Technical Report

School of Sciences and Engineering

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CSCE 3313 Project

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First Part

FTP/TFTP Protocol

FTP:

File Transfer Protocol (FTP) is an application layer protocol that moves files between local and remote file systems. It runs on top of TCP, like HTTP. To transfer a file, 2 TCP connections are used by FTP in parallel: control connection and data connection.

1. **Control Connection:** For sending control information like user identification, password, commands to change the remote directory, commands to retrieve and store files, etc., FTP makes use of a control connection. The control connection is initiated on port number 21.
2. **Data Connection:** For sending the actual file, FTP makes use of a data connection. A data connection is initiated on port number 20.

FTP session: When an FTP session is started between a client and a server, the client initiates a control TCP connection with the server side. The client sends control information over this connection. When the server receives this, it initiates data connection to the client side. Only one file can be sent over the data connection. But the control connection remains active throughout the user session. FTP needs to maintain a state about its user throughout the session.

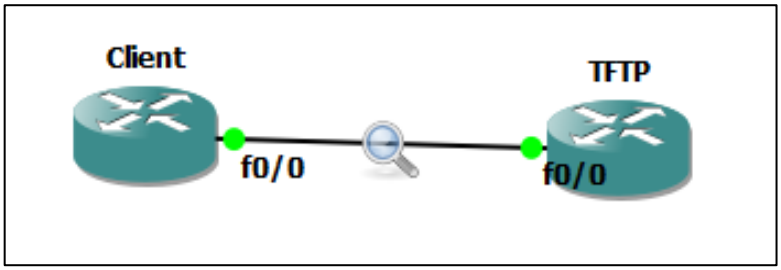
TFTP:

TFTP stands for Trivial File Transfer Protocol. TFTP is defined as a protocol that is used to transfer a file from a client to a server and from a server to a client. TFTP is majorly used when no complex instructions are required by the client and server. The service of TFTP is provided by UDP (User Datagram Protocol) and works on port number 69. TFTP does not provide security features therefore it is not used in communications that take place over the Internet. Therefore, it is used only for the systems that are set up on the local internet. TFTP requires less amount of memory.

Feature	FTP	TFTP
Purpose	Transfer files between computers	Transfer files between computers
Connection	Establishes a connection between two computers, Control connection and Data connection	Establishes a connection between two computers
Authentication	Use username and password for authentication	Does not support authentication
Security	Encrypts data transfer	Does not encrypt data transfer
Error Handling	Can recover from errors during transfer	Does not have error recovery
File Transfer Mode	Supports both ASCII and binary transfer modes	Only supports binary transfer modes
Transfer Options	Supports resuming interrupted transfer and setting transfer modes, transfer type, and other options	Does not support any transfer option

In general, FTP is a more robust and feature-rich protocol for transferring files, while TFTP is simpler and easier to set up but has fewer options and capabilities. FTP is commonly used for transferring larger files or transferring files between computers with different architectures, while TFTP is often used in small networks where a simple file transfer solution is sufficient.

TFTP (GNS3)



Packets captured in Wireshark

No.	Time	Source	Destination	Protocol	Length	Info
4	1.347546	192.168.12.1	192.168.12.2	TFTP	60	Read Request, File: config, Transfer type: octet
5	1.363545	192.168.12.2	192.168.12.1	TFTP	558	Data Packet, Block: 1
6	1.394862	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 1
7	1.426863	192.168.12.2	192.168.12.1	TFTP	500	Data Packet, Block: 2 (last)
8	1.458781	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 2
10	1.490788	192.168.12.1	192.168.12.2	TFTP	60	Read Request, File: config, Transfer type: octet
11	1.506789	192.168.12.2	192.168.12.1	TFTP	558	Data Packet, Block: 1
12	1.522102	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 1
13	1.553576	192.168.12.2	192.168.12.1	TFTP	500	Data Packet, Block: 2 (last)
14	1.568576	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 2
16	1.599583	192.168.12.1	192.168.12.2	TFTP	60	Read Request, File: config, Transfer type: octet
17	1.630583	192.168.12.2	192.168.12.1	TFTP	558	Data Packet, Block: 1
18	1.662587	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 1
19	1.694583	192.168.12.2	192.168.12.1	TFTP	500	Data Packet, Block: 2 (last)
20	1.725584	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 2
22	1.757576	192.168.12.1	192.168.12.2	TFTP	60	Read Request, File: config, Transfer type: octet
23	1.773659	192.168.12.2	192.168.12.1	TFTP	558	Data Packet, Block: 1
24	1.789691	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 1
25	1.820683	192.168.12.2	192.168.12.1	TFTP	500	Data Packet, Block: 2 (last)
26	1.835684	192.168.12.1	192.168.12.2	TFTP	60	Acknowledgement, Block: 2

Headers

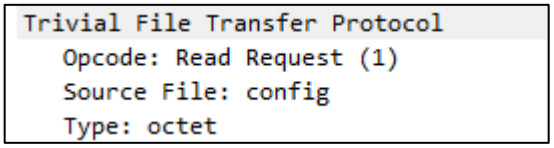
```
▾ Internet Protocol Version 4, Src: 192.168.12.2, Dst: 192.168.12.1
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  › Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 544
    Identification: 0x0000 (0)
  › 000. .... = Flags: 0x0
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 255
    Protocol: UDP (17)
    Header Checksum: 0x2079 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.12.2
    Destination Address: 192.168.12.1
▾ User Datagram Protocol, Src Port: 53005, Dst Port: 58877
    Source Port: 53005
    Destination Port: 58877
    Length: 524
    Checksum: 0x4cb0 [unverified]
    [Checksum Status: Unverified]
    [Stream index: 3]
  › [Timestamps]
    UDP payload (516 bytes)
▾ Trivial File Transfer Protocol
    Opcode: Data Packet (3)
    [Destination File: config]
    [Read Request in frame 10]
    Block: 1
    [Full Block Number: 1]
▾ Data (512 bytes)
    Data: 0a210a76657273696f6e2031322e340a7365727669636520746d657374616d70732064…
    [Length: 512]
```

TFTP runs on UDP, which uses a conventional "header/data" formatting scheme. The original TFTP standard defines five different types of messages: Read Request (RRQ), Write Request (WRQ), Data (DATA), Acknowledgment (ACK), and Error (ERROR).

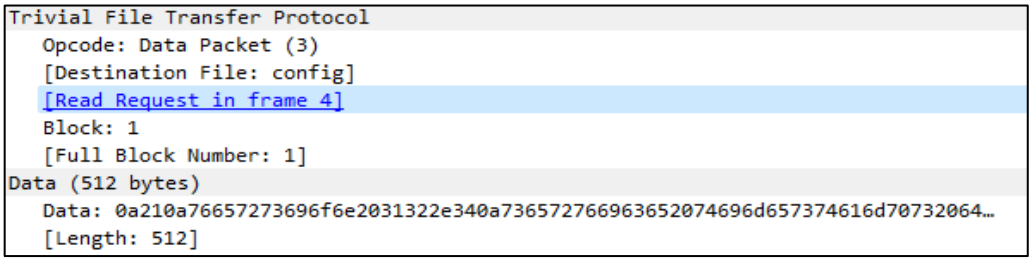
Opcode indicates the type of message:

1. RRQ: 1
2. DATA: 3
3. ACK: 4
4. WRQ: 2
5. ERROR: 5

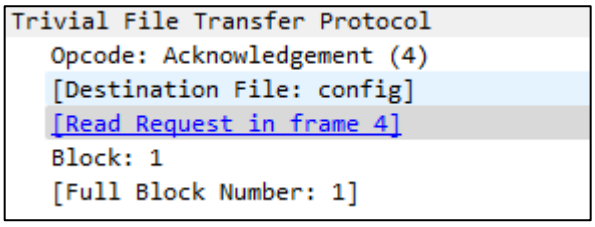
Read Request (RRQ):



Data (DATA)



Acknowledgment (ACK)



Source File: the file that has been requested.

Destination file: the file that has been selected by the client.

Data: is data gotten from the source file.

Block: each data packet contains one block of data which must be acknowledged by an acknowledgment packet before the next packet can be sent.

Octet mode: is used to transfer a file that is in the 8-bit format of the machine from which the file is being transferred.

FTP Session

```
C:\Users\karimsherif2410>ftp test.rebex.net
Connected to test.rebex.net.
220 Rebex FTP Server ready.
200 Enabled UTF-8 encoding.
User (test.rebex.net:(none)): demo
331 Password required for 'demo'.
Password:
230 User 'demo' logged in.
ftp> help
Commands may be abbreviated.  Commands are:

!               delete          literal         prompt          send
?               debug           ls              put             status
append          dir             mdelete         pwd             trace
ascii           disconnect      mdir            quit            type
bell            get             mget            quote           user
binary          glob            mkdir           recv            verbose
bye             hash            mls             remotehelp
cd              help            mput            rename
close           lcd             open            rmdir
ftp> ls
200 'PORT' OK.
125 Data connection already open; starting 'BINARY' transfer.
pub
readme.txt
226 Transfer complete.
ftp: 20 bytes received in 0.01Seconds 1.33Kbytes/sec.
ftp> opem readme.txt
Invalid command.
ftp> open readme.txt
Already connected to test.rebex.net, use disconnect first.
ftp> get readme.txt
200 'PORT' OK.
125 Data connection already open; starting 'BINARY' transfer.
226 Transfer complete.
ftp: 379 bytes received in 0.05Seconds 8.06Kbytes/sec.
ftp> close
221 Closing session.
ftp> bye
```

