Bialystok University of Technology
Faculty of Electrical Engineering

LABORATORY REPORT

Computer Networks
IS-FEE-10082S

Subject:
Principles of configuration of network devices
Configuration and testing of static routing in a multi-segment network

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Contents

1 Objective

The objective of this laboratory exercise was to configure, analyze, and troubleshoot a small-scale network using Cisco routers and switches. The key tasks included:

- Gathering router system information using `show` commands
- Configuring Ethernet and serial interfaces with appropriate IP addressing
- Establishing static routing between two subnets for end-to-end connectivity
- Testing network functionality using `ping` and `traceroute`
- Analyzing Cisco Discovery Protocol (CDP) frames to understand neighbor discovery
- Measuring transmission delays across a serial link with varying packet sizes

This exercise provided hands-on experience in fundamental network configuration, verification, and performance analysis, reinforcing essential concepts in Cisco networking.

2 Obtaining Router System Information

In this section, various `show` commands were used to gather information about the router's operating system, processor type, installed memory, and available interfaces. The context-sensitive help system (using the `?` character) was tested to explore available options and subcommands.

Commands Used

```
show ip interface brief Interface
show version
s?
```

Observations

```
Router>show ip interface brief
Interface                  IP-Address      OK? Method Status
                     Prot

   ocol
FastEthernet0/0            unassigned      YES unset  administratively
   down down
Serial0/0                  unassigned      YES unset  administratively
   down down
Serial0/1                  unassigned      YES unset  administratively
   down down

```

```
Router>show version
Cisco IOS Software, C2600 Software (C2600-ADVENTERPRISEK9-M), Version
    12.4(15)T14, RELEASE SOFTWARE (fc2)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2010 by Cisco Systems, Inc.
Compiled Tue 17-Aug-10 05:40 by prod_rel_team

ROM: System Bootstrap, Version 12.2(8r) [cmong 8r], RELEASE SOFTWARE (
    fc1)

Router uptime is 5 minutes
System returned to ROM by reload
System image file is "flash:c2600-adventerprisek9-mz.124-15.T14.bin"


This product contains cryptographic features and is subject to United
States and local country laws governing import, export, transfer and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use encryption.
Importers, exporters, distributors and users are responsible for
compliance with U.S. and local country laws. By using this product you
agree to comply with applicable laws and regulations. If you are unable
to comply with U.S. and local laws, return this product immediately.

A summary of U.S. laws governing Cisco cryptographic products may be
    found at:
http://www.cisco.com/wwl/export/crypto/tool/stqrg.html

If you require further assistance please contact us by sending email to
export@cisco.com.

Cisco 2610XM (MPC860P) processor (revision 2.0) with 253952K/8192K bytes
     of memory.
Processor board ID JAE08061HSS
M860 processor: part number 5, mask 2
1 FastEthernet interface
2 Serial(sync/async) interfaces
2 Voice FXO interfaces
2 Voice FXS interfaces
32K bytes of NVRAM.
49152K bytes of processor board System flash (Read/Write)

Configuration register is 0x2102


Router>s?
*s=show  set     show  slip
ssh      systat
```

3 Mode Switching And Changing the Name of the Routers Practice

This section covers the practice of switching between different router modes: user EXEC, privileged EXEC, and global configuration mode, also changing the name of routers. The significance and permissions of each mode were observed and understood.

Commands Used

```
enable
configure terminal
hostname R1
```

Observations

```
Router>enable
Router#

Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#
```

4 Viewing the Current Configuration

This section involves viewing the router's current active configuration using the `show running-config` command. Key parameters like interface settings, hostname, and passwords were reviewed.

4.1 Commands Used

```
show running-config
```

4.2 Observations

```
R1#show running-config
Building configuration...

Current configuration : 829 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
```

```
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
no network-clock-participate slot 1
no network-clock-participate wic 0
ip cef
!
!
!
!
!
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
!
archive
 log config
  hidekeys
!
!
!
!
!
!
!
!
interface FastEthernet0/0
```

```
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 shutdown
 no fair-queue
!
interface Serial0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
!
ip http server
no ip http secure-server
!
!
!
!
!
!
control-plane
!
!
!
voice-port 1/0/0
!
voice-port 1/0/1
!
voice-port 1/1/0
!
voice-port 1/1/1
!
!
!
!
!
!
!
!
line con 0
line aux 0
line vty 0 4
!
!
end
```

5 Ethernet Interface Setup, IP Configuration, and Connectivity Testing

This section describes the physical and logical network setup. Routers R1 and R2 are connected to end devices PC1 and PC2 via FastEthernet interfaces, and they are interconnected using a Serial link. All devices are configured with appropriate IP addresses within their respective subnets.

