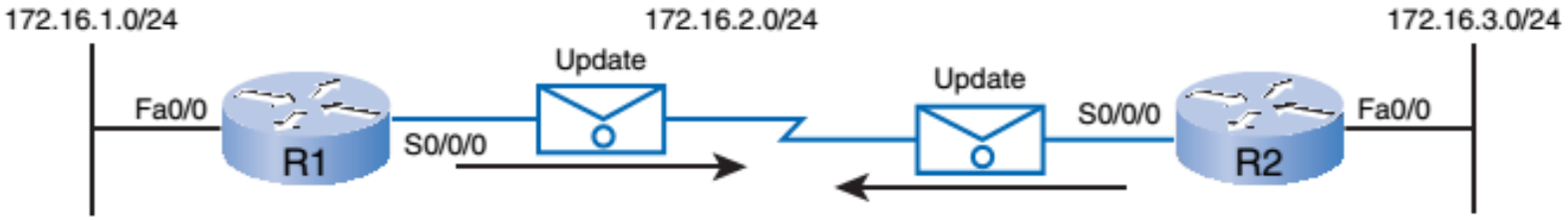
Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0
10.1.0.0	S0/0/0	1
10.4.0.0	S0/0/1	1

Network	Interface	Hop
10.3.0.0	S0/0/1	0
10.4.0.0	Fa0/0	0
10.2.0.0	S0/0/1	1
10.1.0.0	S0/0/1	2

R1 and R3 now have complete routing tables.

Topic Heading..

Another Example

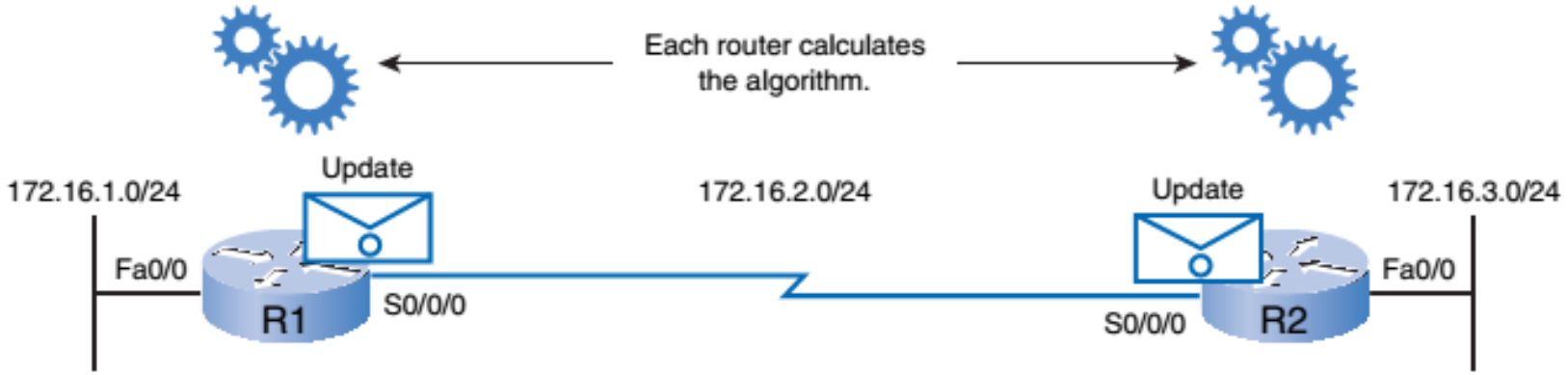


Network	Interface	Hop
172.16.1.0/24	Fa0/0	0
172.16.2.0/24	S0/0/0	0

Network	Interface	Hop
172.16.2.0/24	S0/0/0	0
172.16.3.0/24	Fa0/0	0

Topic Heading..

New route



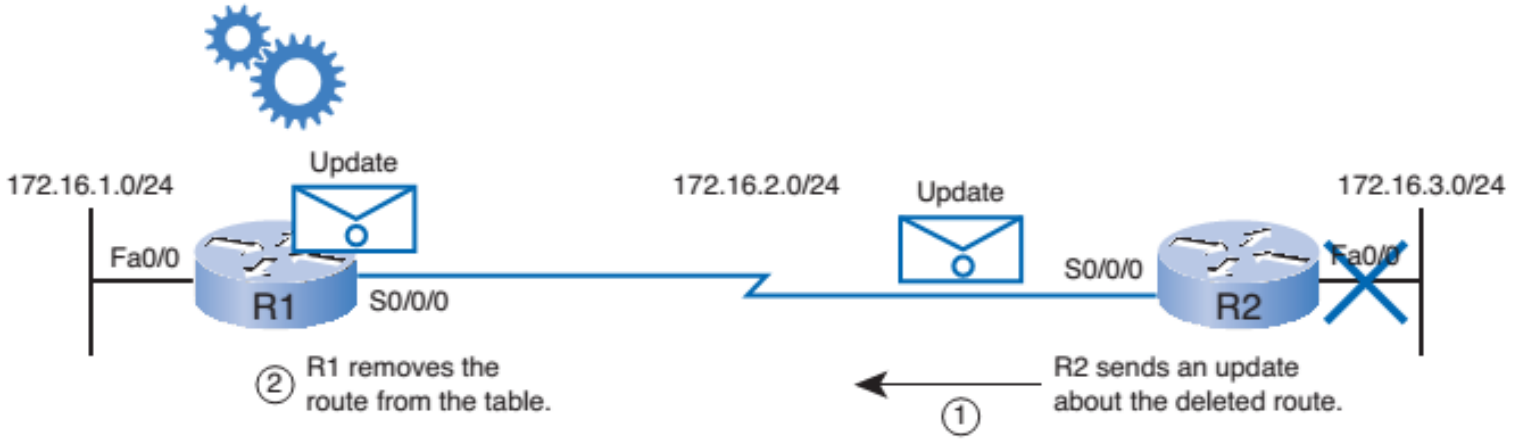
Network	Interface	Hop
172.16.1.0/24	Fa0/0	0
172.16.2.0/24	S0/0/0	0
172.16.3.0/24	S0/0/0	1

New routes are installed.

Network	Interface	Hop
172.16.2.0/24	S0/0/0	0
172.16.3.0/24	Fa0/0	0
172.16.1.0/24	S0/0/0	1

Topic Heading..

Removing a route

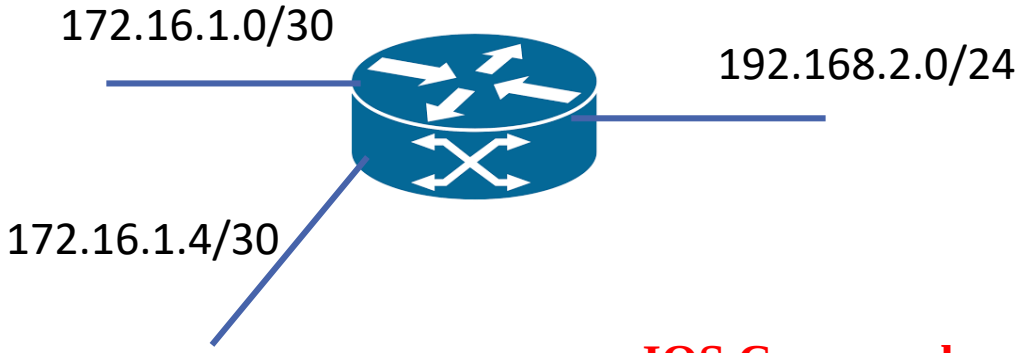


172.16.3.0/24 Down

Network	Interface	Hop
172.16.1.0/24	Fa0/0	0
172.16.2.0/24	S0/0/0	0
~~172.16.3.0/24~~	~~S0/0/0~~	~~1~~

Network	Interface	Hop
172.16.2.0/24	S0/0/0	0
~~172.16.3.0/24~~	~~Fa0/0~~	~~0~~
172.16.1.0/24	S0/0/0	1

RIPv2 Configuration

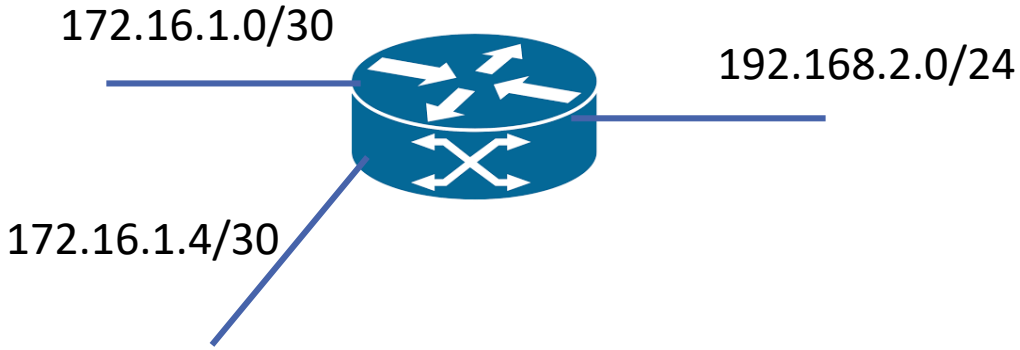


IOS Commands

R1(config)# router rip
R1(config-router)# version 2
R1(config-router)#network 172.16.1.0
R1(config-router)#network 172.16.1.4
R1(config-router)#network 192.168.2.0
R1(config-router)#no auto-summary

RIPv2 Configuration

Trableshooting



- To show protocol properties
  show ip protocols
- To show all routes
  show ip route
- To show all RIP activities in real-time
  debug ip rip
- To stop debugging
  no debug all
- To show RIP database
  show ip rip database

References

[1] R. Graziani and A. Johnson, *Routing Protocols and Concepts*, 2nd ed., Cisco Systems, Inc., USA, 2008, pp. 148-173.

[2] J. Macfarlane, *Network Routing Basics*, Wiley Publications. Inc., 2006, USA, pp. 70-104.

Books

1. Official Cert Guide CCNA 200-301 , vol. 1, *W. Odom*, Cisco Press, First Edition, 2019, USA.

2. CCNA Routing and Switching, *T. Lammle*, John Wily & Sons, Second Edition, 2016, USA.

EIGRP

Course Code: CSC 3116 Course Title: Computer Networks

Dept. of Computer Science
Faculty of Science and Technology

Lecturer No:	Lab 6	**Week No:**	6	**Semester:**	Summer 22-23
Lecturer:	*Shakila Rahman; Shakila.Rahman@aiub.edu*				

Lecture Outline

1. Introduction
2. Metric
3. Neighbor Discovery
4. EIGRP Tables
5. EIGRP Tables
6. EIGRP Configuration

Introduction

RIP vs EIGRP

	RIP	EIGRP
1	It support maximum 15 routers in the network. 16 router is unreachable.	It supports maximum 255 routers in the network. However, the default is 100 routers. (highly scalable)
2	Slow convergence	Fast convergence due to feasible successor
3	In RIP routing protocol, we cannot create a separate administrative boundary in the network.	In EIGRP routing protocol we can create a separate administrative boundary in the network with the help of autonomous system No. Less routing Table exchange is required.
4	It calculates the metric In terms of Hop Count from source network to destination network.	It calculates the metric In terms of bandwidth and delay (default).
5	RIP works on Bellman Ford algorithm.	EIGRP works on DUAL(Diffusing Update Algorithm) Algorithm.
6	It only maintains the best route to each destination.	It maintains the best route and some other alternative routes for each destination.
7	It is basically use for smaller size organization.	It is basically use for medium to lager size organization in the network [1].

Metric

- Combination of different factors
  - Bandwidth
  - Delay
  - Load
  - Reliability

Default

Metric….

Bandwidth

- No. of bits that can be sent over a link (kbps)
- Depends on interface type
- Use *bandwidth <1-10,000,000>* command to set bandwidth in kbps
- This is not real bandwidth; real bandwidth depends on clock rate
- The *bandwidth* command only influence route selection by routing protocol
- If no bandwidth is set, the default bandwidth of an interface is considered
- Calculated as the lowest bandwidth among all links in a route

Metric….

Table II Default bandwidth and delay

Interface	*Bandwdith*	*Delay (microseconds)*
Serial (T1)	1544 Kbps	20,000
Ethernet	10 Mbps	1000
Fast Ethernet	100 Mbps	100
Gigbit Ethernet	1000 Mbps	10
10 Gigbit Ethernet	10 Gbps	10

Metric….