Packets Captured in Wireshark

558	17.837430	194.108.117.16	10.7.57.54	FTP	83	Response: 220 Rebex FTP Server ready.
560	17.844712	10.7.57.54	194.108.117.16	FTP	68	Request: OPTS UTF8 ON
570	17.909956	194.108.117.16	10.7.57.54	FTP	83	Response: 200 Enabled UTF-8 encoding.
764	24.824270	10.7.57.54	194.108.117.16	FTP	65	Request: USER demo
766	24.890518	194.108.117.16	10.7.57.54	FTP	89	Response: 331 Password required for 'demo'.
881	29.255472	10.7.57.54	194.108.117.16	FTP	69	Request: PASS password
884	29.321301	194.108.117.16	10.7.57.54	FTP	82	Response: 230 User 'demo' logged in.
1010	35.431011	10.7.57.54	194.108.117.16	FTP	79	Request: PORT 10,7,57,54,143,216
1012	35.497451	194.108.117.16	10.7.57.54	FTP	70	Response: 200 'PORT' OK.
1013	35.505451	10.7.57.54	194.108.117.16	FTP	60	Request: NLST
1020	35.570665	194.108.117.16	10.7.57.54	FTP	117	Response: 125 Data connection already open; starting 'BINARY' transfer.
1027	35.630129	194.108.117.16	10.7.57.54	FTP	78	Response: 226 Transfer complete.
2447	124.408348	10.7.57.54	194.108.117.16	FTP	79	Request: PORT 10,7,57,54,143,238
2452	124.474128	194.108.117.16	10.7.57.54	FTP	70	Response: 200 'PORT' OK.
2457	124.478985	10.7.57.54	194.108.117.16	FTP	71	Request: RETR readme.txt
2471	124.544598	194.108.117.16	10.7.57.54	FTP	117	Response: 125 Data connection already open; starting 'BINARY' transfer.
2478	124.605522	194.108.117.16	10.7.57.54	FTP	78	Response: 226 Transfer complete.
3020	154.646304	10.7.57.54	194.108.117.16	FTP	60	Request: QUIT
3023	154.711084	194.108.117.16	10.7.57.54	FTP	76	Response: 221 Closing session.

Definition of all the commands used in FTP sessions

Command	Definition
!	The exclamation point command switches temporarily from FTP to operating system. When using the operating system, typing **exit** takes you back to the FTP command line
?	Access the help screen.
append	Append text to a local file.
ascii	Switch to ASCII transfer mode.
bell	Turns bell mode on or off.
binary	Switches to binary transfer mode.
bye	Exits from FTP.
cd	Changes directory.
close	Exits from FTP.
delete	Deletes a file.
debug	Sets debugging on or off.
dir	Lists files if connected. dir -C: lists files in wide format. dir -1: lists files in bare format in alphabetical order. dir -r: lists directory in reverse alphabetical order. dir -R: lists all files in current directory and subdirectories. dir -S: lists files in bare format in alphabetical order.
disconnect	Exits from FTP.
get	Grabs file from the connected computer.
glob	Sets globbing on or off. When turned off the file name in the put and get commands is taken literally and wildcards are not used.
hash	Sets hash mark printing on or off. When turned on, for each 1024 bytes of data received, a hash mark (#) is displayed.
help	Access the help screen and displays information about command if command typed after help.

lcd	Displays local directory if typed alone, or if path typed after lcd, changes local directory.
literal	Sends a literal command to the connected computer with an expected one line response.
ls	Lists files of the remotely connected computer.
mdelete	Multiple delete.
mdir	Lists contents of multiple remote directories.
mget	Get multiple files.
mkdir	Make directory.
mls	Lists contents of multiple remote directories.
mput	Sent multiple files
open	Opens address.
prompt	Enables or disables the prompt.
put	Send one file.
pwd	Print working directory.
quit	Exits from FTP.
quote	Same as the literal command.
recv	Receive file.
remotehelp	Get help from remote server.
rename	Renames a file.
rmdir	Removes a directory on the remote computer.
send	Send single file.
status	Shows status of currently enabled and disabled options.
trace	Toggles packet tracing.
type	Set file transfer type.
user	Send new user information.
verbose	Sets verbose on or off. It provides additional details as to what the computer is doing and what drivers and software it is loading during startup.

Second Part

OSPF Protocol

What is the OSPF protocol and under which routing protocol the OSPF classified.

OSPF stands for Open Shortest Path First and falls under Intra-AS Routing which is also known as Interior gateway protocols (IGP). It distributes routing information between routers within one Autonomous System (AS). OSPF uses link-state routing, which consists of:

- Link state packet flooding
- Topology map at each node
- Route computation using Dijkstra's shortest path algorithm

Router floods OSPF link-state advertisements to all other routers within the entire AS. It's based upon a two-level hierarchy: local area and backbone where link-state advertisements are only within an area and each node has detailed area topology; only know direction (shortest path) to nets in other area.

There are 4 types of routers in OSPF:

1. Backbone Router: runs OSPF and has at least one interface connected to OSPF backbone area.
2. Area Border Router (ABR): has OSPF neighbor relationships with devices in multiple areas.
3. Internal Router: has OSPF neighbor relationships only with devices in the same area.
4. Autonomous System Border Router (ASBR): exchanges routing information with routers belonging to other Autonomous Systems (AS).

Difference between Neighbor and Adjacency Routers:

Neighbor routers are OSPF routers on the same network connected to the same subnet. They share the same configuration information such as: Area ID, Area Type, and Subnet Mask. Neighbor routers do not exchange any routing information. Adjacency Routers are OSPF routers that exchange LSAs (Link State Advertisements). Therefore, adjacent routers exchange routing information. In order for routers to become adjacent, they must first be neighbors. Adjacency cannot be formed between routers if they are not neighbors.

What is LSA and LSDB?

LSA stands for Link State Advertisements and represents multicast messages to other routers in the OSPF domain. They are sent from internal routers to DR/BDR (Designed Routers/Backup Designated Routers) to communicate a router's routing information to all other local routers in the same OSPF area.

LSDB stands for the Link State Database and it keeps information about all link states in the network. Each router stores received LSA packets in the LSDB. The difference between LSA and LSDB is that LSAs are information messages about the network, but LSDB is database with LSAs for each area.

What is DR and BDR? How to elect either one of them and how their assignment work?

DR stands for Designated Router and BDR stands for Backup Designated Router. In an OSPF network, one router is chosen to be the DR and another router is chosen to be the BDR. If DR fails, BDR takes DR responsibilities. All LSAs (information messages) are forwarded to the designated router and backup designated router. The DR and BDR are like a central point for exchanging information. Therefore, non-DR and non-BDR routers only need to send routing information to the DR and BDR instead of all routers.

Each router on the network sends a Hello message, which has information about the router such as identity, priority and options. Router with the highest priority and second highest priority become the DR and BDR respectively. If 2 routers have same priority, one with highest ID is selected.

How does router ID work in OSPF?

Router identifier is IP address of local routing device. It is the routing device from which a packet originated. If the router identifier is not configured manually, the highest IP address on a loopback interface will become the router ID. If no loopback is present, the largest IP of any interface will become the router ID.

Define the concept of Areas and their different types and properties.

Concept of Areas:

Every router learns the overview of the network such as every router in network, its interfaces and what they connect to. This leads to complications in large networks, since there can be too many routes and any changes will result in the routers having to reconverge which is time-consuming.

Therefore, OSPF has a hierarchical design which breaks large networks into smaller areas. Every router keeps information about its own area and summaries about routers in other areas. As a result, there will be less routes in the routing table and it won't be directly affected by any changes in other areas.

There are 5 OSPF area types:

Backbone Area: Every AS must have only one backbone area (known as area 0). It acts like a central node in the OSPF network, since the information of all links of other areas are transmitted through area 0. It connects all other OSPF areas.

Standard Area: Any OSPF area that is not the Backbone Area but is connected to the Backbone Area.

Stub Area: is an area that doesn't allow external (Type 5) LSAs from entering the area.
Type 5 LSA is generated by the ASBR (Autonomous System Border Router) and describes the routes that have entered the OSPF domain from an external AS. It blocks external routes from being advertised into the area.

Totally Stubby Area: is a variation of the Stub Area. It blocks both external (Type 5) and summary (Type 3) LSAs from entering the area.

Type 3 LSA is generated by the ABR (Area Border Router) and describes inter-area routes. It doesn't accept external routes or link information of other areas outside of their own area.

Not So Stubby Area (NSSA): it allows external routes, but not Type 5 LSAs. Basically, it allows external routes to enter the area through Type 7 LSAs which are translated into Type 5 LSAs at the area border router (ABR) before advertising them into other areas.

Type 7 LSA is generated by the ASBR within a NSSA to describe external routes. It's sent from ASBR to ABR, converted into a Type 5 by the ABR, then advertised to other areas.

What's the metric used in OSPF and how to calculate the cost? Give an example.

The metric used in OSPF is the cost. Cost is inversely proportional to the bandwidth of the link. Therefore, the higher bandwidth, the lower the cost and faster the path.

Cost calculation is as follows:

Cost = Reference Bandwidth / Interface Bandwidth

The Reference Bandwidth in OSPF is 100Mbps by default. The interface bandwidth is the bandwidth of the link/interface.

For example, if the bandwidth of a link is 10Mbps, then the cost is simply 100/10 which is 10.

What are the steps to build a routing table in OSPF protocol?

There are 5 steps involved in building a routing table in OSPF.

1. Discovering Neighbors:

The OSPF routers send 'Hello' packets to find neighboring OSPF routers and exchange routing information such as area ID, router ID, and interface IP addresses. The routers will then form adjacencies with neighboring routers.

2. Generating and Sending LSAs (Link State Advertisements):

Routers generate LSAs about its directly connected networks and interfaces, then send LSAs using OSPF multicast address to all other OSPF routers in their same area.

3. Storing in LSDB (Link State Database):

Routers store the LSAs they received from their neighbors in the Link State Database (LSDB). The LSDB has the complete network topology of each OSPF area (LSDB synchronization).

4. Calculate Lowest Cost/Shortest Path:

Routers run Dijkstra's algorithm to calculate shortest path to each network destination in the area using the cost metric of each link/interface which is based upon the bandwidth of the link.

5. Build Routing Table:

Routers build the Routing Table which contains all network destinations in the OSPF area.

What are the OSPF packet types that can be captured using Wireshark?