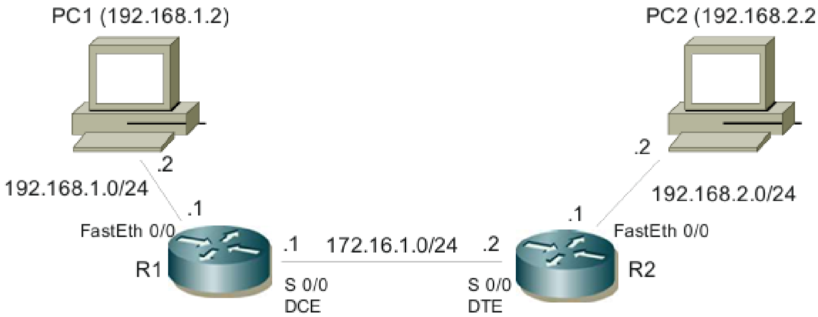

Figure 1: Overview of the Network Topology

5.1 Network Addressing

- **PC1** – IP: `192.168.1.2`, Subnet Mask: `255.255.255.0`, Gateway: `192.168.1.1`
- **R1 FastEthernet0/0** – IP: `192.168.1.1`/24
- **R1 Serial0/0 (DCE)** – IP: `172.16.1.1`/24
- **R2 Serial0/0 (DTE)** – IP: `172.16.1.2`/24
- **R2 FastEthernet0/0** – IP: `192.168.2.1`/24
- **PC2** – IP: `192.168.2.2`, Subnet Mask: `255.255.255.0`, Gateway: `192.168.2.1`

5.2 Router Configuration Commands

```
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 no shutdown
exit

interface Serial0/0
 ip address 172.16.1.1 255.255.255.0
 clock rate 64000
```

```
 no shutdown
exit

interface FastEthernet0/0
 ip address 192.168.2.1 255.255.255.0
 no shutdown
exit

interface Serial0/0
 ip address 172.16.1.2 255.255.255.0
 no shutdown
exit
```

5.3 Connectivity Testing and Interface Verification

After all interfaces were configured and brought up, several verification commands were used to ensure connectivity and correct interface status.

5.3.1 Commands Used

```
show ip interface brief
interface fastEthernet0/0
ip address 192.168.1.2 255.255.255.0
ping 192.168.1.2
ping 192.168.2.2
interface serial0/0
ip address 172.16.1.1 255.255.255.0
clock rate 512000
ping 172.16.1.2
traceroute 192.168.2.2
sh cdp neighbors
```

5.4 Observations

```
R1(config)#interface fastEthernet0/0
R1(config-if)#

R1(config-if)#no shutdown
R1(config-if)#
*Dec 22 15:02:17.203: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed
    state to up
*Dec 22 15:02:18.205: %LINEPROTO-5-UPDOWN: Line protocol on Interface
   FastEthernet0/0, changed state to up

R1#show ip interface br
Interface                  IP-Address      OK? Method Status
                  Protocol
FastEthernet0/0            unassigned      YES unset  up
                      up
```

```
Serial0/0               unassigned      YES unset  administratively down down
Serial0/1               unassigned      YES unset  administratively down down

R1(config-if)#ip address 192.168.1.2 255.255.255.0


R1(config-if)#do show ip int brief
Interface               IP-Address      OK? Method Status                Protocol
FastEthernet0/0         192.168.1.2     YES manual up                    up
Serial0/0               unassigned      YES unset  administratively down down
Serial0/1               unassigned      YES unset  administratively down down


R1#ping 192.168.2.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)


R1#ping 192.168.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms

R1#ping 192.168.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms

R1#traceroute 192.168.1.1

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 192.168.1.1 0 msec 0 msec *


C:\Users\Student>ping 192.168.1.1
```

```

Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes=32 time=1ms TTL=255
Reply from 192.168.1.1: bytes=32 time=2ms TTL=255
Reply from 192.168.1.1: bytes=32 time=2ms TTL=255
Reply from 192.168.1.1: bytes=32 time=2ms TTL=255

Ping statistics for 192.168.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 2ms, Average = 1ms

C:\Users\Student>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes=32 time=1ms TTL=255
Reply from 192.168.1.1: bytes=32 time=2ms TTL=255
Reply from 192.168.1.1: bytes=32 time=2ms TTL=255
Reply from 192.168.1.1: bytes=32 time=2ms TTL=255

Ping statistics for 192.168.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 2ms, Average = 1ms


R1#ping 192.168.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms


R1#ping 172.16.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/6/8 ms


R1(config)#interface serial0/0
R1(config-if)#ip address 172.16.1.0 255.255.255.0
Bad mask /24 for address 172.16.1.0
R1(config-if)#ip address 172.16.1.1 255.255.255.0
R1(config-if)#no shutdown