Delay

- *Delay* is a measure of the time for a packet to reach its destination over a route (In theory)
- In practice, it is a constant set by the network engineer
- To set delay for an interface, use *delay* <value> command
- The value can be anything between 10 to 167,772,140 microseconds
- If it is not set, the default value (Table II) of each interface comes into effect
- Calculated as sum of delays in exit interfaces of all routers in a route.

Metric….

Metric calculation

$$Metric = \left[\frac{10^7}{least\ bandwidth} + delay_{total}\right] \times 256$$

Units

Bandwidth: kbps

Delay: Tens of microsecond

If the total delay is 30 seconds, $delay_{total}$=30/10=3

Metric....

Metric calculation

$$Metric = \left[\frac{10^7}{least\ bandwidth} + delay_{total}\right] \times 256$$

Route: 1-4-2-B

$Least\ BW = 56\ kbps$

$Total\ delay = 100/10 + 100/10 + 2000/10 = 220$

$Metric = \left[\frac{10^7}{56} + 220\right] \times 256 = 45770496^*$

Route: 1-3-2-B

$Least\ BW = 128\ kbps$

$Total\ delay = 100/10 + 100/10 + 1000/10 = 120$

$Metric = \left[\frac{10^7}{128} + 120\right] \times 256 = 20030720$

Perform rounding in every steps of calculation

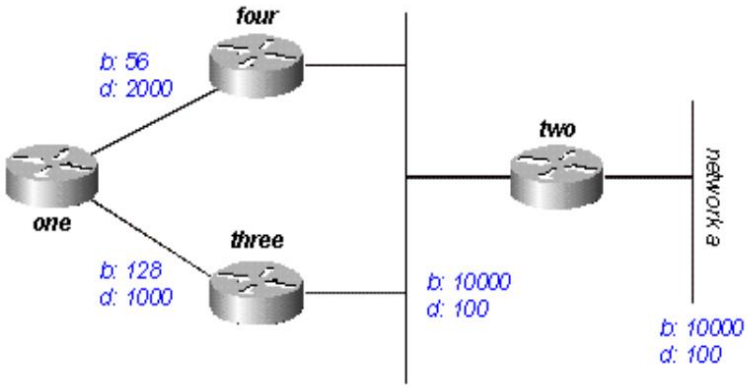


Fig. 1 A sample network [2]

Exercise

Calculate metric for all possible routes from router ONE to network A

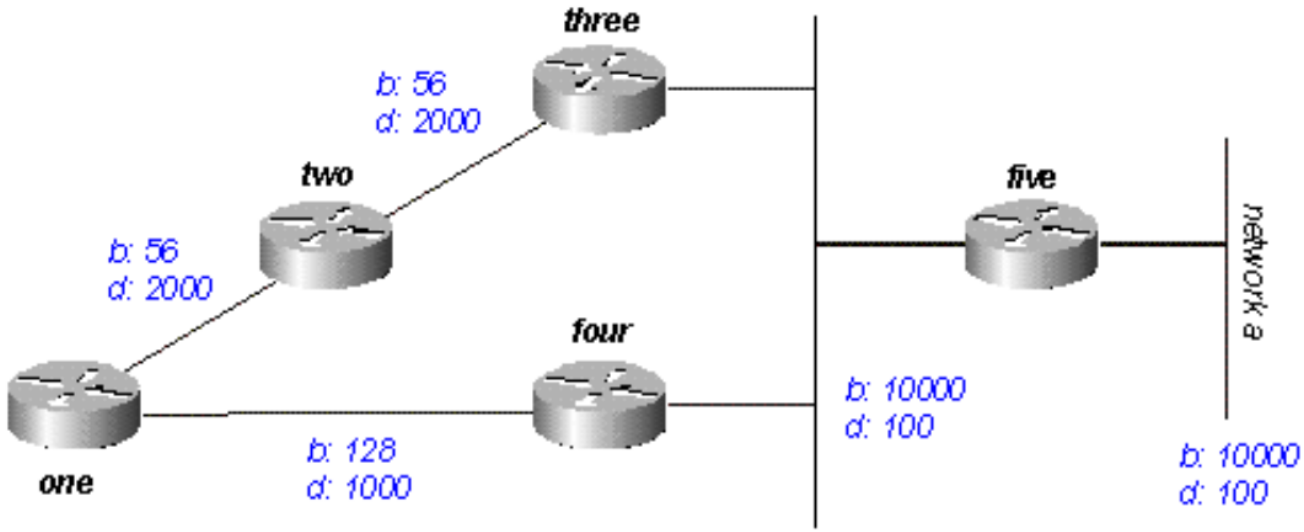


Fig. 2 A sample network [2]

Neighbor discovery

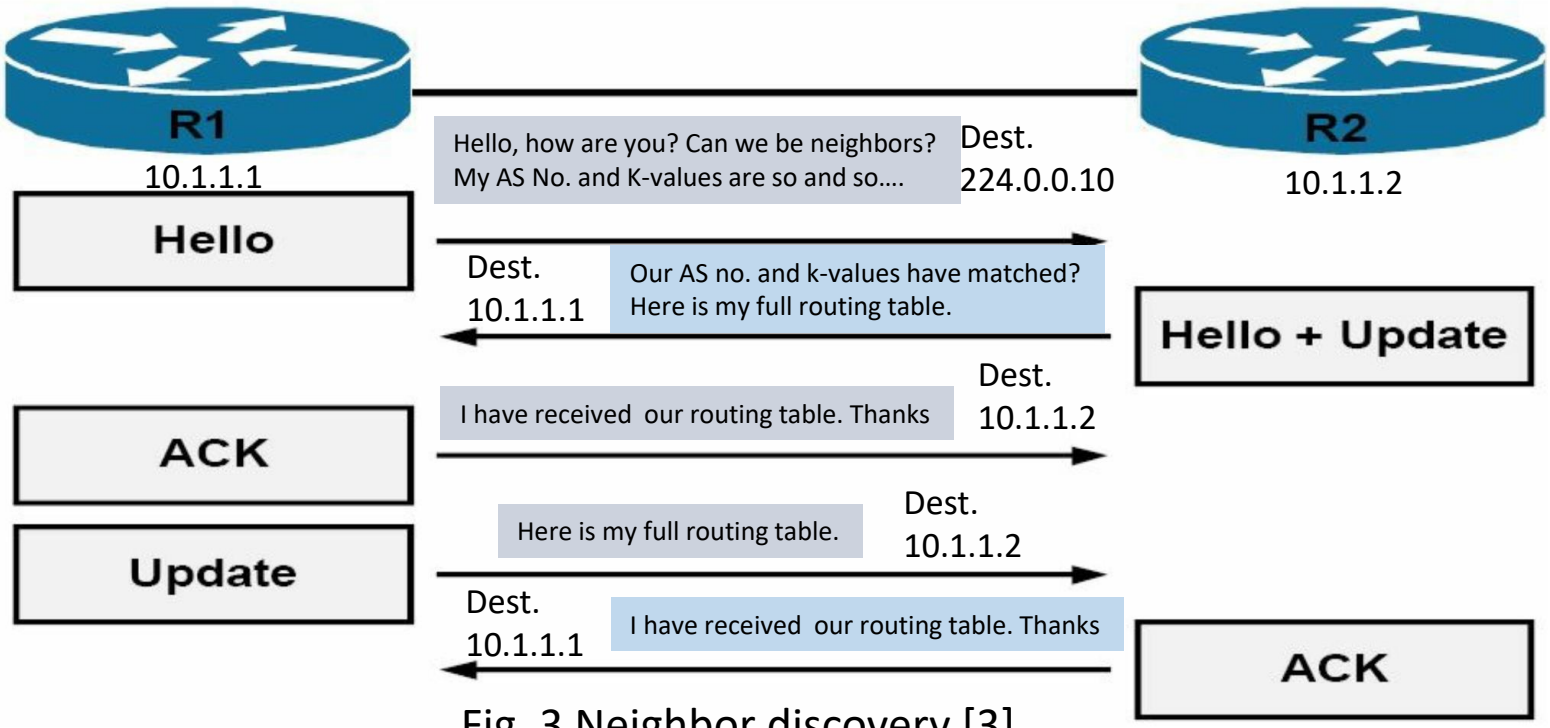


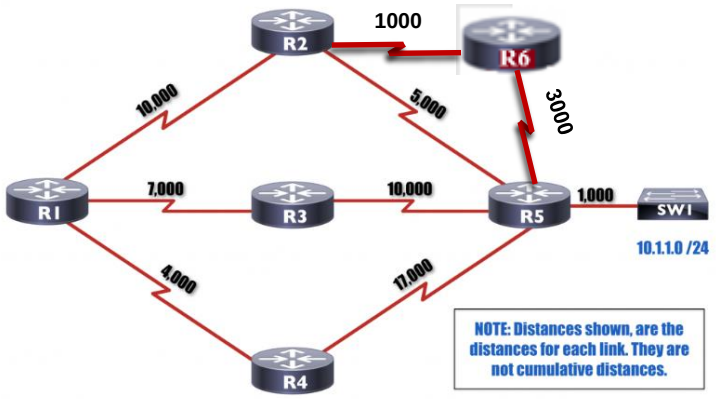
Fig. 3 Neighbor discovery [3]

Neighbor maintenance

- In neighbor discovery process, full routing table is sent
- Otherwise, only the change in routing table is sent
- After a neighbor discovery, the Hello packet is sent in every 5 second to know if the neighbor is still alive
- If a router does not receive any Hello packet from a neighbor within 15 seconds (called hold time), the neighbor is considered dead.
- For low-bandwidth link (e.g., T1), the periods are 60 sec and 180 sec.

EIGRP Tables….

Feasibility condition: reported distance must be less than the feasible distance through the successor



Neighbor	Reported Distance (RD)	Feasible Distance (FD)	(Feasible) Successor?
R2	6,000	16,000	Yes: Successor
R3	11,000	18,000	Yes: Feasible Successor
R4	18,000	22,000	No

Reported distance:
Distance advertised from neighbor as the distance between the Neighbor and the destination.

Feasible distance (FD):
Sum of Reported distance and distance between the router and the neighbor which reports the distance.

A is the route whose reported distance is less than the feasible distance of the best path.

EIGRP Tables

- Neighbor Table

  EIGRP shares routing information only with neighbors. To know who the neighbors are, it uses neighbor table. When a new neighbor is discovered, EIGRP would add its address and interface on which neighbor is connected in neighbor table [4].

- Topology Table

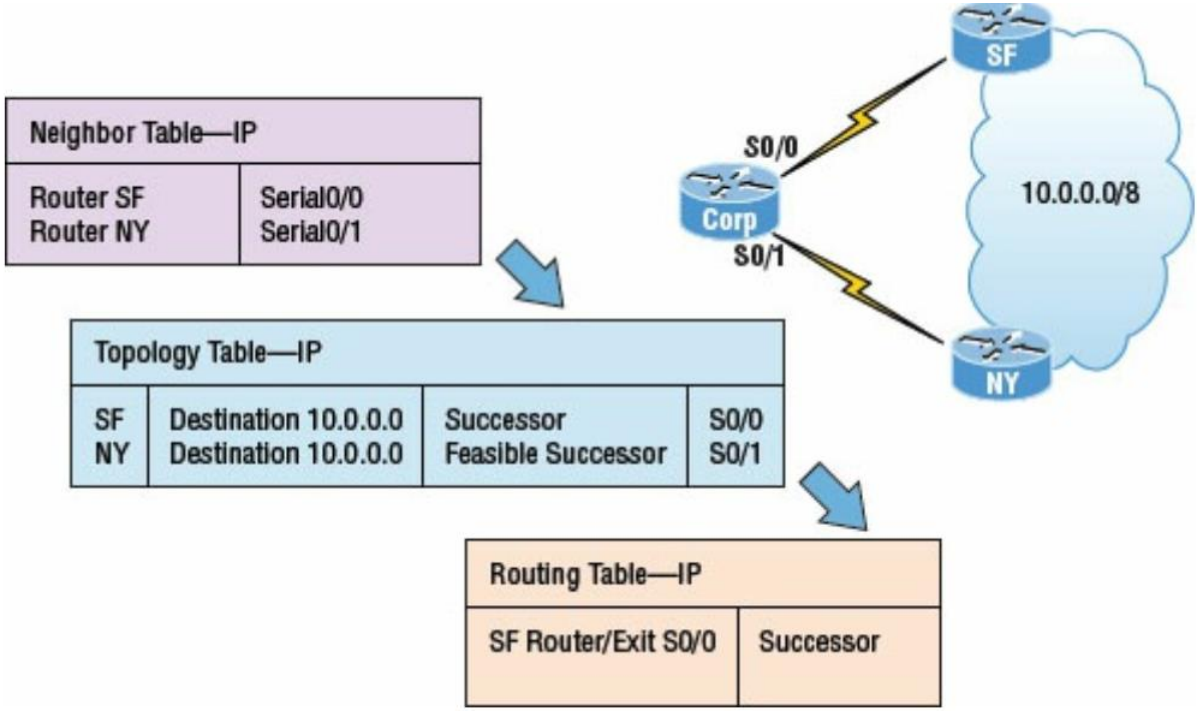
  Stores all feasible successors along with the successor (best route) for each destination network. EIGRP can store up to 32 feasible successors.