There are 5 types of OSPF Packets:

1. Hello packet:

Used for discovering neighbors and forming adjacencies. It has information such as Router ID, Area ID, and interface IP addresses.

2. Database Descriptor packet (DBD):

Used to share information about OSPF Link State Database (LSDB). It has list of LSAs that sending router has in its LSDB. It's needed to synchronize LSDBs of all routers.

3. Link State Request packet (LSR):

Used to request specific LSAs from neighboring routers. It determines the LSAs that sending router wants to receive.

4. Link State Update packet (LSU):

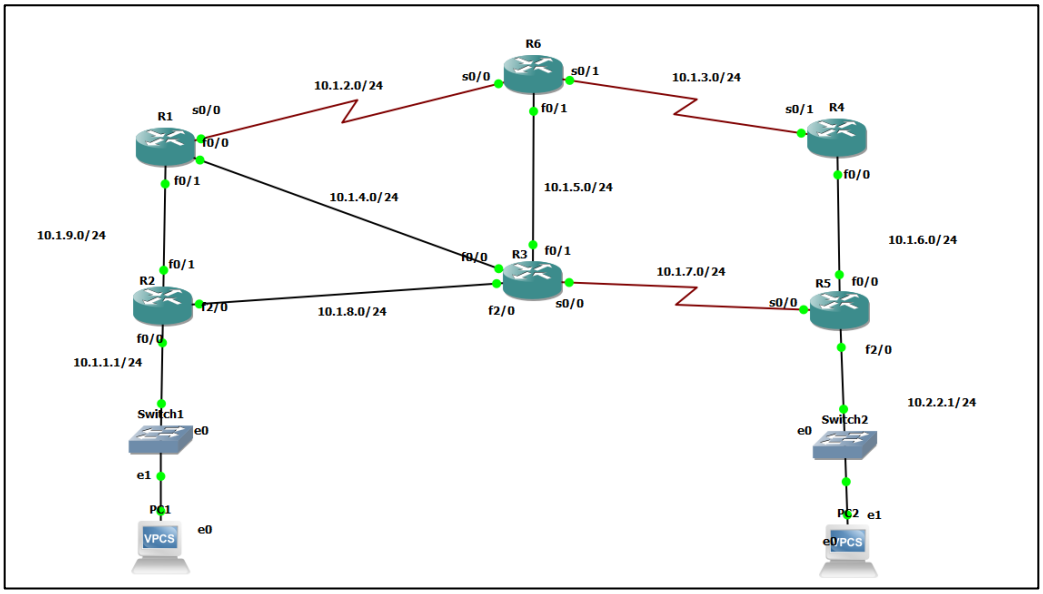
Used to send/flood LSAs throughout network. Each LSA contains routing, metric and topology information to describe parts of the OSPF network.

5. Link State Acknowledgment packet (LSAck):

Used to acknowledge that LSU packets have been received. Multiple LSAs can be acknowledged in a single LSAck packet.

Second Part
OSPF Practical Questions

Network Topology



Question 1

R1 Configuration (Backbone Router)

```
R1(config)#router ospf 1
R1(config-router)#network 10.1.2.0 0.0.0.255 area 0
R1(config-router)#network 10.1.9.0 0.0.0.255 area 0
R1(config-router)#network 10.1.4.0 0.0.0.255 area 0
R1(config-router)#end
R1#wr
```

R2 Configuration (Backbone Router)

```
R2(config-router)#network 10.1.9.0 0.0.0.255 area 0
R2(config-router)#network 10.1.1.0 0.0.0.255 area 0
R2(config-router)#network 10.1.8.0 0.0.0.255 area 0
R2(config-router)#end
R2#
*Mar  1 00:59:17.375: %SYS-5-CONFIG_I: Configured from console by console
R2#wr
```

R3 Configuration (ABR)

```
R3#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#router ospf 1
R3(config-router)#network 10.1.8.0 0.0.0.255 area 0
R3(config-router)#network 10.1.4.0 0.0.0.255 area 0
R3(config-router)#
*Mar  1 01:00:10.247: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.2 on FastEthernet2/0 from LOADING to FULL, Loading Done
R3(config-router)#network 10.1.5.0 0.0.0.255 area 0
R3(config-router)#network 10.1.7.0 0.0.0.255 area 1
R3(config-router)#end
R3#wr
```

R4 Configuration (Normal)

```
R4(config-router)#network 10.1.6.0 0.0.0.255 area 1
R4(config-router)#network 10.1.3.0 0.0.0.255 area 1
R4(config-router)#end
R4#wr
```

R5 Configuration (Normal)

```
R5(config)#router ospf 1
R5(config-router)#network 10.2.2.0 0.0.0.255 area 1
R5(config-router)#network 10.1.7.0 0.0.0.255 area 1
R5(config-router)#network 10.1.7.0 0.0.0.255 area 1
*Mar  1 01:03:01.247: %OSPF-5-ADJCHG: Process 1, Nbr 3.3.3.3 on Serial0/0 from LOADING to FULL, Loading Done
R5(config-router)#network 10.1.6.0 0.0.0.255 area 1
R5(config-router)#end
```

R6 Configuration (ABR)

```
R6(config)#router ospf 1
R6(config-router)#network 10.1.5.0 0.0.0.255 area 0
R6(config-router)#network 10.1.2.0 0.0.0.2
*Mar  1 01:04:05.415: %OSPF-5-ADJCHG: Process 1, Nbr 3.3.3.3 on FastEthernet0/1 from LOADING to FULL, Loading Done
R6(config-router)#network 10.1.2.0 0.0.0.255 area 0
R6(config-router)#network
*Mar  1 01:04:12.587: %OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on Serial0/0 from LOADING to FULL, Loading Done
R6(config-router)#network 10.1.3.0 0.0.0.255 area 1
R6(config-router)#end
R6#wr
```

Question 2

R1 OSPF Areas of Interfaces Verification

```
R1#show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Fa0/0        1     0               10.1.4.1/24        10    DR    0/0
Fa0/1        1     0               10.1.9.1/24        10    DR    0/0
Se0/0        1     0               10.1.2.1/24        64    P2P   1/1
R1#
```

R2 OSPF Areas of Interfaces Verification

```
R2#show ip ospf interface BRIEF
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Fa2/0        1     0               10.1.8.1/24        1     DR    1/1
Fa0/0        1     0               10.1.1.1/24        10    DR    0/0
Fa0/1        1     0               10.1.9.2/24        10    DR    0/0
R2#
```

R3 OSPF Areas of Interfaces Verification

```
R3#show ip ospf interface BRIEF
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Fa0/1        1     0               10.1.5.2/24        10    DR    1/1
Fa0/0        1     0               10.1.4.2/24        10    DR    0/0
Fa2/0        1     0               10.1.8.2/24        1     BDR   1/1
Se0/0        1     1               10.1.7.2/24        64    P2P   1/1
R3#
```

R4 OSPF Areas of Interfaces Verification

```
R4#show ip ospf interface BRIEF
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Se0/1        1     1               10.1.3.2/24        64    P2P   1/1
Fa0/0        1     1               10.1.6.2/24        10    DR    1/1
R4#
```

R5 OSPF Areas of Interfaces Verification

```
R5#show ip ospf interface BRIEF
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Fa0/0        1     1               10.1.6.1/24        10    BDR   1/1
Se0/0        1     1               10.1.7.1/24        64    P2P   1/1
Fa2/0        1     1               10.2.2.1/24        1     DR    0/0
R5#
```

R6 OSPF Areas of Interfaces Verification

```
R6#show ip ospf interface BRIEF
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Se0/0        1     0               10.1.2.2/24        64    P2P   1/1
Fa0/1        1     0               10.1.5.1/24        10    BDR   1/1
Se0/1        1     1               10.1.3.1/24        64    P2P   1/1
R6#
```

Question 3

R1 OSPF Router ID: 1.1.1.1

```
R1#show ip ospf
 Routing Process "ospf 1" with ID 1.1.1.1
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
```

Question 4

R1 Neighbors

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
6.6.6.6           0   FULL/  -        00:00:39    10.1.2.2        Serial0/0
```

R2 Neighbors

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           1   FULL/BDR        00:00:35    10.1.8.2        FastEthernet2/0
```

R3 Neighbors

```
R3#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
6.6.6.6           1   FULL/BDR        00:00:35    10.1.5.1        FastEthernet0/1
2.2.2.2           1   FULL/DR         00:00:32    10.1.8.1        FastEthernet2/0
5.5.5.5           0   FULL/  -        00:00:30    10.1.7.1        Serial0/0
```

R4 Neighbors

```
R4#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
6.6.6.6           0   FULL/  -        00:00:37    10.1.3.1        Serial0/1
5.5.5.5           1   FULL/BDR        00:00:31    10.1.6.1        FastEthernet0/0
```

R5 Neighbors

```
R5#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
4.4.4.4           1   FULL/DR         00:00:35    10.1.6.2        FastEthernet0/0
3.3.3.3           0   FULL/  -        00:00:31    10.1.7.2        Serial0/0
```

R6 Neighbors

```
R6#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           0   FULL/  -        00:00:39    10.1.2.1        Serial0/0
3.3.3.3           1   FULL/DR         00:00:37    10.1.5.2        FastEthernet0/1
4.4.4.4           0   FULL/  -        00:00:30    10.1.3.2        Serial0/1
```

Question 5

R1 Interface Brief

```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.1.4.1        YES manual up                    up
Serial0/0                  10.1.2.1        YES manual up                    up
FastEthernet0/1            10.1.9.1        YES manual up                    up
Serial0/1                  unassigned      YES unset  administratively down down
FastEthernet1/0            unassigned      YES unset  administratively down down
FastEthernet2/0            unassigned      YES unset  administratively down down
```

R2 Interface Brief

```
R2#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.1.1.1        YES manual up                    up
FastEthernet0/1            10.1.9.2        YES manual up                    up
FastEthernet1/0            unassigned      YES unset  administratively down down
FastEthernet2/0            10.1.8.1        YES manual up                    up
Loopback2                  2.2.2.2         YES manual up                    up
```