```

```
R1(config-if)#do show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            192.168.1.1     YES manual up                    up
Serial0/0                  172.16.1.1      YES manual up                    up
Serial0/1                  unassigned      YES unset  administratively down down
R1(config-if)#
*Dec 22 15:27:20.367: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to down
R1(config-if)#exit
R1(config)#exit
R1#ping
*Dec 22 15:28:01.551: %SYS-5-CONFIG_I: Configured from console by console172.16.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
R1#show ip interface br
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            192.168.1.1     YES manual up                    up
Serial0/0                  172.16.1.1      YES manual up                    down
Serial0/1                  unassigned      YES unset  administratively down down
R1#configure t
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface se
R1(config)#interface serial0/0
R1(config-if)#clock rate ?
        Speed (bits per second)
  1200
  2400
  4800
  9600
  14400
  19200
  28800
  32000
  38400
  56000
  57600
  64000
```

```
  72000
  115200
  125000
  128000
  148000
  192000
  250000
  256000
  384000
  500000
  512000
  768000
  800000
  1000000
  1300000
  2000000
  4000000
  8000000

  <300-8000000>    Choose clockrate from list above

R1(config-if)#clock rate 512000
R1(config-if)#
*Dec 22 15:31:20.377: %LINEPROTO-5-UPDOWN: Line protocol on Interface
    Serial0/0, changed state to up
R1(config-if)#exit
R1(config)#exit
R1#ping
*Dec 22 15:31:42.781: %SYS-5-CONFIG_I: Configured from console by
    console 172.16.1.2


C:\Users\Student>ping 172.16.1.1

Pinging 172.16.1.1 with 32 bytes of data:
Reply from 172.16.1.1: bytes=32 time=1ms TTL=255
Reply from 172.16.1.1: bytes=32 time=2ms TTL=255
Reply from 172.16.1.1: bytes=32 time=2ms TTL=255
Reply from 172.16.1.1: bytes=32 time=2ms TTL=255

Ping statistics for 172.16.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 2ms, Average = 1ms


R1#sh cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

```

```
Device ID          Local Intrfce      Holdtme     Capability   Platform   Port
     ID
R2                 Ser 0/0             163          R S I      2621XM     Ser
    0/0
```

All interfaces were successfully brought up, and communication was established between both PCs via the routers. The ‘ping‘ and ‘traceroute‘ commands confirmed that packets were properly routed through the network.

6 CDP Frame Analysis with Protocol Analyzer

In this section, we analyze the structure and transmission details of a CDP (Cisco Discovery Protocol) frame captured using Wireshark. CDP is a Cisco proprietary Layer 2 protocol used to share information about directly connected Cisco devices.

6.1 Frame Type and Format

The captured CDP frame does not use a traditional EtherType to identify its payload. Instead, it uses a value in the **Length/Type** field of the Ethernet header to indicate that it contains a SNAP-encapsulated frame. Specifically, CDP uses IEEE 802.3 framing with LLC and SNAP headers.