- Routing Table

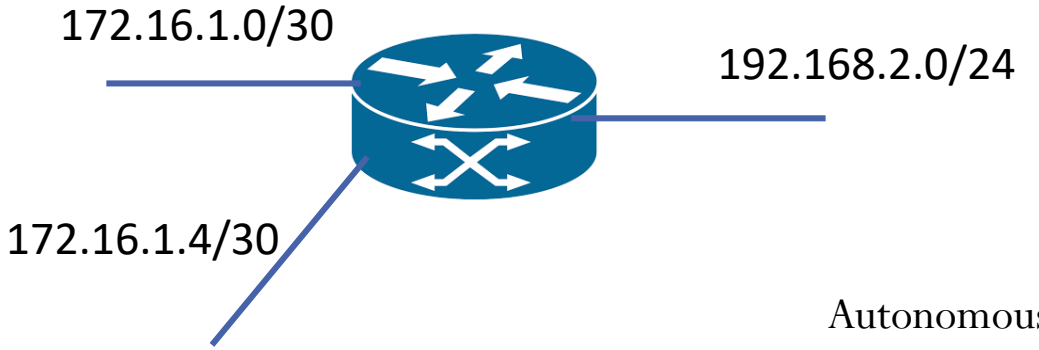
  EIGRP stores single best route for each destination in this table. Router uses this table to forward the packet.

EIGRP Tables….

Example



EIGRP Configuration



Autonomous system no.

RIP v2

R1(config)# router rip
R1(config-router)# version 2
R1(config-router)#network 172.16.1.0
R1(config-router)#network 172.16.1.4
R1(config-router)#network 192.168.2.0
R1(config-router)#no auto-summary

EIGRP

R1(config)# router eigrp <1 -65535>
R1(config-router)#network 172.16.1.0 0.0.0.3
R1(config-router)#network 172.16.1.4 0.0.0.3
R1(config-router)#network 192.168.2.0 0.0.0.255
R1(config-router)#no auto-summary

EIGRP Configuration….

- To show protocol properties
  show ip protocols
- To show neighbor table
  show ip eigrp neighbor
- To show topology table
  show ip eigrp topology

- To show routes made by eigrp
  show ip route eigrp
- To set maximum hops
  metric maximum-hops <1-255>
- To set the number of feasible successors
  maximum-paths <0-32>

References

[1] Computer Networking Class, https://computernetworkingclass.blogspot.com... /2016/08/comparison-between-rip-eigrp-igrp-and.html, [Accessed: April. 27, 2020].

[2] Cisco, "https://www.cisco.com/c/en/us/support/docs/ip/enhanced-interior... -gateway-routing-protocol-eigrp/16406-eigrp-toc.html, [Accessed: April. 27, 2020].

[3] P. Browning, F. Tafa, D. Gheorghe, and D. Barinic, *Cisco CCNA in 60 Days*, Reality Press Ltd., UK, 2014, pp. 581

[4] Computer Networking Notes, https://www.computernetworkingnotes.com/ccna... -study-guide/eigrp-tutorial-basic-concept-explained.html, [Accessed: April. 27, 2020].

Recommended Books

1. **Official Cert Guide CCNA 200-301 , vol. 1**, *W. Odom*, Cisco Press, First Edition, 2019, USA.
2. **CCNA Routing and Switching**, *T. Lammle*, John Wily & Sons, Second Edition, 2016, USA.

OSPF

Course Code: CSC 3116 Course Title: Computer Networks

Dept. of Computer Science
Faculty of Science and Technology

Lecturer No:	Lab 8	**Week No:**	10	**Semester:**	Summer 22-23
Lecturer:	*Shakila Rahman; Shakila.Rahman@aiub.edu*				

Lecture Outline

1. OSPF Theory
2. OSPF Configuration

Topic Heading..

Topic sub heading..

	EIGRP	OSPF
1	It supports maximum 255 routers in the network. However, the default is 100 routers. (highly scalable)	Supports unlimited number of routers
2	Fast convergence due to feasible successor	Fastest convergence speed due to the area concept
3	Cisco proprietary protocol and can be implemented only in Cisco routers.	Open standard protocol and can be implement in any router.
4	It calculates the metric In terms of bandwidth and delay (default).	It calculates the metric In terms of bandwidth only.
5	EIGRP works on DUAL(Diffusing Update Algorithm) Algorithm.	OSPF works on Dijkstra Algorithm.
6	It maintains the best route and some other alternative routes for each destination.	It maintains the best route in routing table and all routes in database table.
7	It is basically use for medium to lager size organization in the network [1].	It is basically use for lager size organization in the network [1].
8	Administrative distance 90	Administrative distance 110
9	Easy to implement	The implementation is complicated

OSPF Theory

OSPF Area

- An autonomous system (AS) is divided into one or more area.
- Each area is given an area ID
- An AS must have an area having ID 0 (zero) for multi-area OSPF. Such area is called backbone area.
- All areas of an AS must be connected to the backbone area.
- A router in an area exchanges routing information with the routers of its area only (by default)

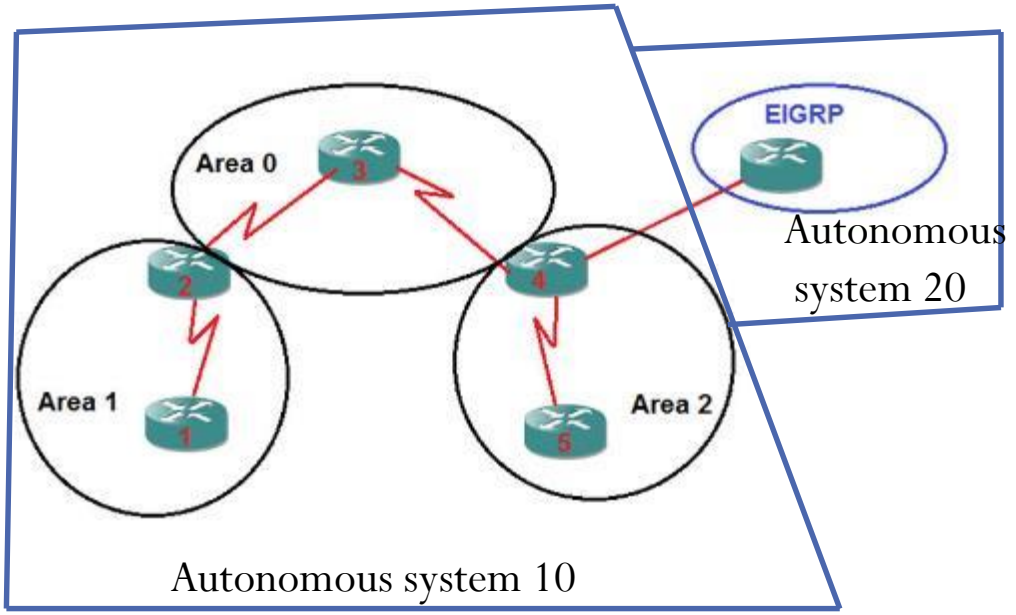


Fig. 1 Autonomous systems and area

OSPF Theory....

OSPF Routers

- Internal Router (IR): The router for which all its interface belong to one area. Router 1 and Router 5.
- Area Border Router (ABRs):The router that contains interfaces in more than one area. Router 2 and Router 4
- Backbone Router: The router that has all or at least one interface in Area 0. Router 3, Router 2 and Router 4.

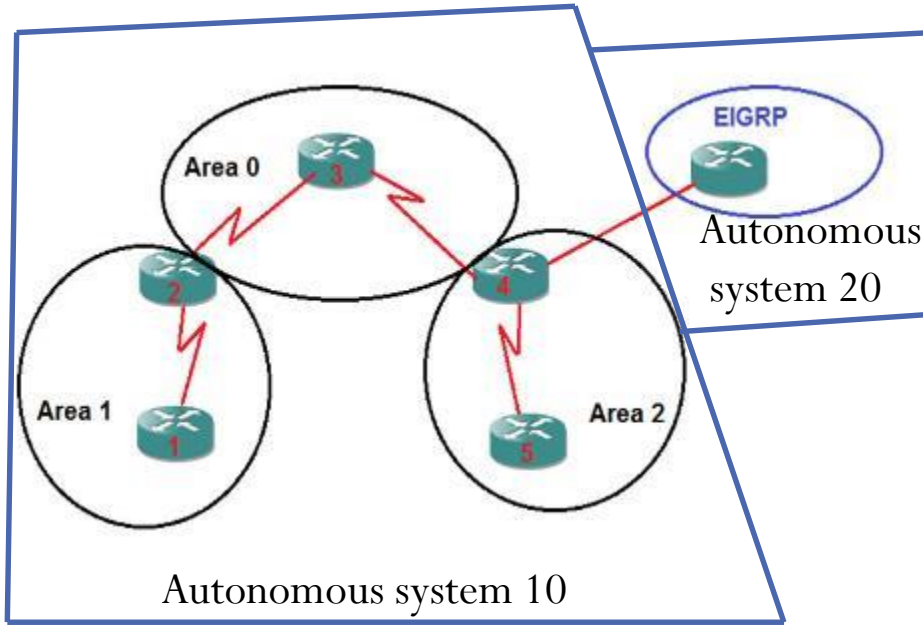


Fig. 1 Autonomous systems and area

- Autonomous System Boundary Router (ASBR): The routers with connection to a separate autonomous system. R4 in the example is connected to EIGRP [4].

OSPF Theory....

OSPF data structure and packets

- Link state advertisement (LSA)
  - A data structure with some specific information about the networks [2].
  - Depending on its type, it holds information about
    - a router's interfaces,
    - all routers attached to network,
    - summary routing information of an area,
    - all routers of an AS.
- Link state database (LSDB)
  - A collection of all LSAs known to a router
  - In a convergent network, all routers of a network have the same LSDB.

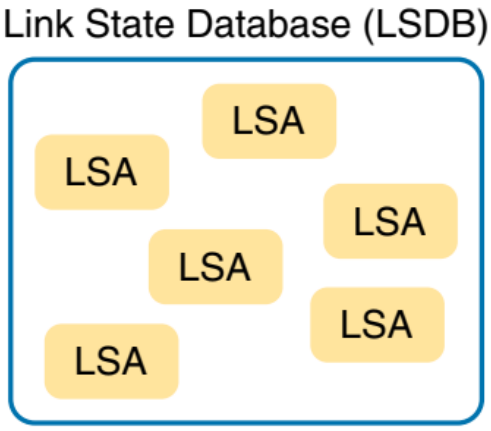


Fig. 2 LSA & LSDB relationship

OSPF Theory....

OSPF data structure and packets

- Hello

  Used to build and maintain neighbor relationships.
- DBD – Database Description

  List of LSAs contained in a LSDB. This packet type is circulated when two routers are initially exchanging their link-state databases.
- Link State Request (LSR)

  Used to request complete information about a link learned from another router.
- Link State Update (LSU)

  Used to send one or LSA(s)
- Links State Acknowledgement (LSAck)

  Used to acknowledge the reception of an LSA

OSPF Theory....