R3 Interface Brief

```
R3#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.1.4.2        YES manual up                    up
Serial0/0                  10.1.7.2        YES manual up                    up
FastEthernet0/1            10.1.5.2        YES manual up                    up
Serial0/1                  unassigned      YES unset  administratively down down
FastEthernet1/0            unassigned      YES unset  administratively down down
FastEthernet2/0            10.1.8.2        YES manual up                    up
Loopback3                  3.3.3.3         YES manual up                    up
```

R4 Interface Brief

```
R4#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.1.6.2        YES manual up                    up
Serial0/0                  unassigned      YES unset  administratively down down
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial0/1                  10.1.3.2        YES manual up                    up
FastEthernet1/0            unassigned      YES unset  administratively down down
FastEthernet2/0            unassigned      YES unset  administratively down down
Loopback4                  4.4.4.4         YES manual up                    up
```

R5 Interface Brief

```
R5#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.1.6.1        YES manual up                    up
Serial0/0                  10.1.7.1        YES manual up                    up
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial0/1                  unassigned      YES unset  administratively down down
FastEthernet1/0            unassigned      YES unset  administratively down down
FastEthernet2/0            10.2.2.1        YES manual up                    up
Loopback5                  5.5.5.5         YES manual up                    up
```

R6 Interface Brief

```
R6#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            unassigned      YES unset  administratively down down
Serial0/0                  10.1.2.2        YES manual up                    up
FastEthernet0/1            10.1.5.1        YES manual up                    up
Serial0/1                  10.1.3.1        YES manual up                    up
FastEthernet1/0            unassigned      YES unset  administratively down down
FastEthernet2/0            unassigned      YES unset  administratively down down
Loopback6                  6.6.6.6         YES manual up                    up
```

Question 6

There are 2 paths to reach that R1 could use to reach the 5.5.5.5 network (10.1.7.0 and 10.1.6.0).

The route in the routing table is via 10.1.2.2.

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback1
     10.0.0.0/24 is subnetted, 10 subnets
C       10.1.9.0 is directly connected, FastEthernet0/1
O       10.1.8.0 [110/75] via 10.1.2.2, 01:00:23, Serial0/0
O IA    10.1.3.0 [110/128] via 10.1.2.2, 01:00:19, Serial0/0
C       10.1.2.0 is directly connected, Serial0/0
O IA    10.2.2.0 [110/139] via 10.1.2.2, 01:00:09, Serial0/0
O       10.1.1.0 [110/85] via 10.1.2.2, 01:00:23, Serial0/0
O IA    10.1.7.0 [110/138] via 10.1.2.2, 01:00:11, Serial0/0
O IA    10.1.6.0 [110/138] via 10.1.2.2, 01:00:11, Serial0/0
O       10.1.5.0 [110/74] via 10.1.2.2, 01:00:25, Serial0/0
C       10.1.4.0 is directly connected, FastEthernet0/0
R1#
```

Question 7

OSPF Packets Capture

Capturing from - [Switch2 Ethernet1 to PC2 Ethernet0]

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
11	89.977159	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
12	99.973121	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
13	109.965157	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
14	110.483365	c2:05:0a:c8:00:20	CDP/VTP/DTP/PAgP/UD…	CDP	340	Device ID: R5 Port ID: FastEthernet2/0
15	119.960758	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
16	129.969474	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
17	139.980336	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
18	149.979331	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
19	159.974871	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
20	170.047793	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
21	170.519428	c2:05:0a:c8:00:20	CDP/VTP/DTP/PAgP/UD…	CDP	340	Device ID: R5 Port ID: FastEthernet2/0
22	180.025483	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
23	190.032399	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
24	200.056551	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
25	209.998519	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
26	220.012082	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
27	230.004921	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
28	230.523508	c2:05:0a:c8:00:20	CDP/VTP/DTP/PAgP/UD…	CDP	340	Device ID: R5 Port ID: FastEthernet2/0
29	240.047982	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
30	250.032340	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
31	260.036261	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
32	270.031265	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
33	280.022541	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
34	290.040028	10.2.2.1	224.0.0.5	OSPF	90	Hello Packet
35	290.543132	c2:05:0a:c8:00:20	CDP/VTP/DTP/PAgP/UD…	CDP	340	Device ID: R5 Port ID: FastEthernet2/0

OSPF Header

```
    [Coloring Rule Name: Routing]
    [Coloring Rule String: hsrp || eigrp || ospf || bgp || cdp || vrrp || carp || gvrp || igmp || ismp]
> Ethernet II, Src: c2:05:0a:c8:00:20 (c2:05:0a:c8:00:20), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 10.2.2.1, Dst: 224.0.0.5
v Open Shortest Path First
  v OSPF Header
      Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 44
      Source OSPF Router: 5.5.5.5
      Area ID: 0.0.0.1
      Checksum: 0xd690 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  v OSPF Hello Packet
      Network Mask: 255.255.255.0
      Hello Interval [sec]: 10
    > Options: 0x12, (L) LLS Data block, (E) External Routing
      Router Priority: 1
      Router Dead Interval [sec]: 40
      Designated Router: 10.2.2.1
      Backup Designated Router: 0.0.0.0
  v OSPF LLS Data Block
      Checksum: 0xfff6
      LLS Data Length: 12 bytes
    > Extended options TLV
```

Question 8

Area 0

Designated Router (DR) Router IDs

1.1.1.1 2.2.2.2 3.3.3.3

Backup Designated Router (BDR) Router IDs

3.3.3.3 6.6.6.6

```
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.1.4.1/24, Area 0
  Process ID 1, Router ID 1.1.1.1, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 1.1.1.1, Interface address 10.1.4.1
  No backup designated router on this network
```

```
FastEthernet0/1 is up, line protocol is up
  Internet Address 10.1.9.1/24, Area 0
  Process ID 1, Router ID 1.1.1.1, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 1.1.1.1, Interface address 10.1.9.1
  No backup designated router on this network
```

```
FastEthernet2/0 is up, line protocol is up
  Internet Address 10.1.8.1/24, Area 0
  Process ID 1, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 2.2.2.2, Interface address 10.1.8.1
  Backup Designated router (ID) 3.3.3.3, Interface address 10.1.8.2
```

```
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.1.1.1/24, Area 0
  Process ID 1, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 2.2.2.2, Interface address 10.1.1.1
  No backup designated router on this network
```

```
FastEthernet0/1 is up, line protocol is up
  Internet Address 10.1.9.2/24, Area 0
  Process ID 1, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 2.2.2.2, Interface address 10.1.9.2
  No backup designated router on this network
```

```
FastEthernet0/1 is up, line protocol is up
  Internet Address 10.1.5.2/24, Area 0
  Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 3.3.3.3, Interface address 10.1.5.2
  Backup Designated router (ID) 6.6.6.6, Interface address 10.1.5.1
```

```
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.1.4.2/24, Area 0
  Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 3.3.3.3, Interface address 10.1.4.2
  No backup designated router on this network
```

```
FastEthernet2/0 is up, line protocol is up
  Internet Address 10.1.8.2/24, Area 0
  Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 2.2.2.2, Interface address 10.1.8.1
  Backup Designated router (ID) 3.3.3.3, Interface address 10.1.8.2
```

```
FastEthernet0/1 is up, line protocol is up
  Internet Address 10.1.5.1/24, Area 0
  Process ID 1, Router ID 6.6.6.6, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 3.3.3.3, Interface address 10.1.5.2
  Backup Designated router (ID) 6.6.6.6, Interface address 10.1.5.1
```

Area 1

Designated Router (DR) Router IDs

4.4.4.4 5.5.5.5

Backup Designated Router (BDR) Router IDs

5.5.5.5

```
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.1.6.2/24, Area 1
  Process ID 1, Router ID 4.4.4.4, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 4.4.4.4, Interface address 10.1.6.2
  Backup Designated router (ID) 5.5.5.5, Interface address 10.1.6.1
```

```
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.1.6.1/24, Area 1
  Process ID 1, Router ID 5.5.5.5, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 4.4.4.4, Interface address 10.1.6.2
  Backup Designated router (ID) 5.5.5.5, Interface address 10.1.6.1
```

```
FastEthernet2/0 is up, line protocol is up
  Internet Address 10.2.2.1/24, Area 1
  Process ID 1, Router ID 5.5.5.5, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 5.5.5.5, Interface address 10.2.2.1
  No backup designated router on this network
```

There is more than one network segment in each of Area 0 and Area 1. Therefore, there is more than one Designated Router (DR) and Backup Designated Router (BDR) in each area.

Question 9

Bandwidth Configuration

```
R1(config)#int f0/0
R1(config-if)#bandwidth 100000
R1(config-if)#end
R1#wr
Building configuration...
[OK]
```

R1 Bandwidths of Interfaces

```
R1#show int f0/1
FastEthernet0/1 is up, line protocol is up
  Hardware is Gt96k FE, address is c201.2958.0001 (bia c201.2958.0001)
  Internet address is 10.1.9.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000 usec,
```

```
R1#show int s0/0
Serial0/0 is up, line protocol is up
  Hardware is GT96K Serial
  Internet address is 10.1.2.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 20000 usec,
```

```
R1#show int f0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is c201.2958.0000 (bia c201.2958.0000)
  Internet address is 10.1.4.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000 usec,
```

R2 Bandwidths of Interfaces

```
R2#show int f0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is c202.26e8.0000 (bia c202.26e8.0000)
  Internet address is 10.1.1.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000 usec,
```

```
R2#show int f2/0
FastEthernet2/0 is up, line protocol is up
  Hardware is AmdFE, address is c202.26e8.0020 (bia c202.26e8.0020)
  Internet address is 10.1.8.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
```

```
R2#show int f0/1
FastEthernet0/1 is up, line protocol is up
  Hardware is Gt96k FE, address is c202.26e8.0001 (bia c202.26e8.0001)
  Internet address is 10.1.9.2/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000 usec,
```

R3 Bandwidths of Interfaces