- **Destination MAC Address:** `01:00:0c:cc:cc:cc`
- **Source MAC Address:** `00:0f:24:9a:11:20`
- **Length/Type field:** `0x2000` – Indicates length, not EtherType
- **SNAP OUI:** `00:00:0c` (Cisco Systems)
- **Protocol ID:** `0x2000` – Identifies CDP

CDP uses SNAP (Subnetwork Access Protocol) encapsulation to identify the protocol above the data link layer. This is why the field `0x2000` is interpreted as a length rather than a type, and the SNAP header follows.

6.2 Multicast MAC Address

CDP messages are sent to the Cisco-specific multicast MAC address:

`01:00:0c:cc:cc:cc`

This address is used by all Cisco devices participating in CDP to listen for and send CDP packets on a local segment.

6.3 Payload Contents

The payload contains several TLV (Type-Length-Value) fields, including:

- Device ID: `R1`
- Software Version: Cisco IOS 12.4(15)T14
- Platform: Cisco 2610XM
- IP Address: `192.168.1.1`
- Interface: `FastEthernet0/0`

These details help neighboring Cisco devices identify each other and discover network topology.

6.4 Observed Hex Dump Value From Wireshark

```
0000   01 00 0c cc cc cc 00 0f 24 9a 11 20 01 5e aa aa   ........$..
    .^..
0010   03 00 00 0c 20 00 02 b4 98 a5 00 01 00 06 52 31   .... .........
    R1
0020   00 05 00 fe 43 69 73 63 6f 20 49 4f 53 20 53 6f   ....Cisco IOS
    So
0030   66 74 77 61 72 65 2c 20 43 32 36 30 30 20 53 6f   ftware, C2600
    So
0040   66 74 77 61 72 65 20 28 43 32 36 30 30 2d 41 44   ftware (C2600-
    AD
0050   56 45 4e 54 45 52 50 52 49 53 45 4b 39 2d 4d 29   VENTERPRISEK9-M
    )
0060   2c 20 56 65 72 73 69 6f 6e 20 31 32 2e 34 28 31   , Version
    12.4(1
0070   35 29 54 31 34 2c 20 52 45 4c 45 41 53 45 20 53   5)T14, RELEASE
    S
0080   4f 46 54 57 41 52 45 20 28 66 63 32 29 0a 54 65   OFTWARE (fc2).
    Te
0090   63 68 6e 69 63 61 6c 20 53 75 70 70 6f 72 74 3a   chnical Support
    :
00a0   20 68 74 74 70 3a 2f 2f 77 77 77 2e 63 69 73 63    http://www.
    cisc
00b0   6f 2e 63 6f 6d 2f 74 65 63 68 73 75 70 70 6f 72   o.com/
    techsuppor
00c0   74 0a 43 6f 70 79 72 69 67 68 74 20 28 63 29 20   t.Copyright (c)
00d0   31 39 38 36 2d 32 30 31 30 20 62 79 20 43 69 73   1986-2010 by
    Cis
00e0   63 6f 20 53 79 73 74 65 6d 73 2c 20 49 6e 63 2e   co Systems, Inc
    .
00f0   0a 43 6f 6d 70 69 6c 65 64 20 54 75 65 20 31 37   .Compiled Tue
    17
```

```
0100    2d 41 75 67 2d 31 30 20 30 35 3a 34 30 20 62 79    -Aug-10 05:40
    by
0110    20 70 72 6f 64 5f 72 65 6c 5f 74 65 61 6d 00 06     prod_rel_team
    ..
0120    00 10 43 69 73 63 6f 20 32 36 31 30 58 4d 00 02    ..Cisco 2610XM
    ..
0130    00 11 00 00 00 01 01 01 cc 00 04 c0 a8 01 01 00
    ................
0140    03 00 13 46 61 73 74 45 74 68 65 72 6e 65 74 30    ...
    FastEthernet0
0150    2f 30 00 04 00 08 00 00 00 29 00 07 00 09 ac 10    /0.......)
    ......
0160    01 00 18 00 09 00 04 00 0b 00 05 01                ............
```

6.5 Conclusion

The CDP frame is transmitted using a Layer 2 multicast address and encapsulated using IEEE 802.3 with LLC and SNAP headers. This analysis confirms that CDP operates entirely at Layer 2 and provides device information without requiring Layer 3 connectivity.