Neighbor discovery

Parameters need to be identical for two routers to become neighbors

- Network mask—*net mask of the sending router*
- Subnet number —derived using the subnet mask and each router's interface Internet Protocol (IP) address
- Area ID—*area ID of the sending interface*
- Hello interval—*how often Hello packets are transmitted*
- Dead interval—*how long to wait for Hello packets before terminating neighbor*
- Authentication type and password—*optional*
- Stub area flag—*specifies the type of stub area, if applicable* [3]

Hello packet contains all these information

OSPF Theory....

Neighbor discovery....

The scenario begins with the link down, so the routers have no knowledge of each other as OSPF neighbors

1. Link between R1 and R2 comes up
2. R1 sends the first Hello to multicast IP address 224. 0.0.5, so R2 learns of the existence of R1 as an OSPF router. At that point, R2 lists R1 as a neighbor, with an interim beginning state of init.

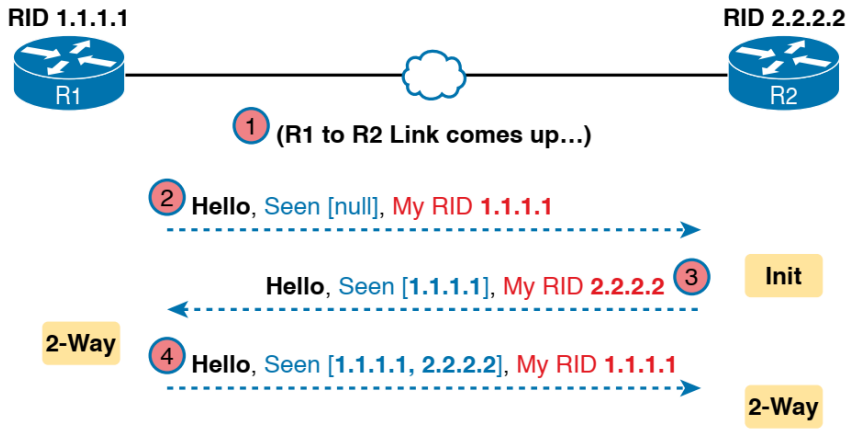


Fig. 3 Neighbor discovery

3. R2 sends back a Hello which tells R1 that R2 exists, and it allows R1 to move through the init state and quickly to a 2-way state.
4. R2 receives the next Hello from R1, and R2 can also move to a 2-way state [2]

OSPF Theory....

Router ID

- 32-bit unique dotted decimal number

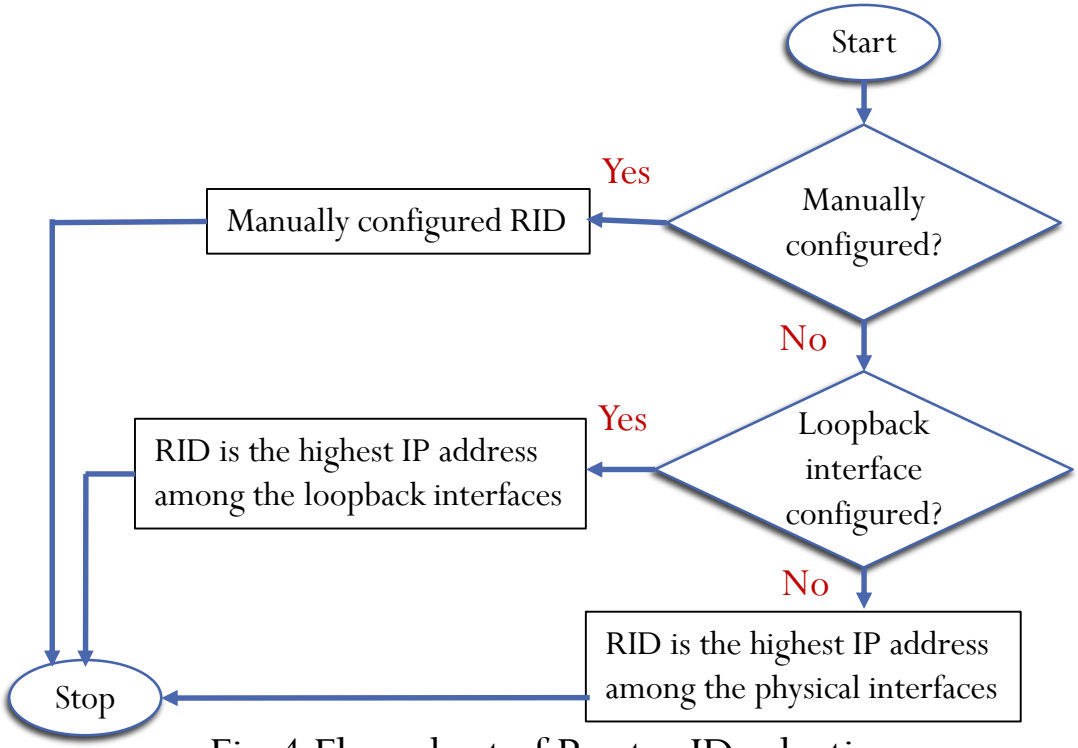


Fig. 4 Flow chart of Router ID selection

OSPF Theory....

DR and BDR

- Point-to-point network

  A network in an area connecting only two routers directly.

- Broadcast network

  A network in an area connecting more than two routers

- Designated router (DR)

  In a broad cast network, a router with the highest priority .

  If the priorities tie, the router having the highest RID

  All database exchange is done via DR

- Backup Designated router (BDR)

  In a broad cast network, a router with the second highest priority .

  If the priorities tie, the router having the second highest RID

  If the DR fails, the BDR takes over.

- DROTHER: The router which is neither DR nor BDR [2]

OSPF Theory....

DR and BDR....

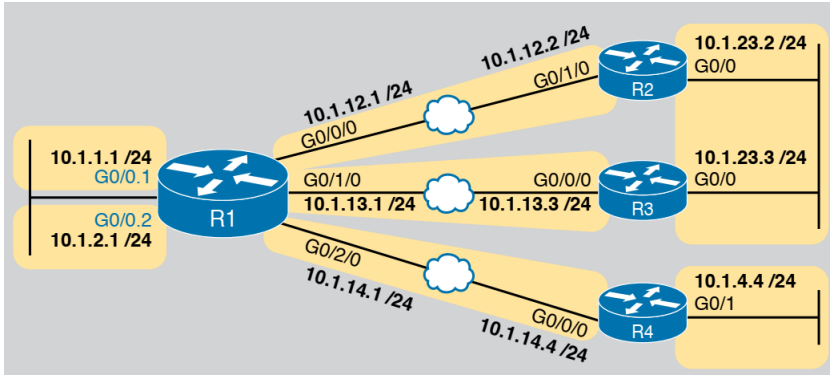


Fig. 5 point-to-point network

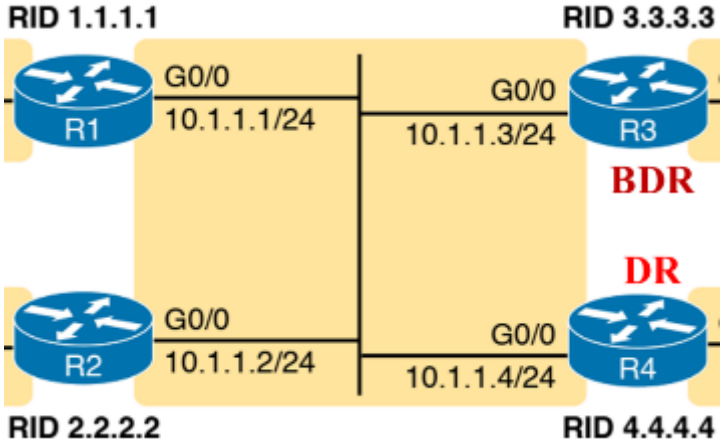


Fig. 6 Broadcast network , DR and BDR election

OSPF Theory....

DR and BDR....

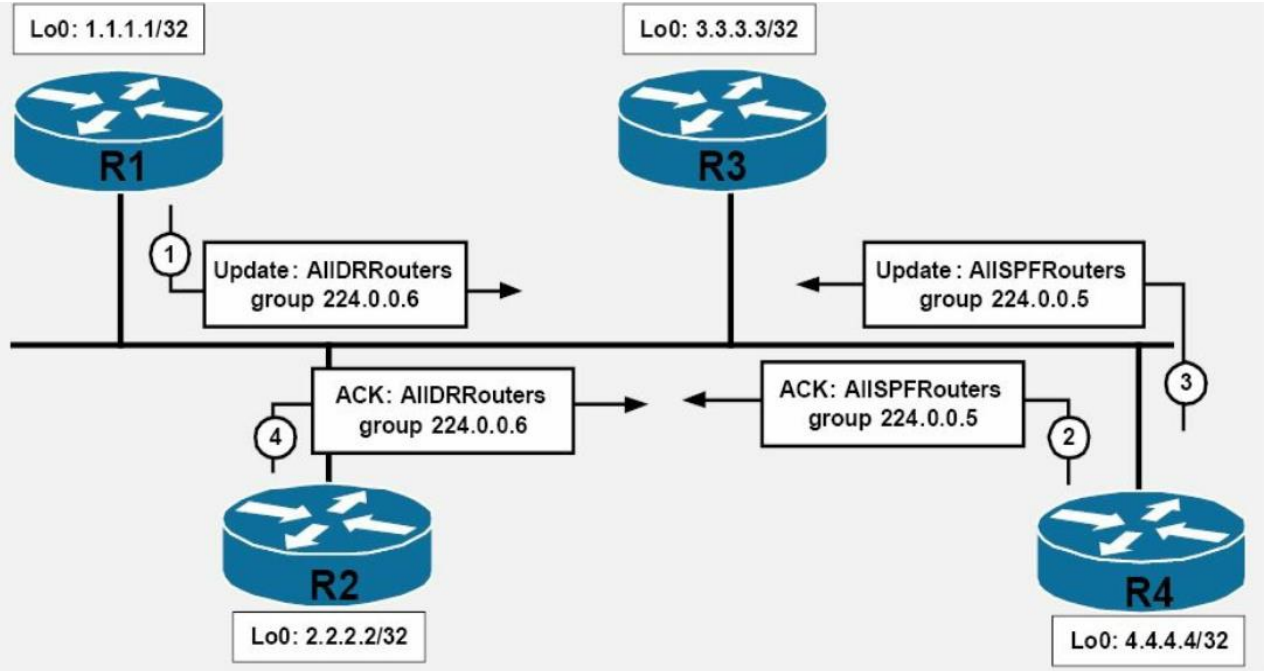


Fig. 7 Illustration of update exchange through DR and BDR

Configuration

Wildcard mask

- Used to specify a range of network addresses.
- Inverted subnet mask
- Used in EIGRP, OSPF and Access-List.

- How to get wildcard mask of an IP address?

  Subtract the subnet mask from 255.255.255.255

- What does each bit of a wildcard mask mean?

  0 : All IP address in the range must match the bit

  1 : Different IP address in the range can have different value in the bit position

Configuration….

Wildcard mask….

- Only 192.168.3.0

  All bits must match.

  WCM: All bits 0. (00000000.00000000.00000000.00000000)

  WCM: 0.0.0.0

- IP address range: 192.168.3.0 to 192.168.3.255

  Match first three block (24 bits) and fourth block can take any value

  WCM: 0.0.0.255

- IP address range: 192.168.3.4 to 192.168.3.13

  11000000.10101000.00000011.00000100

  11000000.10101000.00000011.00001101

  First 28 bits same.

  Match first 28 bits; make them all zero

  Make rest of the bits 1

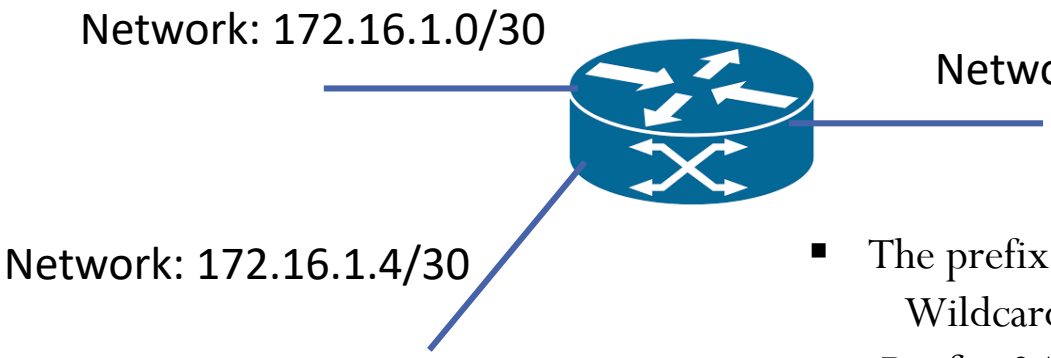
  00000000.0000000.00000000.00001111

  WCM: 0.0.0.15

Actual IP range: 192.168.3.0 to 192.168.3.15 under WCM: 0.0.0.15

Configuration....