```
R3#show int f0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is c203.2c08.0000 (bia c203.2c08.0000)
  Internet address is 10.1.4.2/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000 usec,
```

```
R3#show int f2/0
FastEthernet2/0 is up, line protocol is up
  Hardware is AmdFE, address is c203.2c08.0020 (bia c203.2c08.0020)
  Internet address is 10.1.8.2/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
```

```
R3#show int s0/0
Serial0/0 is up, line protocol is up
  Hardware is GT96K Serial
  Internet address is 10.1.7.2/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 20000 usec,
```

```
R3#show int f0/1
FastEthernet0/1 is up, line protocol is up
  Hardware is Gt96k FE, address is c203.2c08.0001 (bia c203.2c08.0001)
  Internet address is 10.1.5.2/24
  MTU 1500 bytes, BW 155000 Kbit, DLY 1000 usec,
```

R4 Bandwidths of Interfaces

```
R4#show int f0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is c204.0c04.0000 (bia c204.0c04.0000)
  Internet address is 10.1.6.2/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec,
```

```
R4#show int s0/1
Serial0/1 is up, line protocol is up
  Hardware is GT96K Serial
  Internet address is 10.1.3.2/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 20000 usec,
```

R5 Bandwidths of Interfaces

```
R5#show int s0/1
Serial0/1 is administratively down, line protocol is down
  Hardware is GT96K Serial
  MTU 1500 bytes, BW 10000 Kbit, DLY 20000 usec,
```

```
R5#show int f2/0
FastEthernet2/0 is up, line protocol is up
  Hardware is AmdFE, address is c205.0ac8.0020 (bia c205.0ac8.0020)
  Internet address is 10.2.2.1/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 100 usec,
```

```
R5#show int f0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is c205.0ac8.0000 (bia c205.0ac8.0000)
  Internet address is 10.1.6.1/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec,
```

R6 Bandwidths of Interfaces

```
R6#show int s0/1
Serial0/1 is up, line protocol is up
  Hardware is GT96K Serial
  Internet address is 10.1.3.1/24
  MTU 1500 bytes, BW 10000 Kbit, DLY 20000 usec,
```

```
R6#show int f0/1
FastEthernet0/1 is up, line protocol is up
  Hardware is Gt96k FE, address is c206.12a4.0001 (bia c206.12a4.0001)
  Internet address is 10.1.5.1/24
  MTU 1500 bytes, BW 155000 Kbit, DLY 1000 usec,
```

```
R6#show int s0/0
Serial0/0 is up, line protocol is up
  Hardware is GT96K Serial
  Internet address is 10.1.2.2/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 20000 usec,
```

Cost of the route between R4 and network 10.1.1.0/24 is **13**.

110 is the Administrative Distance. 13 is the metric.

OSPF uses cost as a metric. Cost of interfaces is inversely proportional to bandwidth of interfaces. Therefore, the higher the bandwidth, the lower the cost.

```
R4#show ip route ospf
     10.0.0.0/24 is subnetted, 10 subnets
O IA    10.1.9.0 [110/12] via 10.1.3.1, 00:03:21, Serial0/1
O IA    10.1.8.0 [110/12] via 10.1.3.1, 00:03:21, Serial0/1
O IA    10.1.2.0 [110/11] via 10.1.3.1, 00:03:21, Serial0/1
O       10.2.2.0 [110/20] via 10.1.6.1, 00:03:21, FastEthernet0/0
O IA    10.1.1.0 [110/13] via 10.1.3.1, 00:03:21, Serial0/1
O       10.1.7.0 [110/74] via 10.1.6.1, 00:03:21, FastEthernet0/0
O IA    10.1.5.0 [110/11] via 10.1.3.1, 00:03:21, Serial0/1
O IA    10.1.4.0 [110/12] via 10.1.3.1, 00:03:21, Serial0/1
R4#show ip route 10.1.1.0 255.255.255.0
Routing entry for 10.1.1.0/24
  Known via "ospf 1", distance 110, metric 13, type inter area
  Last update from 10.1.3.1 on Serial0/1, 00:04:34 ago
  Routing Descriptor Blocks:
  * 10.1.3.1, from 6.6.6.6, 00:04:34 ago, via Serial0/1
      Route metric is 13, traffic share count is 1
```

Verification using Manual Calculation

Route from R4 to network 10.1.1.0/24 via 10.1.3.1.

Cost = Reference Bandwidth/Interface Bandwidth

Reference Bandwidth = 100Mbps

Cost of Link 10.1.3.0/24 = 100/10 = 10

Cost of Link 10.1.5.0/24 = 100/100 = 1

Cost of Link 10.1.8.0/24 = 100/100 = 1

Cost of Link 10.1.1.0/24 = 100/100 = 1

Total Cost = 10 + 1 + 1 + 1 = **13**

Third Part

IPv6

1. Demonstrate the differences between IPv4 and IPv6

IPv4 and IPv6 are two distinct protocols used for identifying and routing networked devices. Differences are:

Address Length:

IPv4 uses 32-bit addresses, which limits the number of possible unique addresses to 4.3 billion.

IPv6 uses 128-bit addresses, allowing for a huge number of unique addresses. IPv6 was developed to address the shortcomings of IPv4, primarily the exhaustion of available addresses.

Address Representation:

IPv4 addresses are expressed in a dotted decimal format.

IPv6 addresses are represented in hexadecimal separated by colons.

Address Configuration:

IPv4, addresses are configured manually or through DHCP.

IPv6 supports multiple method for address configuration, including stateless address autoconfiguration (SLAAC) and DHCPv6, which simplifies address assignment and network reconfiguration.

Header Format:

IPv4 header is 20 bytes minimum and does not include support options. Options, if used, are included as an extension of the header.

IPv6 is 40 bytes and includes extension headers, allowing for additional functionalities and options. Extension headers are used for features such as fragmentation, security, and mobility.

Compatibility:

IPv4 is not directly compatible with IPv6, leading to the need for transition mechanisms such as tunneling, which is a mechanism for transmitting IPv6 packets over an IPv4 network where IPv6 packets become the payload of IPv4 packets as they are encapsulated within an IPv4 header.

2. Explain the IPv6 address format

IPv6 address are 128-bits long and are typically represented in hexadecimal notation separated by colons (:). For example: ‘2001:0db8:85a3:0000:0000:8a2e:0370:7334’

To shorten the representation and reduce the number of zeros, IPv6 allows the omission of leading zeros within each group. For example: ‘2001:db8:85a3:0000:0000:8a2e:370:7334’

Additionally, a double colon (::) can be used once in an IPv6 address to replace consecutive groups of zeros. However, the double colon can only be used once within the address to avoid ambiguity. For example: ‘2001:db8:85a3::8a2e:370:7334’

IPv6 addresses are commonly expressed with a prefix length to denote the network portion of the address. For example, 2001:db8::/32 indicates the first 32 bits represent the network portion, leaving 96 bits for addressing within that network.

The interface ID part of an IPv6 address identifies a specific interface on a network. It's the host part of the address, usually derived from the hardware MAC address or generated using other methods, like randomized identifiers in privacy extensions, SLAAC, or DHCPv6.

IPv6 Address types:

• Unicast Address: identifies a single interface within the IPv6 network. A packet sent to a unicast address is delivered to the interface identified by that address.

• Multicast Address: represents a set of interfaces and is used for one-to-many communication. A packet sent to a multicast address is delivered to all interfaces identified by that address.

• Anycast Address: represents a group of interfaces. A packet sent to an anycast address is delivered to the nearest interface within that group according to the routing protocols' measure of distance.

3. Explain the following Address types:

- Global Unicast Address

Global Unicast Address is equivalent to IPv4 public address. Global Unicast Addresses in IPv6 are globally identifiable and uniquely addressable. The most significant 48-bits are designated as global routing prefix which is assigned to a specific automatic system. The three most significant bits of the global routing prefix are always set to 001.

• 2000::/3 (First hextet: 2000::/3 to 3FFF::/3). • Globally unique and routable.

- Unique Local Address

Unique local addresses work like the IPv4 private addresses. These addresses can be used on your own network if you don't intend to connect to the Internet or if you plan to use IPv6 NAT. The advantage of unique local addresses is that you don't need to register at an authority to get some address space. The FC00::/7 prefix is reserved for unique local addresses.

- Link Local Address

Link-local addresses are designed for use on a single local link (local network). Link-local addresses are automatically configured on all interfaces. The prefix used for a link-local address is fe80::/10. Routers do not forward packets with a destination or source address containing a link-local address. In simpler terms, it is used for communication within the same local network segment and not routable beyond it.

4. What is SLAAC?

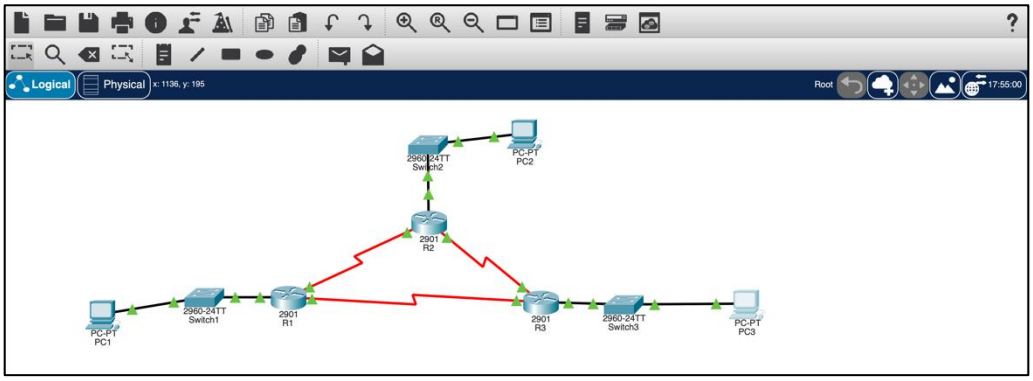
Stateless Address Auto-Configuration (SLAAC) can automatically configure IPv6 host parameters on an IPv6 host without the need for manual configuration or a DHCP server.

"Stateless" refers to the fact that there is no centralized server tracking address assignments, corresponding MAC addresses, and lease times. It's stateless in the sense that there is no entity that currently has a record of the current state of address assignments and related information.

SLAAC is designed to be a simple, automatic approach to assigning IPv6 addresses. It is defined in RFC4862 and is specifically used to assign only a global unicast IPv6 address, an IPv6 prefix length, and, optionally, a default router. These are the minimum network parameters required for communication on the network.

Third Part
Bonus Part

Network Topology



Question a

R1 IPV6 Configuration