7 Establishing Connection With Switch And Obtaining Information

This section focuses on verifying interface status and discovering directly connected Cisco devices using basic diagnostic commands. The `show ip interface brief` command was used to inspect the current interface status of the switch, revealing which ports are active or inactive. Additionally, the `show cdp neighbors` command was utilized on Router R1 to identify neighboring Cisco devices, confirming physical and logical connectivity between routers and switches.

7.1 Commands Used

```
show ip interface brief
sh cdp neighbors
```

7.2 Observations

```
Sw1>show ip interface brief
Interface                  IP-Address      OK? Method Status
                 Protocol
Vlan1                      192.168.1.50    YES NVRAM  up
                     down
FastEthernet0/1            unassigned      YES unset  up
                     up
```

```
FastEthernet0/2          unassigned      YES unset  down                  down
FastEthernet0/3          unassigned      YES unset  down                  down
FastEthernet0/4          unassigned      YES unset  down                  down
FastEthernet0/5          unassigned      YES unset  up                    up
FastEthernet0/6          unassigned      YES unset  down                  down
FastEthernet0/7          unassigned      YES unset  down                  down
FastEthernet0/8          unassigned      YES unset  down                  down
FastEthernet0/9          unassigned      YES unset  down                  down
FastEthernet0/10         unassigned      YES unset  down                  down
 --More--
00:00:55: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed sFastEthernet0/11          unassigned      YES unset  down                  down
FastEthernet0/12         unassigned      YES unset  down                  down

R1#sh cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
Sw1              Fas 0/0            137          S I      WS-C2950C Fas 0/1
R2               Ser 0/0            130        R S I      2621XM    Ser 0/0
```

From the `show ip interface brief` output on the switch, we observed that interfaces FastEthernet0/1 and FastEthernet0/5 are in an `up/up` state, indicating they are both physically connected and have an active data link. Other interfaces are either administratively down or not connected. The VLAN1 interface has an assigned IP address (192.168.1.50) and is administratively up, but the protocol is down, suggesting a lack of active Layer 2 connectivity. The `show cdp neighbors` output from Router R1 confirmed two neighboring Cisco devices: the switch (Sw1) connected via FastEthernet0/0 and another router (R2) connected via Serial0/0. This verifies that the router's interfaces are correctly connected and that CDP (Cisco Discovery Protocol) is successfully identifying directly connected devices.

8 Static Routing Configuration and End-to-End Connectivity Testing

In this part of the exercise, static routes were configured on both routers R1 and R2 to enable inter-network communication between the Ethernet networks connected to each router.

8.1 Routing Configuration

On Router R1, a static route was added to direct traffic destined for the 192.168.2.0/24 network (connected to R2) through R2's serial interface at IP address 172.16.1.2:

```
R1(config)#ip route 192.168.2.0 255.255.255.0 172.16.1.2
```

Similarly, a static route was configured on R2 to reach the 192.168.1.0/24 network via R1:

```
R2(config)#ip route 192.168.1.0 255.255.255.0 172.16.1.1
```

Routing Table Verification

After configuring the routes, the routing table on R1 was examined using the `show ip route` command. The output confirmed the presence of directly connected networks and the newly added static route. The routing code `S` indicates that the entry is a static route:

```
R1(config)#do sh ip route
...
S     192.168.2.0/24 [1/0] via 172.16.1.2
C     192.168.1.0/24 is directly connected, FastEthernet0/0
C     172.16.1.0/24 is directly connected, Serial0/0
```

8.2 End-to-End Connectivity Test

To verify that the routing configuration works correctly, a traceroute was performed from PC1 (192.168.1.2) to PC2 (192.168.2.2). The traceroute successfully reached its destination in three hops:

```
C:\Users\Student>tracert 192.168.2.2

Tracing route to DESKTOP-8B2AJE2 [192.168.2.2]
over a maximum of 30 hops:

  1     1 ms     1 ms     1 ms  192.168.1.1
  2    17 ms    17 ms    16 ms  172.16.1.2
  3    21 ms    21 ms    20 ms  DESKTOP-8B2AJE2 [192.168.2.2]
```

This output confirms that packets are correctly routed from PC1 through R1 and R2 to reach PC2, demonstrating successful implementation of static routing between the networks.