Commands



- The prefix 30 means subnet mask: 255.255.255.252
  Wildcard mask: 0.0.0.3
- Prefix 24 indicates subnet mask: 255.255.255.0
  Wildcard mask: 0.0.0.255

OSPF Configuration

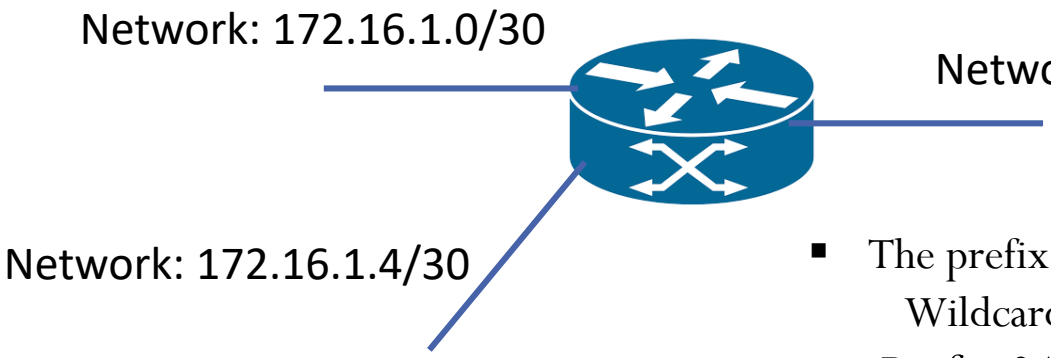
R1(config)# router ospf *process_id*

R1(config-router)#network *network_IP WCM* area *area_id*

Process ID is an integer. Not all routers need to have the same process ID.

Configuration….

Commands….

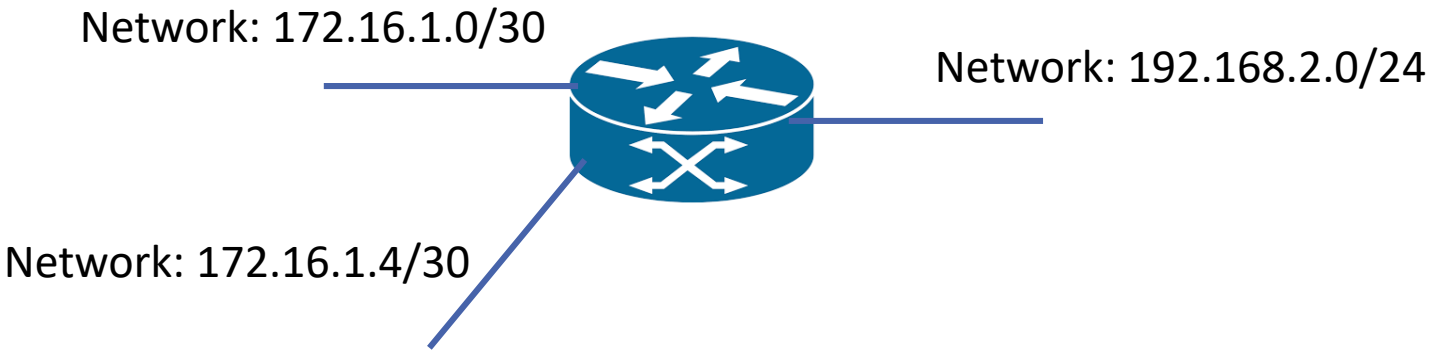


- The prefix 30 means subnet mask: 255.255.255.252
  Wildcard mask: 0.0.0.3
- Prefix 24 indicates subnet mask: 255.255.255.0
  Wildcard mask: 0.0.0.255

R1(config)# router ospf 10
R1(config)# router –id 1.1.1.1
R1(config-router)#network 192.168.2.0 0.0.0.255 area 0
R1(config-router)#network 172.16.1.0 0.0.0.3 area 0
R1(config-router)#network 172.16.1.4 0.0.0.3 area 0

Configuration….

Commands….




```
R1(config)# router ospf 10
R1(config-router)#network 192.168.2.0   0.0.0.255  area 0
R1(config-router)#network 172.16.1.0   0.0.0.255  area 0
```

ospf protocol will be used in any network of area 0 which is connected to the router, having network IP address with first three octets 172.16.1 [2]

Topic Heading..

Commands….

TABLE II Command for verifying configuration [2]

Command	Description
show ip ospf neighbor [*type number*]	Lists brief output about neighbors, identified by neighbor router ID, including current state, with one line per neighbor; optionally, limits the output to neighbors on the listed interface.
show ip ospf neighbor *neighbor-ID*	Lists the same output as the **show ip ospf neighbor** detail command, but only for the listed neighbor (by neighbor RID).
show ip ospf database	Lists a summary of the LSAs in the database, with one line of output per LSA. It is organized by LSA type (first type 1, then type 2, and so on).
show ip route	Lists all IPv4 routes.
show ip route ospf	Lists routes in the routing table learned by OSPF.
show ip route *ip-address mask*	Shows a detailed description of the route for the listed subnet/mask.
clear ip ospf process	Resets the OSPF process, resetting all neighbor relationships and also causing the process to make a choice of OSPF RID.

References

[1] Computer Networking Class, https://computernetworkingclass.blogspot.com…/2016/08/comparison-between-rip-eigrp-igrp-and.html, [Accessed: May 2, 2020].

[2] W. Odom, Official Cert Gudie CCNA 200-301 Volume 1, Pearson Education, Inc., USA, 2020, pp. 449-497.

[3] J. Macfarlane, *Network Routing Basics*, Wiley Publications. Inc., USA, 2006, pp. 254.

[4] OSPF, "http://www.certiology.com/cisco-certifications/ccna/ccna-routing-and-switching/free-cisco-ccna-study-guide/ospf.html, [Accessed: May 2, 2020]..

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1. Official Cert Guide CCNA 200-301 , vol. 1, *W. Odom*, Cisco Press, First Edition, 2019, USA.

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VLAN & VTP

Course Code: CSC 3116 Course Title: Computer Networks

Dept. of Computer Science
Faculty of Science and Technology

Lecturer No:	Lab 9	**Week No:**	10	**Semester:**	Summer 22-23
Lecturer:	*Shakila Rahman; Shakila.Rahman@aiub.edu*				

Lecture Outline

1. Configuring VLANs
2. VTP Configuration

Configuring VLANs

Introduction

A technique of logically grouping of computers of LAN to limit broadcast domain and improve security.

- Each VLAN must have a LAN number → Valid numbers are 1 to 4094
- Normal VLANS 1 to 1005
  - Stored in in vlan.dat file of Flash memory
  - Normally used
- Extended VLANS 1006 to 4094
  - Stored in running configuration file
  - Limited options
- Factory set VLANs (cannot be changed)
  - VLAN 1 ---Administrative VLAN or default VLAN (for Cisco switch)
  - VLAN 1001 to 1005 used for Token ring and FDDI networks (Not used usually)
- VLAN name is optional [1]

Configuring VLANs….

Creation of VLANs

- All configuration must be done in Global Configuration mode

❖ VLAN Creation

1. # ***enable*** to access privileged exec mode.
2. # ***configure terminal*** to access global configuration mode.
3. # ***vlan 2*** to create VLAN 2 and access VLAN configuration mode.
4. # ***name Production*** to name this VLAN Production.
5. # ***vlan 3*** to create VLAN 3.
6. # ***name HR*** to name this VLAN HR [1].

❖ Verify VLAN creation

show vlan brief

Configuring VLANs….

- Cisco IOS commands for creating four VLANs

```
Switch>enable
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#VLAN 2
Switch(config-vlan)#name production
Switch(config-vlan)#VLAN 3
Switch(config-vlan)#name HR
Switch(config-vlan)#VLAN 4
Switch(config-vlan)#name sales
Switch(config-vlan)#VLAN 5
Switch(config-vlan)#name IT
Switch(config-vlan)#exit
Switch(config)#
```

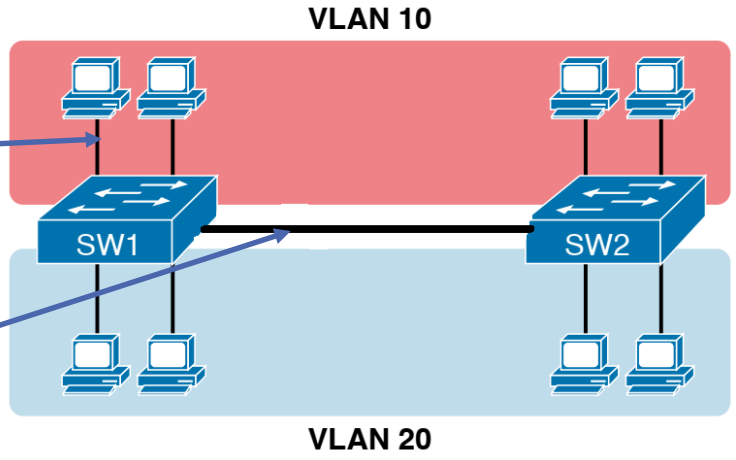
Configuring VLANs….

- Modes of Interfaces

- Access
  - Used to connect an end device such as PC
- Trunk
  - Used to connect a connecting device such as another switch or a router to carry data for multiple VLANs

Access

Trunk if it is configured to carry data of multiple VLANs



Configuring VLANs....

Topic sub heading..

❖ Adding interface to a VLAN

1. # **enable** to access privileged exec mode.
2. # **configure terminal** to access global configuration mode.
3. # ***interface fa0/1*** to access FastEthernet port 0/1.
4. # ***switchport mode access*** to set this port into a nontrunking access mode.
5. # ***switchport access vlan 2*** to set this port to use VLAN 2.
6. # ***interface fa0/2*** to access FastEthernet port 0/2.
7. # ***switchport mode access*** to set this port into a nontrunking access mode.
8. # ***switchport access vlan 3*** to set this port to use VLAN 3
9. # ***interface fa0/3*** to access FastEthernet port 0/3
10. # ***switchport mode trunk*** to set this port into a trunking mode

Configuring VLANs....

Commands for adding interfaces to a VLAN

```
Switch(config)#interface fa0/1
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 2
Switch(config-if)#
Switch(config-if)#interface fa0/2
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 3
Switch(config-if)#
Switch(config-if)#interface fa0/3
Switch(config-if)#switchport mode trunk
Switch(config-if)#
Switch(config-if)#
```

Configuring VLANs….

Verify members of a VLAN

```
Switch#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/4, Fa0/5, Fa0/6, Fa0/7
                                                Fa0/8, Fa0/9, Fa0/10, Fa0/11
                                                Fa0/12, Fa0/13, Fa0/14, Fa0/15
                                                Fa0/16, Fa0/17, Fa0/18, Fa0/19
                                                Fa0/20, Fa0/21, Fa0/22, Fa0/23
                                                Fa0/24, Gig0/1, Gig0/2
2    production                       active    Fa0/1
3    HR                               active    Fa0/2
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
Switch#
```

Fa0/3 is not shown as it is a trunk

Configuring VLANs....

Adding multiple interfaces to a VLAN at a time

❖ Adding multiple interfaces to a VLAN at a time

```
Switch(config)#interface range fa0/4-10
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 3
```

```
Switch(config)#do show vlan brief

VLAN Name                                Status    Ports
---- ----------------------------------- --------- -------------------------------
1    default                             active    Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                                   Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                                   Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                                   Fa0/23, Fa0/24, Gig0/1, Gig0/2
2    production                          active    Fa0/1
3    HR                                  active    Fa0/2, Fa0/4, Fa0/5, Fa0/6
                                                   Fa0/7, Fa0/8, Fa0/9, Fa0/10
1002 fddi-default                        active
1003 token-ring-default                  active
1004 fddinet-default                     active
1005 trnet-default                       active
Switch(config)#
```

Configuring VLANs….