```
Router(config)#ipv6 unicast-routing
```

```
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up

Router(config-if)#ipv6 address 2001:DB8:CAFE:1::1/64
```

```
Router(config-if)#ipv6 address FE80::1 link-local
Router(config-if)#end
```

```
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial0/0/0, changed state to down
Router(config-if)#ipv6 address 2001:DB8:CAFE:A001::1/64
Router(config-if)#ipv6 address FE80::1 link-local
Router(config-if)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

```
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial0/0/1, changed state to down
Router(config-if)#
Router(config-if)#ipv6 address 2001:DB8:CAFE:A003::1/64
Router(config-if)#ipv6 address FE80::1 link-local
Router(config-if)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

R2 IPV6 Configuration

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 unicast-routing
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up

Router(config-if)#ipv6 address 2001:DB8:CAFE:2::1/64
Router(config-if)#ipv6 address FE80::2 link-local
```

```
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface Serial0/0/0, changed state to up
```

```
Router(config-if)#ipv6 address 2001:DB8:CAFE:A001::2/64
Router(config-if)#ipv6 address FE80::2 link-local
Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial0/0/1, changed state to down
Router(config-if)#ipv6 address 2001:DB8:CAFE:A002::1/64
Router(config-if)#ipv6 address FE80::2 link-local
Router(config-if)#end
```

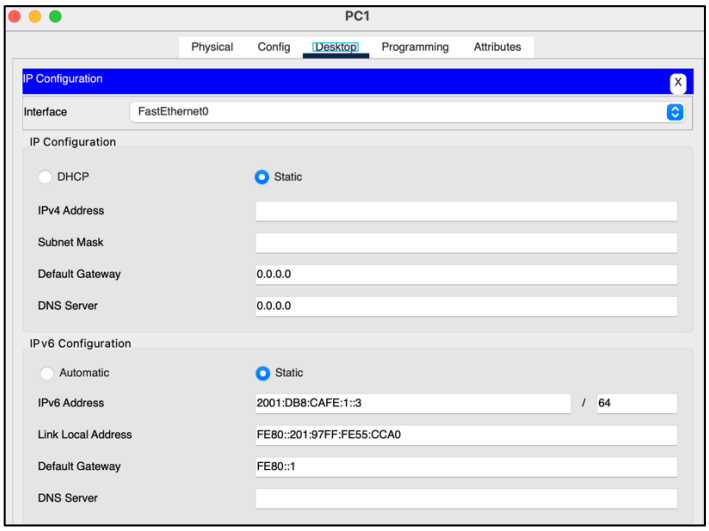
R3 IPV6 Configuration

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 unicast-routing
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up

Router(config-if)#ipv6 address 2001:DB8:CAFE:3::1/64
Router(config-if)#ipv6 address FE80::3 link-local
Router(config-if)#exit
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface Serial0/0/0, changed state to up
```

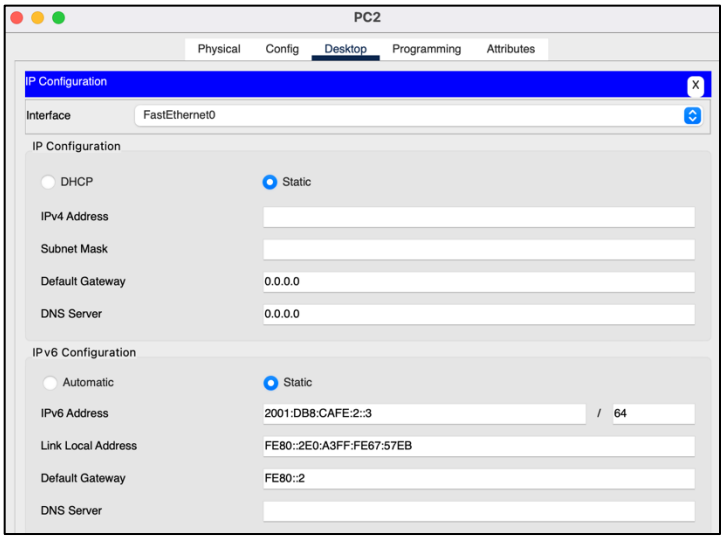
```
Router(config-if)#ipv6 address 2001:DB8:CAFE:A003::2/64
Router(config-if)#ipv6 address FE80::3 link-local
Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#ipv6 enable
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface Serial0/0/1, changed state to up
```

```
Router(config-if)#ipv6 address 2001:DB8:CAFE:A002::2/64
Router(config-if)#ipv6 address FE80::3 link-local
Router(config-if)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

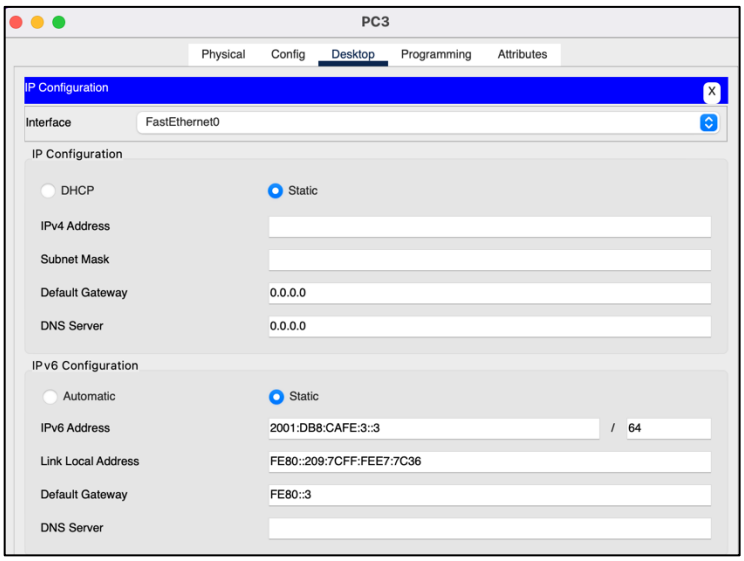
PC1 Configuration



PC2 Configuration



PC3 Configuration



Question b

R1 Interfaces Verification

```
Router#show ipv6 interface brief
GigabitEthernet0/0          [up/up]
    FE80::1
    2001:DB8:CAFE:1::1
GigabitEthernet0/1          [administratively down/down]
    unassigned
Serial0/0/0                 [down/down]
    FE80::1
    2001:DB8:CAFE:A001::1
Serial0/0/1                 [down/down]
    FE80::1
    2001:DB8:CAFE:A003::1
```

R2 Interfaces Verification

```
Router#show ipv6 interface brief
GigabitEthernet0/0          [up/up]
    FE80::2
    2001:DB8:CAFE:2::1
GigabitEthernet0/1          [administratively down/down]
    unassigned
Serial0/0/0                 [up/up]
    FE80::2
    2001:DB8:CAFE:A001::2
Serial0/0/1                 [down/down]
    FE80::2
    2001:DB8:CAFE:A002::1
```

R3 Interfaces Verification

```
Router#show ipv6 interface brief
GigabitEthernet0/0         [up/up]
    FE80::3
    2001:DB8:CAFE:3::1
GigabitEthernet0/1         [administratively down/down]
    unassigned
Serial0/0/0                [up/up]
    FE80::3
    2001:DB8:CAFE:A003::2
Serial0/0/1                [up/up]
    FE80::3
    2001:DB8:CAFE:A002::2
```

PC1 Verification

```
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.....: FE80::201:97FF:FE55:CCA0
   IPv6 Address.....: 2001:DB8:CAFE:1::3
   IPv4 Address.....: 0.0.0.0
   Subnet Mask.....: 0.0.0.0
   Default Gateway.....: FE80::1
                                 0.0.0.0
```

PC2 Verification

```
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.....: FE80::2E0:A3FF:FE67:57EB
   IPv6 Address.....: 2001:DB8:CAFE:2::3
   IPv4 Address.....: 0.0.0.0
   Subnet Mask.....: 0.0.0.0
   Default Gateway.....: FE80::2
                                 0.0.0.0
```

PC3 Verification

```
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.....: FE80::209:7CFF:FEE7:7C36
   IPv6 Address.....: 2001:DB8:CAFE:3::3
   IPv4 Address.....: 0.0.0.0
   Subnet Mask.....: 0.0.0.0
   Default Gateway.....: FE80::3
                                 0.0.0.0
```

Question c

R1 EIGRP Configuration

```
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 router eigrp 10
Router(config-rtr)#eigrp router-id 1.1.1.1
Router(config-rtr)#no shutdown
Router(config-rtr)#exit
```

```
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 eigrp 10
Router(config-if)#exit
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 eigrp 10
Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#ipv6 eigrp 10
Router(config-if)#exit
Router(config)#end
```

R2 EIGRP Configuration

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 router eigrp 10
Router(config-rtr)#eigrp router-id 2.2.2.2
Router(config-rtr)#no shutdown
Router(config-rtr)#end
```

```
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 eigrp 10
Router(config-if)#exit
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 eigrp 10
Router(config-if)#
%DUAL-5-NBRCHANGE: IPv6-EIGRP 10: Neighbor FE80::1 (Serial0/0/0) is up: new adjacency

Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#ipv6 eigrp 10
Router(config-if)#exit
Router(config)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

R3 EIGRP Configuration

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 router eigrp 10
Router(config-rtr)#eigrp router-id 3.3.3.3
Router(config-rtr)#no shutdown
Router(config-rtr)#end
```

```
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 eigrp 10
Router(config-if)#exit
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 eigrp 10
Router(config-if)#
%DUAL-5-NBRCHANGE: IPv6-EIGRP 10: Neighbor FE80::1 (Serial0/0/0) is up: new adjacency

Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#ipv6 eigrp 10
Router(config-if)#
%DUAL-5-NBRCHANGE: IPv6-EIGRP 10: Neighbor FE80::2 (Serial0/0/1) is up: new adjacency

Router(config-if)#exit
Router(config)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

Question d

R1 Neighbors

```
Router#show ipv6 eigrp neighbors
IPv6-EIGRP neighbors for process 10
H   Address                 Interface     Hold   Uptime   SRTT   RTO  Q  Seq
                                          (sec)           (ms)       Cnt Num
0   Link-local address:       Se0/0/0      12   00:03:40  40     1000  0   11
    FE80::2
1   Link-local address:       Se0/0/1      10   00:02:42  40     1000  0   13
    FE80::3
```

R1 Interfaces

```
Router#show ipv6 eigrp interfaces
IPv6-EIGRP interfaces for process 10

                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Gig0/0             0        0/0      1236       0/10           0           0
Se0/0/0            1        0/0      1236       0/10           0           0
Se0/0/1            1        0/0      1236       0/10           0           0
```

R1 Topology

```
Router#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 10/ID(1.1.1.1)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 2001:DB8:CAFE:1::/64, 1 successors, FD is 2816
         via Connected, GigabitEthernet0/0
P 2001:DB8:CAFE:2::/64, 1 successors, FD is 2170112
         via FE80::2 (2170112/2816), Serial0/0/0
P 2001:DB8:CAFE:3::/64, 1 successors, FD is 2170112
         via FE80::3 (2170112/2816), Serial0/0/1
P 2001:DB8:CAFE:A001::/64, 1 successors, FD is 2169856
         via Connected, Serial0/0/0
P 2001:DB8:CAFE:A002::/64, 2 successors, FD is 2681856
         via FE80::2 (2681856/2169856), Serial0/0/0
         via FE80::3 (2681856/2169856), Serial0/0/1
P 2001:DB8:CAFE:A003::/64, 1 successors, FD is 2169856
         via Connected, Serial0/0/1
```

R2 Neighbors

```
Router#show ipv6 eigrp neighbors
IPv6-EIGRP neighbors for process 10
H   Address                 Interface     Hold   Uptime   SRTT   RTO  Q  Seq
                                          (sec)           (ms)       Cnt Num
0   Link-local address:       Se0/0/0      11   00:05:28  40     1000  0   7
    FE80::1
1   Link-local address:       Se0/0/1      13   00:04:19  40     1000  0   14
    FE80::3
```

R2 Interfaces

```
Router#show ipv6 eigrp interfaces
IPv6-EIGRP interfaces for process 10

                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Gig0/0             0        0/0      1236       0/10           0           0
Se0/0/0            1        0/0      1236       0/10           0           0
Se0/0/1            1        0/0      1236       0/10           0           0
```

R2 Topology

```
Router#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 10/ID(2.2.2.2)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 2001:DB8:CAFE:1::/64, 1 successors, FD is 2170112
         via FE80::1 (2170112/2816), Serial0/0/0
P 2001:DB8:CAFE:2::/64, 1 successors, FD is 2816
         via Connected, GigabitEthernet0/0
P 2001:DB8:CAFE:3::/64, 1 successors, FD is 2170112
         via FE80::3 (2170112/2816), Serial0/0/1
P 2001:DB8:CAFE:A001::/64, 1 successors, FD is 2169856
         via Connected, Serial0/0/0
P 2001:DB8:CAFE:A002::/64, 1 successors, FD is 2169856
         via Connected, Serial0/0/1
P 2001:DB8:CAFE:A003::/64, 2 successors, FD is 2681856
         via FE80::1 (2681856/2169856), Serial0/0/0
         via FE80::3 (2681856/2169856), Serial0/0/1
```

R3 Neighbors

```
Router#show ipv6 eigrp neighbors
IPv6-EIGRP neighbors for process 10
H   Address                 Interface     Hold   Uptime   SRTT   RTO  Q  Seq
                                          (sec)           (ms)       Cnt Num
0   Link-local address:       Se0/0/0      13   00:05:57  40     1000  0   8
    FE80::1
1   Link-local address:       Se0/0/1      12   00:05:45  40     1000  0   12
    FE80::2
```

R3 Interfaces

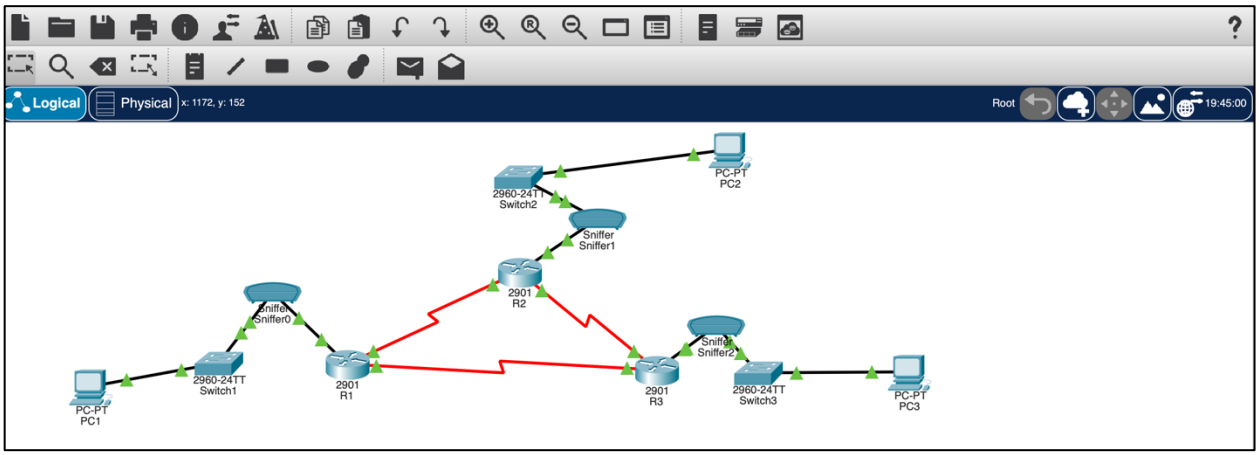
```
Router#show ipv6 eigrp interfaces
IPv6-EIGRP interfaces for process 10

                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Gig0/0             0        0/0      1236       0/10           0           0
Se0/0/0            1        0/0      1236       0/10           0           0
Se0/0/1            1        0/0      1236       0/10           0           0
```

R3 Topology

```
Router#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 10/ID(3.3.3.3)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 2001:DB8:CAFE:1::/64, 1 successors, FD is 2170112
         via FE80::1 (2170112/2816), Serial0/0/0
P 2001:DB8:CAFE:2::/64, 1 successors, FD is 2170112
         via FE80::2 (2170112/2816), Serial0/0/1
P 2001:DB8:CAFE:3::/64, 1 successors, FD is 2816
         via Connected, GigabitEthernet0/0
P 2001:DB8:CAFE:A001::/64, 2 successors, FD is 2681856
         via FE80::1 (2681856/2169856), Serial0/0/0
         via FE80::2 (2681856/2169856), Serial0/0/1
P 2001:DB8:CAFE:A002::/64, 1 successors, FD is 2169856
         via Connected, Serial0/0/1
P 2001:DB8:CAFE:A003::/64, 1 successors, FD is 2169856
         via Connected, Serial0/0/0
```

Question e

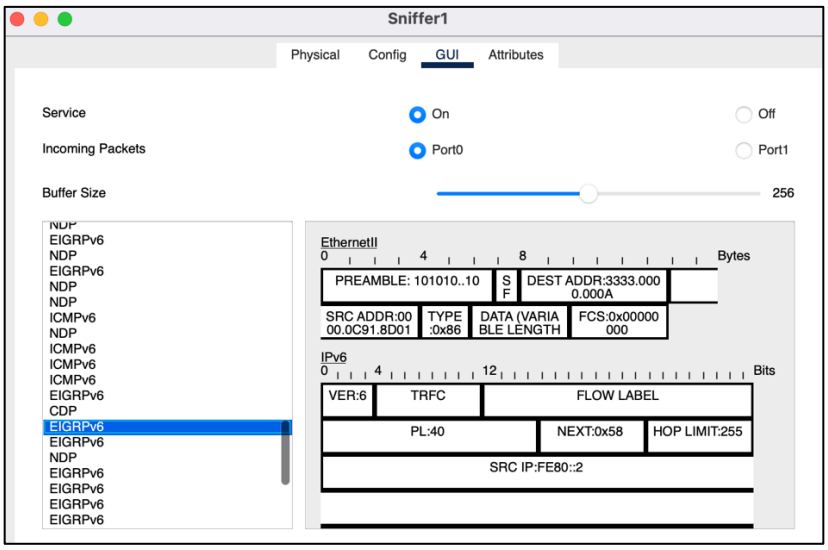
Topology After Adding Cisco Sniffer Tools