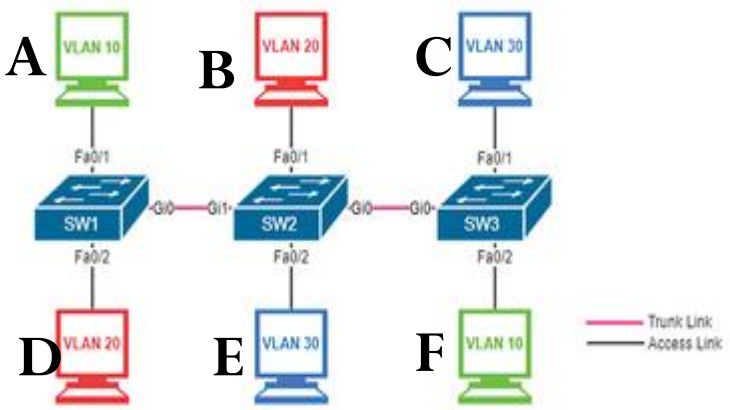
- Verifying VLAN Information

Switch# show vlan	Displays VLAN information
Switch# show vlan brief	Displays VLAN information in brief
Switch# show vlan id 2	Displays information about VLAN 2 only
Switch# show vlan name HR	Displays information about VLAN HR only

VTP Configuration

VTP configuration commands

Suppose
SW1: Sever
SW2 & SW3: Client



SW1

```
Switch(config)# vtp mode server
Switch(config)# vtp domain aiub
Switch(config)# vtp password 123
```

SW2

```
Switch(config)# vtp mode client
Switch(config)# vtp domain aiub
Switch(config)# vtp password 123
```

SW3

```
Switch(config)# vtp mode client
Switch(config)# vtp domain aiub
Switch(config)# vtp password 123
```

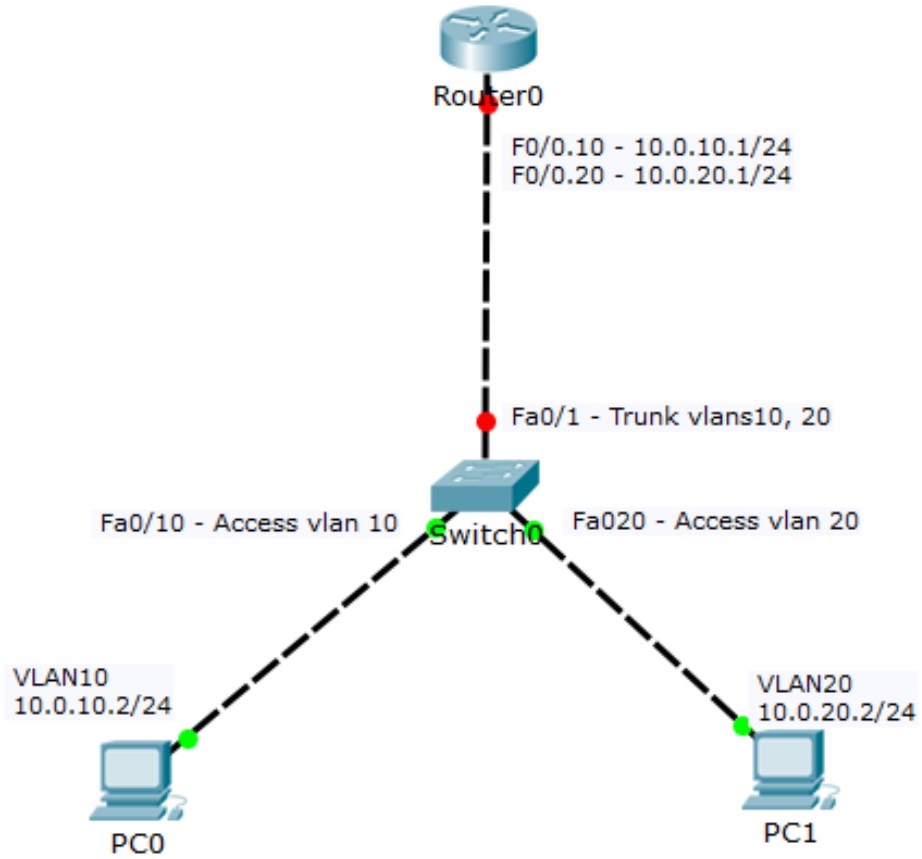
Topic Heading..

VTP configuration verification

❖ Verifying VTP

`Switch# show vtp status`	Displays general information about VTP configuration
`Switch# show vtp counters`	Displays the VTP counters for the switch

router on stick



References

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[2] W. Odom, Official Cert Guide CCNA 200-301 Volume 1, Pearson Education, Inc., 2020, USA, p. 181.

Books

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Inter-VLAN Routing & DHCP

Course Code: CSC 3116 Course Title: Computer Networks

Dept. of Computer Science
Faculty of Science and Technology

Lecturer No:	Lab 10	**Week No:**	10	**Semester:**	Summer 22-23
Lecturer:	*Shakila Rahman; Shakila.Rahman@aiub.edu*				

Lecture Outline

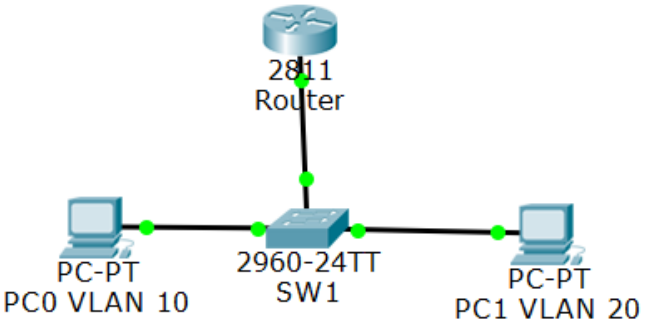
1. Inter-VLAN Routing
2. DHCP configuration

Inter-VLAN Routing

How can we enable PC0 of VLAN 10 to communicate PC1 of VLAN 20?

Using Router

1. Multiple access line between R1 and SW1; one for each VLAN
2. One trunk interface between SW1 and R1, with multiple subinterfaces. ROAS technique
3. Using Layer 3 switch with switch virtual interface



Inter-VLAN Routing....

- Configure the switch to create VLANs & interfaces to each VLAN
- Configure Fa0/3 interface of the switch as a trunk

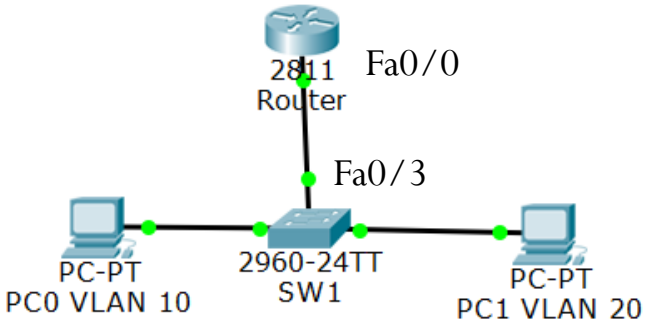
```
Switchport(config)#interface fa0/3
Switch(config-if)#switchport mode trunk
```

- Configure the Router
  - Select the Fa0/0 interface of the router

    ```
    interface fa0/0
    ```
  - Activate the interface

    ```
    no shutdown
    ```
  - Create a virtual subinterface

    ```
    interface fa0/0.10
    ```



Inter-VLAN Routing….

- Specify the trunking protocol & VLAN

  encapsulation dot1q 10

- Assign an IP address to the subinterface (default gateway of the VLAN)

  `ip address 192.168.10.254 255.255.255.0`

- Create another virtual subinterface for VLAN 20

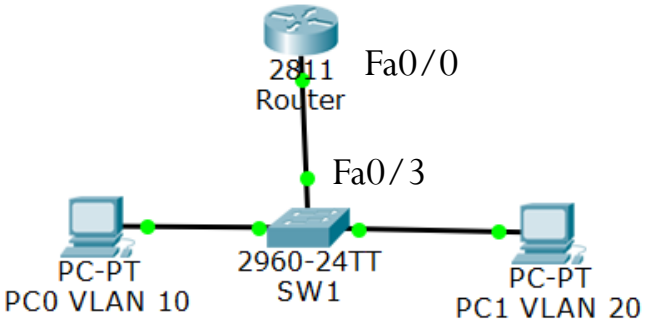
  interface fa0/0.20

- Specify the trunking protocol & VLAN

  encapsulation dot1q 20

- Assign an IP address to the subinterface (default gateway of the VLAN)

  ip address 192.168.20.254 255.255.255.0



DHCP

- DHCP server
  - Router
  - Computer

- DHCP server configuration:

Scenario I: DHCP server located in LAN

Scenario II: DHCP server located in different network

DHCP....

Scenario I: DHCP server located in LAN

1. Configure the interface by which DHCP server is connected to the LAN

```
int fa0/0
ip address 192.168.1.254 255.255.255.0
```

2. Create a DHCP pool and give its name

```
ip dhcp pool  mypool
```

3. Define the network IP address so that IP address from that block can be allocated

```
network  192.168.1.0      255.255.255.0
```

4. Define the DNS server's IP address (optional)

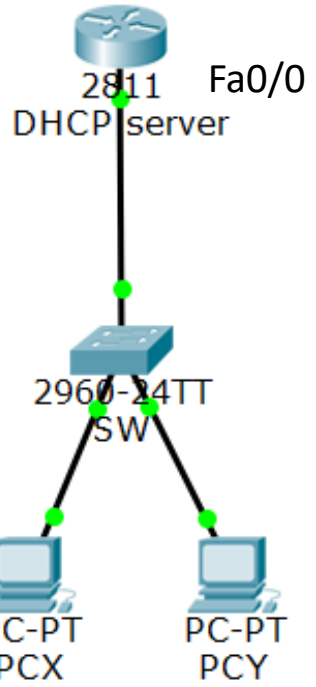
```
dns-server 172.168.1.150
```

5. Define the default gateway (optional)

```
default-router 192.168.1.1
```

6. Specify the range of address not to be leased out to the client (optional)

```
ip dhcp excluded-address   192.168.1.1   192.168.1.10
```



Network: 192.168.1.0

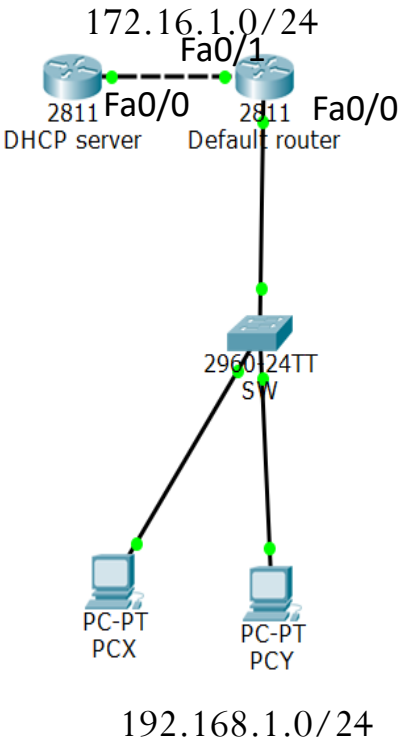
Mask: 255.255.255.0

DHCP....

DHCP server is in different network.

Configure the DHCP server as before

```
ip dhcp pool mypool
network  192.168.1.0    255.255.255.0
dns-server 192.16.1.150 (suppose)
default-router 192.168.1.254
ip dhcp excluded-address 192.168.1.1 192.168.1.10
```



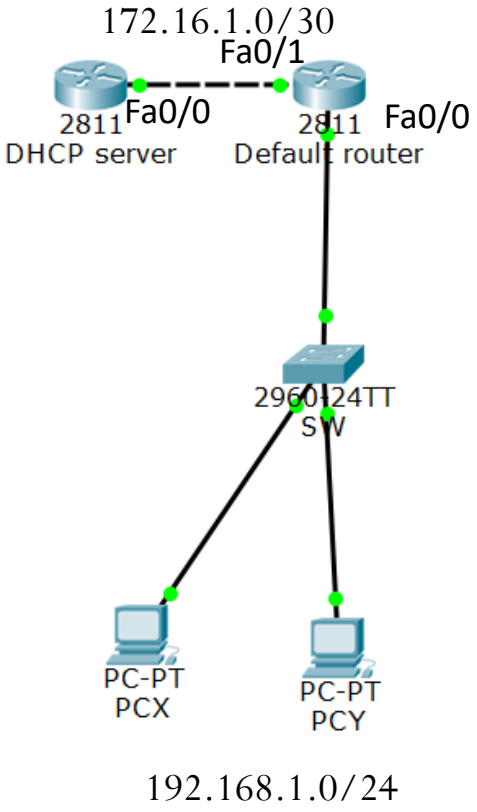
DHCP....