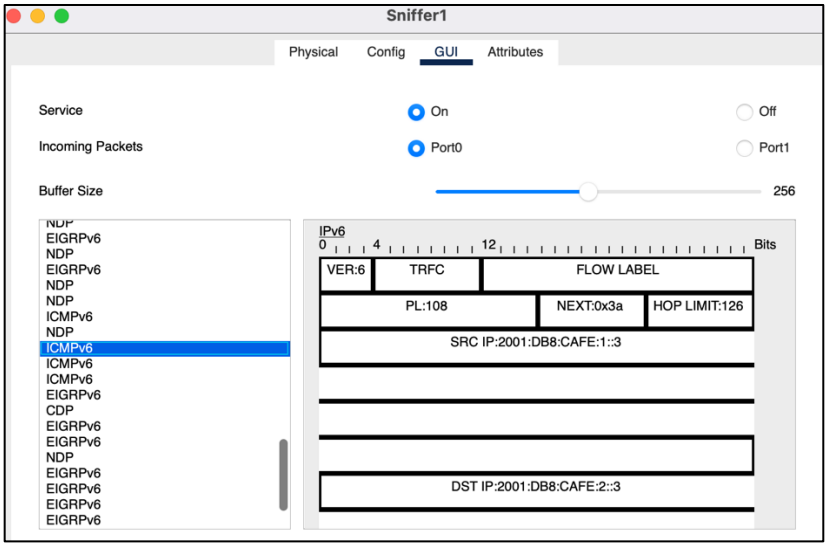
Ping PC1 from PC2

```
C:\>ping 2001:DB8:CAFE:1::3

Pinging 2001:DB8:CAFE:1::3 with 32 bytes of data:

Reply from 2001:DB8:CAFE:1::3: bytes=32 time=8ms TTL=126
Reply from 2001:DB8:CAFE:1::3: bytes=32 time=6ms TTL=126
Reply from 2001:DB8:CAFE:1::3: bytes=32 time=3ms TTL=126
Reply from 2001:DB8:CAFE:1::3: bytes=32 time=6ms TTL=126

Ping statistics for 2001:DB8:CAFE:1::3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 8ms, Average = 5ms
```

Packets Captured (EIGRPv6)



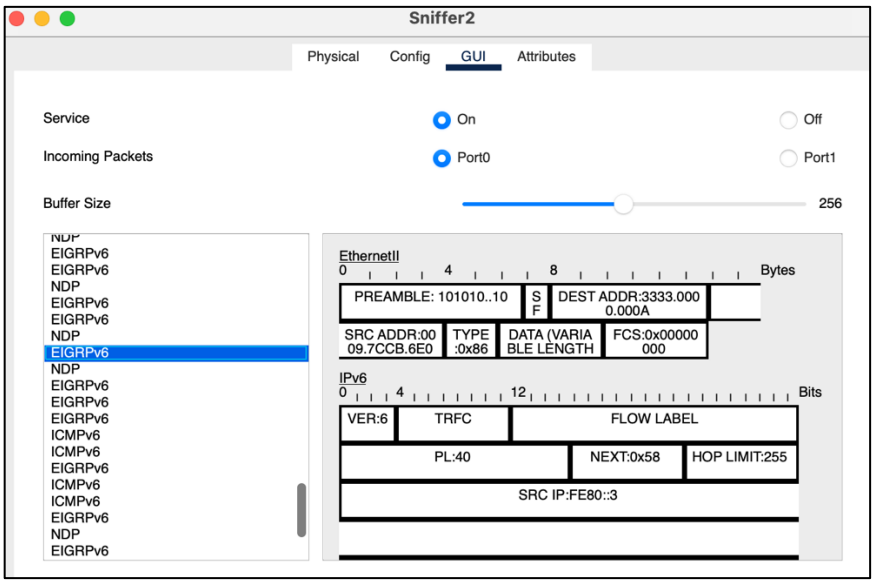
Packets Captured (ICMPv6)



Ping PC2 from PC3

```
C:\>ping 2001:DB8:CAFE:2::3

Pinging 2001:DB8:CAFE:2::3 with 32 bytes of data:

Reply from 2001:DB8:CAFE:2::3: bytes=32 time=14ms TTL=126
Reply from 2001:DB8:CAFE:2::3: bytes=32 time=4ms TTL=126
Reply from 2001:DB8:CAFE:2::3: bytes=32 time=3ms TTL=126
Reply from 2001:DB8:CAFE:2::3: bytes=32 time=92ms TTL=126

Ping statistics for 2001:DB8:CAFE:2::3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 92ms, Average = 28ms
```

Packets Captured (EIGRPv6)



Packets Captured (ICMPv6)

Question f

R1 OSPF Configuration

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 router ospf 1
%OSPFv3-4-NORTRID: OSPFv3 process 1 could not pick a router-id,please configure manually
Router(config-rtr)#router-id 1.1.1.1
Router(config-rtr)#exit
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#end
```

R2 OSPF Configuration

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 router ospf 1
%OSPFv3-4-NORTRID: OSPFv3 process 1 could not pick a router-id,please configure manually
Router(config-rtr)#router-id 2.2.2.2
Router(config-rtr)#exit
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#
02:14:20: %OSPFv3-5-ADJCHG: Process 1, Nbr 1.1.1.1 on Serial0/0/0 from LOADING to FULL, Loading Done

Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
wr
Building configuration...
[OK]
```

R3 OSPF Configuration

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#ipv6 router ospf 1
%OSPFv3-4-NORTRID: OSPFv3 process 1 could not pick a router-id,please configure manually
Router(config-rtr)#router-id 3.3.3.3
Router(config-rtr)#exit
Router(config)#interface GigabitEthernet0/0
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
```

```
Router(config)#interface Serial0/0/0
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#interface Serial0/0/1
Router(config-if)#ipv6 ospf 1 area 0
02:17:17: %OSPFv3-5-ADJCHG: Process 1, Nbr 1.1.1.1 on Serial0/0/0 from LOADING to FULL, Loading Done

Router(config-if)#ipv6 ospf 1 area 0
02:17:22: %OSPFv3-5-ADJCHG: Process 1, Nbr 2.2.2.2 on Serial0/0/1 from LOADING to F
Router(config-if)#ipv6 ospf 1 area 0
Router(config-if)#exit
Router(config)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
wr
Building configuration...
[OK]
```

R1 OSPF Interfaces

```
Router#show ipv6 ospf interface brief
Interface     PID   Area              Intf ID   Cost  State  Nbrs F/C
Gig0/0          1   0                  1         1       DR  0/0
Se0/0/0         1   0                  3         64   POINT  0/0
Se0/0/1         1   0                  4         64   POINT  0/0
```

R1 OSPF Neighbors

```
Router#show ipv6 ospf neighbor

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
2.2.2.2           0   FULL/  -        00:00:38    3               Serial0/0/0
3.3.3.3           0   FULL/  -        00:00:31    3               Serial0/0/1
```

R2 OSPF Interfaces

```
Router#show ipv6 ospf interface brief
Interface     PID   Area              Intf ID   Cost  State  Nbrs F/C
Gig0/0          1   0                  1         1       DR  0/0
Se0/0/0         1   0                  3         64   POINT  0/0
Se0/0/1         1   0                  4         64   POINT  0/0
```

R2 OSPF Neighbors

```
Router#show ipv6 ospf neighbor

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
1.1.1.1           0   FULL/  -        00:00:33    3               Serial0/0/0
3.3.3.3           0   FULL/  -        00:00:33    4               Serial0/0/1
```

R3 OSPF Interfaces

```
Router#show ipv6 ospf interface brief
Interface     PID   Area              Intf ID   Cost  State  Nbrs F/C
Gig0/0          1   0                  1         1       DR  0/0
Se0/0/0         1   0                  3         64   POINT  0/0
Se0/0/1         1   0                  4         64   POINT  0/0
```

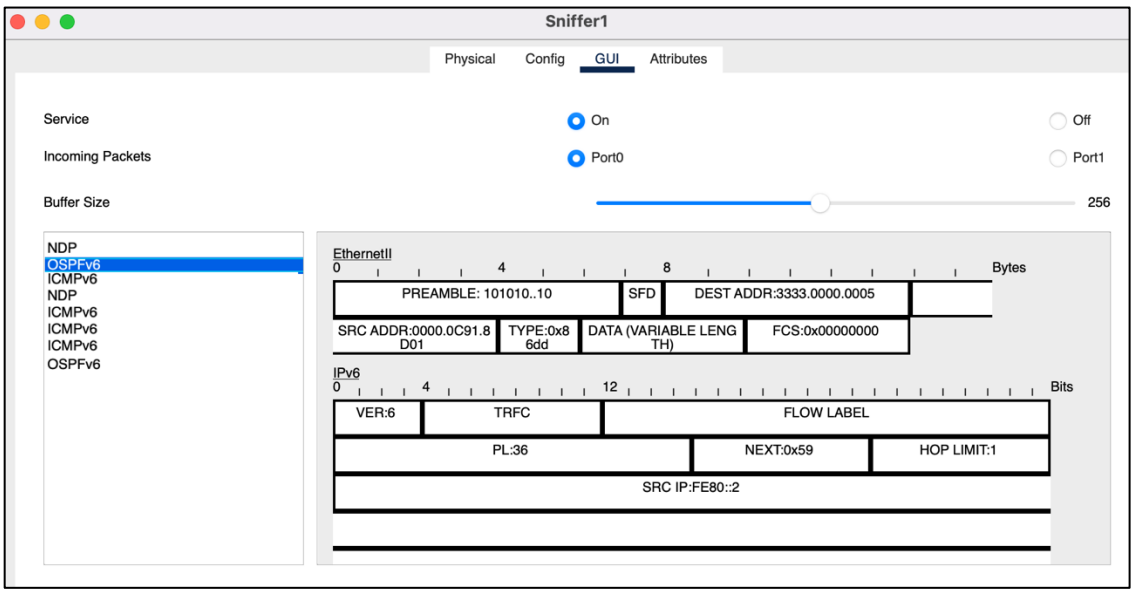
R3 OSPF Neighbors

```
Router#show ipv6 ospf neighbor

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
2.2.2.2           0   FULL/  -        00:00:38    4               Serial0/0/1
1.1.1.1           0   FULL/  -        00:00:33    4               Serial0/0/0
```

Ping PC3 from PC1

```
C:\>ping 2001:DB8:CAFE:3::3

Pinging 2001:DB8:CAFE:3::3 with 32 bytes of data:

Reply from 2001:DB8:CAFE:3::3: bytes=32 time=13ms TTL=126
Reply from 2001:DB8:CAFE:3::3: bytes=32 time=5ms TTL=126
Reply from 2001:DB8:CAFE:3::3: bytes=32 time=9ms TTL=126
Reply from 2001:DB8:CAFE:3::3: bytes=32 time=2ms TTL=126

Ping statistics for 2001:DB8:CAFE:3::3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 2ms, Maximum = 13ms, Average = 7ms
```

Packets Captured (OSPFv6)



Packets Captured (ICMPv6)