DHCP server is in different network….

- Configure the interfaces of the DHCP server and default router
- Configure the Fa0/0 interface of the default router with

```
interface fa0/0
ip address 192.168.1.254 255.255.255.0
no shutdown
```

- Configure each router to perform routing using any protocol, RIPv2 or EIGRP or OSPF



DHCP....

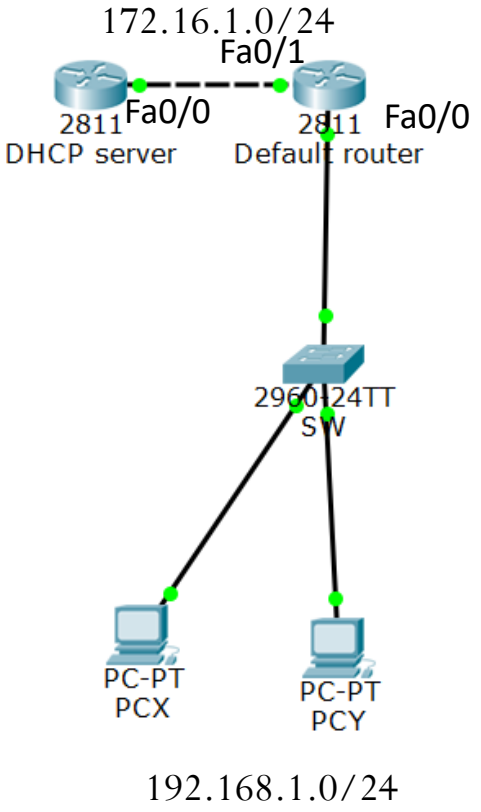
DHCP server is in different network....

What will happen if PCX sends s DCHP broadcast to 255.255.255.255 address?

It will be blocked by the default router.

Why?

Router divide the broadcast domain.



DHCP....

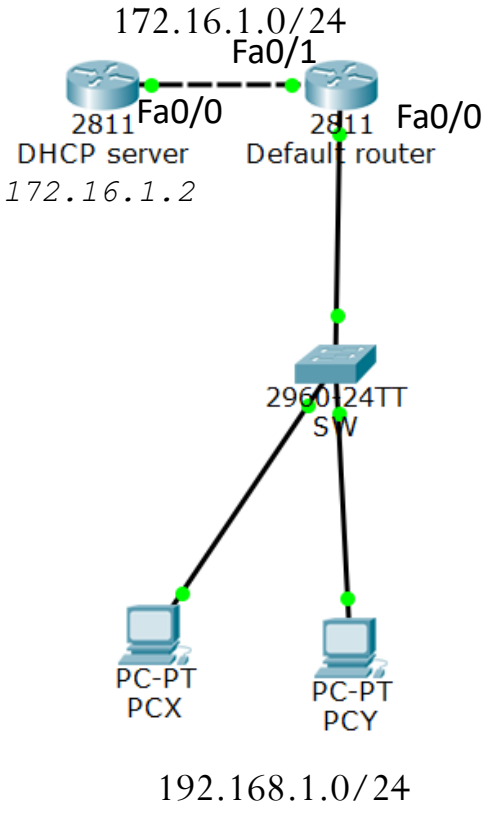
DHCP server is in different network....

How can the PCX be enabled to reach to DHCP server?

In addition to the configuration of Fa0/0 interface of the default router (as done before), configure this interface with the helper-address

```
interface fa0/0
ip helper-address 172.16.1.2
```

Address of the DHCP server



DHCP....

DHCP server is in different network….

IP

0	4	8	16	19	31Bits
4	IHL	DSCP: 0x0	TL: 77		
ID: 0x14			0x0	0x0	
TTL: 128		PRO: 0x11	CHKSUM		
SRC IP: 0.0.0.0					
DST IP: 255.255.255.255					
OPT: 0x0					0x0
DATA (VARIABLE LENGTH)					

Incoming PDU at default router from PCX

IP

0	4	8	16	19	31Bit
4	IHL	DSCP: 0x0	TL: 77		
ID: 0x14			0x0	0x0	
TTL: 128		PRO: 0x11	CHKSUM		
SRC IP: 192.168.1.254					
DST IP: 172.16.1.2					
OPT: 0x0					0x0
DATA (VARIABLE LENGTH)					

Outgoing PDU from default router to DHCP

DHCP....

DHCP server is in different network….

IP

0	4	8	16	19	31Bits
4	IHL	DSCP: 0x0	TL: 81		
ID: 0x1c			0x0	0x0	
TTL: 255		PRO: 0x11	CHKSUM		
SRC IP: 172.16.1.2					
DST IP: 192.168.1.254					
OPT: 0x0				0x0	
DATA (VARIABLE LENGTH)					

Incoming PDU at default router from DHCP

IP

0	4	8	16	19	31Bits
4	IHL	DSCP: 0x0	TL: 81		
ID: 0x1c			0x0	0x0	
TTL: 255		PRO: 0x11	CHKSUM		
SRC IP: 192.168.1.254					
DST IP: 255.255.255.255					
OPT: 0x0				0x0	
DATA (VARIABLE LENGTH)					

Outgoing PDU from default router to PCX

DHCP....

Verifying configuration

`Router#show ip dhcp binding`	Displays a list of all bindings created
`Router#show ip dhcp binding` *w.x.y.z*	Displays the bindings for a specific DHCP client with an IP address of *w.x.y.z*
`Router#clear ip dhcp binding` *a.b.c.d*	Clears an automatic address binding from the DHCP server database
`Router#clear ip dhcp binding *`	Clears all automatic DHCP bindings

References

[1] S. Empson, *CCNA Portable Command Guide*, 2nd ed., Cisco Systems, Inc., 2008, USA.

Recommended Books

1. **Official Cert Guide CCNA 200-301 , vol. 1**, *W. Odom*, Cisco Press, First Edition, 2019, USA.
2. **CCNA Routing and Switching**, *T. Lammle*, John Wily & Sons, Second Edition, 2016, USA.

NAT & PAT

Course Code: CSC 3116 Course Title: Computer Networks

Dept. of Computer Science
Faculty of Science and Technology

Lecturer No:	Lab 11	**Week No:**	11	**Semester:**	Summer 22-23
Lecturer:	*Shakila Rahman; Shakila.Rahman@aiub.edu*				

Lecture Outline

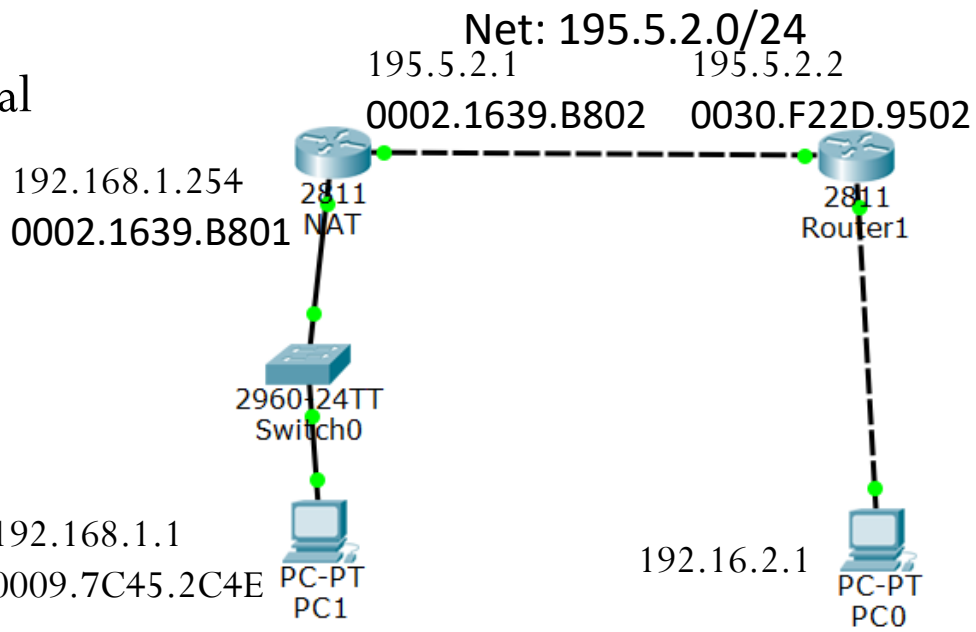
1. Static NAT
2. Dynamic NAT
3. PAT

Static NAT

Configuration

- Configure the routers and PCs as usual
- Perform routing

```
NAT(config)#int fa0/0
NAT(config-if)#ip nat inside
NAT(config)#int fa0/1
NAT(config-if)#ip nat outside
```




```
NAT(config)#ip nat inside source
static 192.168.1.1 195.15.2.3
```

To be replaced

Replaced by

Static NAT

Frames and Packets

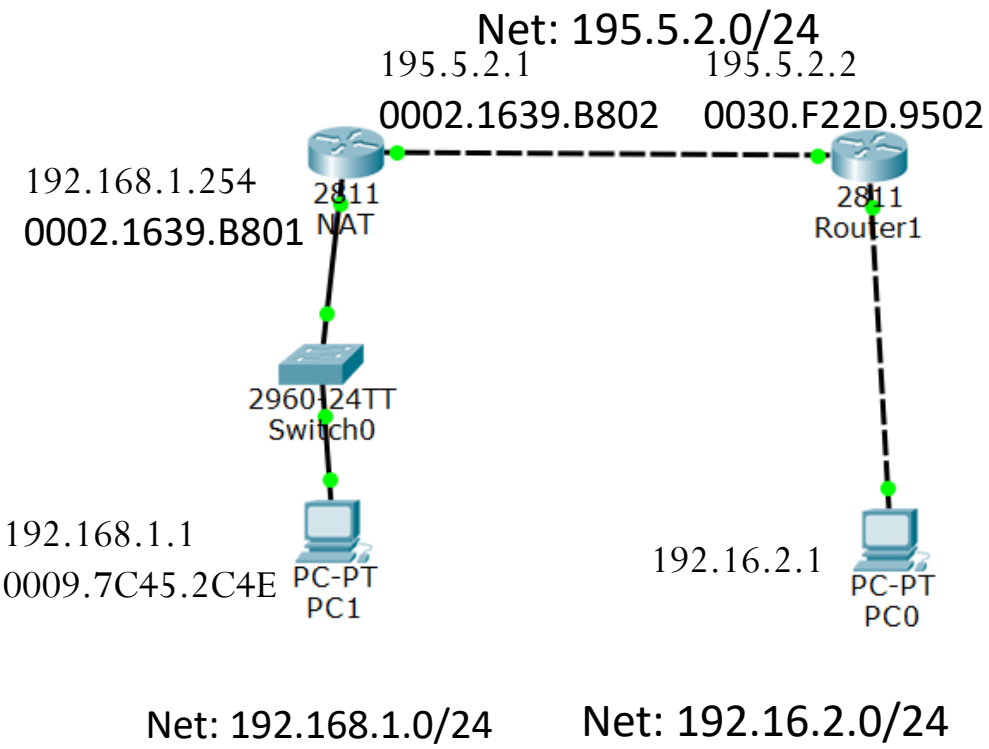
Incoming PDUs at NAT

Ethernet II

0	4	8	14	19 Bytes
PREAMBLE: 101010...1011		DEST MAC: 0002.1639.B801	SRC MAC: 0009.7C45.2C4E	
TYPE: 0x800	DATA (VARIABLE LENGTH)			FCS: 0x0

IP

0	4	8	16	19	31 Bits
4	IHL	DSCP: 0x0	TL: 28		
ID: 0x9			0x0	0x0	
TTL: 255	PRO: 0x1		CHKSUM		
SRC IP: 192.168.1.1					
DST IP: 192.16.2.1					
OPT: 0x0				0x0	
DATA (VARIABLE LENGTH)					



Static NAT

Frames and Packets

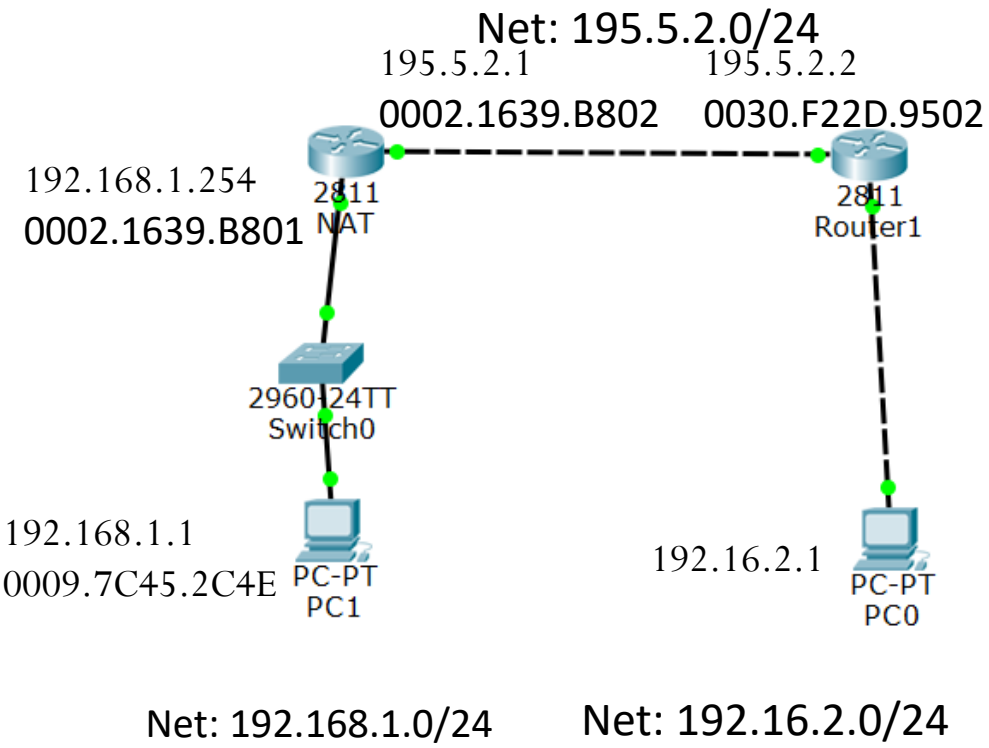
Outgoing PDUs at NAT

Ethernet II

0	4	8	14	19 Bytes
PREAMBLE: 101010...1011		DEST MAC: 0030.F22D.9502	SRC MAC: 0002.1639.B802	
TYPE: 0x800	DATA (VARIABLE LENGTH)			FCS: 0x0

IP

0	4	8	16	19	31Bits
4	IHL	DSCP: 0x0	TL: 28		
ID: 0x9			0x0	0x0	
TTL: 254		PRO: 0x1	CHKSUM		
SRC IP: 195.15.2.3					
DST IP: 192.16.2.1					
OPT: 0x0				0x0	
DATA (VARIABLE LENGTH)					



Dynamic NAT

Configuration


```
NAT(config)#int fa0/0
NAT(config-if)#ip nat inside
NAT(config-if)#int fa0/1
NAT(config-if)#ip nat outside
NAT(config)#ip nat pool mypool  195.15.2.3  195.15.2.100
            netmask 255.255.255.0
```

First IP

Last IP

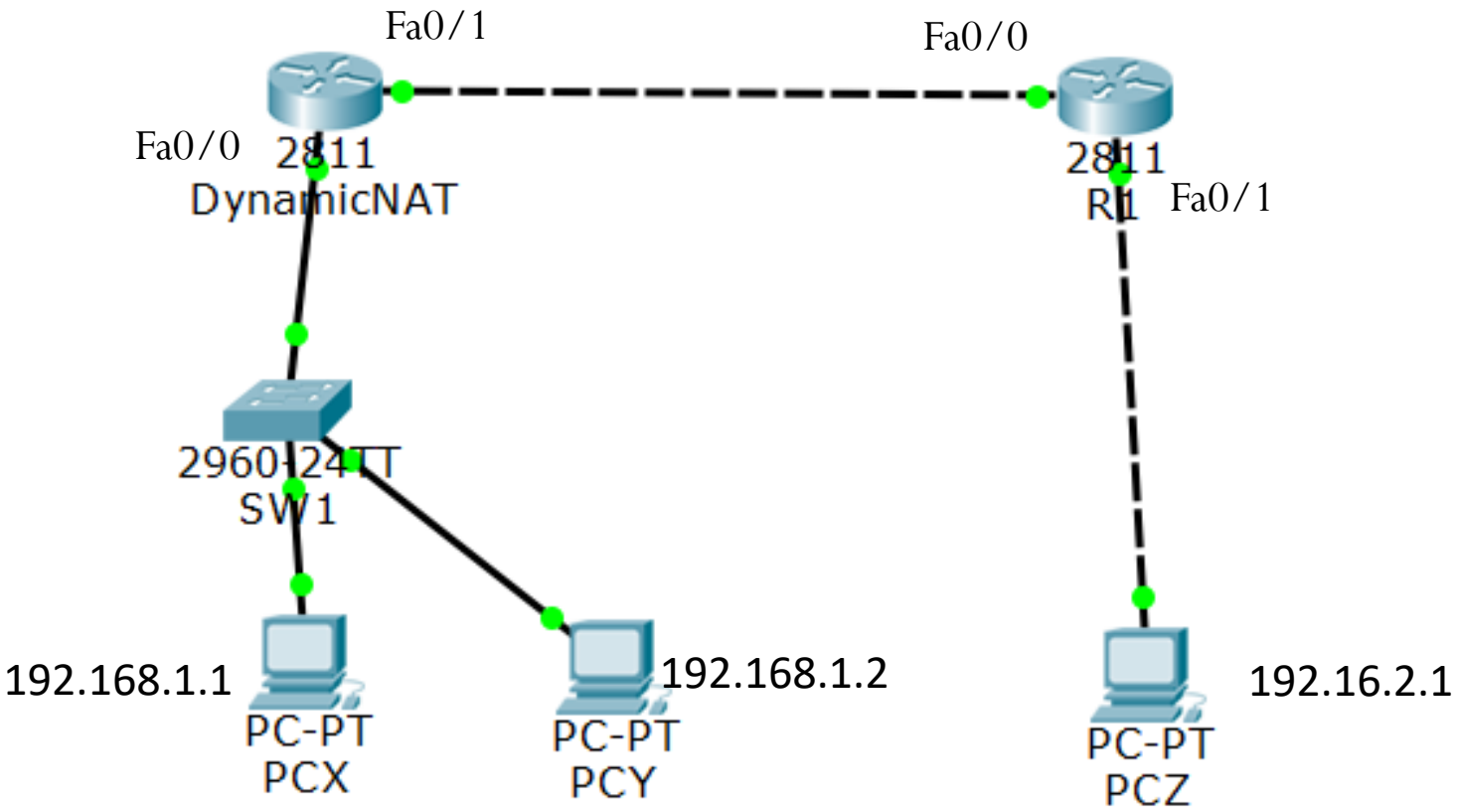
```
NAT(config)#access-list 1 permit 192.168.1.0   0.0.0.255
```

IP in the range 192.168.1.0 to 192.168.1.255 will only be translated

```
NAT(config)#ip nat inside source list 1 pool mypool
```

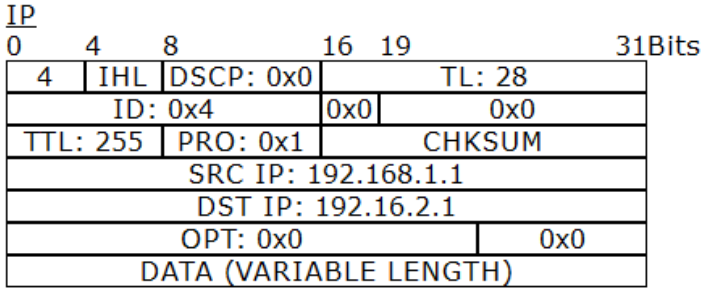
Dynamic NAT....

Sample network for dynamic NAT illustration

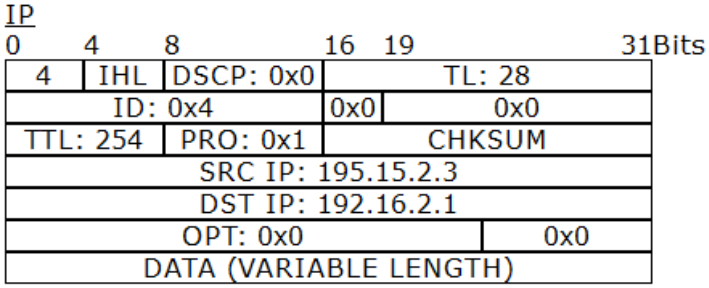


Dynamic NAT....

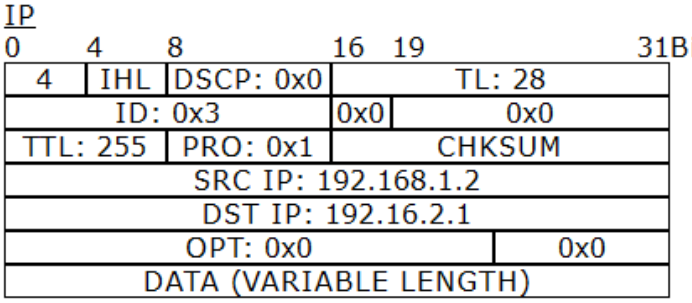
Sample network for dynamic NAT illustration



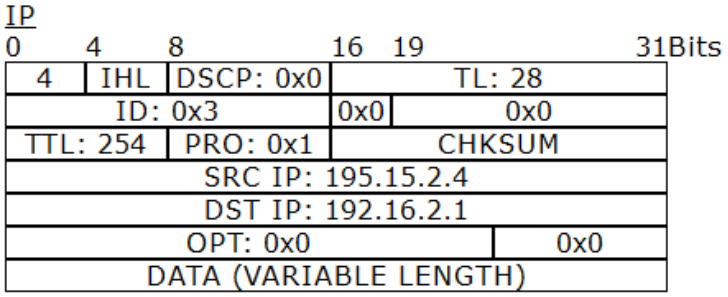
(a) Incoming IP header at fa0/0 from PCX



(b) Outgoing IP header at fa0/1 from PCX



(c) Incoming IP header at fa0/0 from PCY



(d) Outgoing IP header at fa0/1 from PCY

PAT

```
NAT(config)#int fa0/0
NAT(config-if)#ip nat inside
NAT(config-if)#int fa0/1
NAT(config-if)#ip nat outside

NAT(config)#access-list 1 permit 192.168.1.0    0.0.0.255
```

IP in the range 192.168.1.0 to 192.168.1.255 will only be translated

```
NAT(config)#ip nat inside source list 1 interface
                fastethernet 0/1 overload
```

PAT....

Verifying Configurations of NAT and PAT

`Router#show access-list`	Displays access lists
`Router#show ip nat translations`	Displays the translation table
`Router#show ip nat statistics`	Displays NAT statistics
`Router#clear ip nat translation inside 1.1.1.1 2.2.2.2 outside 3.3.3.3 4.4.4.4`	Clears a specific translation from the table before it times out 1.1.1.1 = Global IP address 2.2.2.2 = Local IP address 3.3.3.3 = Local IP address 4.4.4.4 = Global IP address
`Router#clear ip nat translation*`	Clears the entire translation table before entries time out

References

[1] S. Empson, *CCNA Portable Command Guide*, 2nd ed., Cisco Systems, Inc., 2008, USA.

Recommended Books

1. **Official Cert Guide CCNA 200-301 , vol. 1**, *W. Odom*, Cisco Press, First Edition, 2019, USA.
2. **CCNA Routing and Switching**, *T. Lammle*, John Wily & Sons, Second Edition, 2016, USA.