9 Measuring IP Packet Transmission Delay Over Serial Link

In this section, the `ping` command was used from PC1 to PC2 to analyze the transmission delay of IP packets across the serial connection between routers R1 and R2. The test was conducted for three different packet sizes: 32, 200, and 1000 bytes. The goal was to observe the relationship between packet size and round-trip delay, particularly over a slower V.35 DCE serial interface.

9.1 Ping Results for 32-byte Packets

```
C:\Users\Student>ping 192.168.2.2 -l 32

Pinging 192.168.2.2 with 32 bytes of data:
Reply from 192.168.2.2: bytes=32 time=10ms TTL=126
Reply from 192.168.2.2: bytes=32 time=10ms TTL=126
Reply from 192.168.2.2: bytes=32 time=10ms TTL=126
Reply from 192.168.2.2: bytes=32 time=10ms TTL=126

Approximate round trip times:
Minimum = 10ms, Maximum = 10ms, Average = 10ms
```

9.2 Ping Results for 200-byte Packets

```
C:\Users\Student>ping 192.168.2.2 -l 200

Reply from 192.168.2.2: bytes=200 time=31ms TTL=126
Reply from 192.168.2.2: bytes=200 time=32ms TTL=126
Reply from 192.168.2.2: bytes=200 time=31ms TTL=126
Reply from 192.168.2.2: bytes=200 time=32ms TTL=126

Approximate round trip times:
Minimum = 31ms, Maximum = 32ms, Average = 31ms
```

9.3 Ping Results for 1000-byte Packets

```
C:\Users\Student>ping 192.168.2.2 -l 1000

Reply from 192.168.2.2: bytes=1000 time=132ms TTL=126
Reply from 192.168.2.2: bytes=1000 time=132ms TTL=126
Reply from 192.168.2.2: bytes=1000 time=132ms TTL=126
Reply from 192.168.2.2: bytes=1000 time=132ms TTL=126

Approximate round trip times:
Minimum = 132ms, Maximum = 132ms, Average = 132ms
```

Analysis

The results clearly show that the packet transmission delay increases with packet size. For small packets (32 bytes), the average round-trip delay was only 10 ms. When the packet size increased to 200 bytes, the delay roughly tripled to around 31 ms. With 1000-byte packets, the delay significantly increased to 132 ms.

This trend demonstrates the effect of serialization delay over the serial link—larger packets take longer to transmit, especially on lower-bandwidth interfaces like the V.35 serial link used between R1 and R2. In practical applications, this insight helps in understanding performance trade-offs when designing or troubleshooting network links with limited bandwidth.

10 Conclusion

This laboratory exercise successfully demonstrated the configuration and operation of a multi-router network with static routing. The key accomplishments include:

- **Interface Configuration:** Proper setup of Ethernet and serial interfaces with IP addresses, including clock rate configuration on the DCE side of the serial link
- **Static Routing:** Implementation of manual routes on R1 and R2, enabling communication between `192.168.1.0/24` and `192.168.2.0/24` networks
- **Connectivity Verification:** Successful packet routing confirmed through `ping` and `traceroute` tests between end devices
- **CDP Analysis:** Examination of CDP frames using Wireshark, revealing Layer 2 neighbor discovery mechanisms
- **Performance Testing:** Observation of increasing latency with larger packet sizes across the serial link, demonstrating bandwidth limitations

Initial challenges such as interface misconfigurations (particularly the missing clock rate on DCE interfaces) were resolved through systematic troubleshooting using `show` commands, reinforcing the importance of verification in network operations.

11 LAB 4

12 Aim of the Exercise

The main objective of this laboratory is to understand the configuration and operation of static routing in a TCP/IP-based multi-segment network. Students will practice building a complex topology with multiple routers and verify routing paths using tools such as `ping` and `traceroute`.

13 Equipment Used

- Cisco 2610XM Routers (R1, R2, R3)
- Two PCs (PC1 and PC2)
- Cisco Catalyst Switch (optional)
- Console cables (rollover), V.35 serial cables (DCE/DTE)
- Terminal software (Putty)

14 Router Configuration

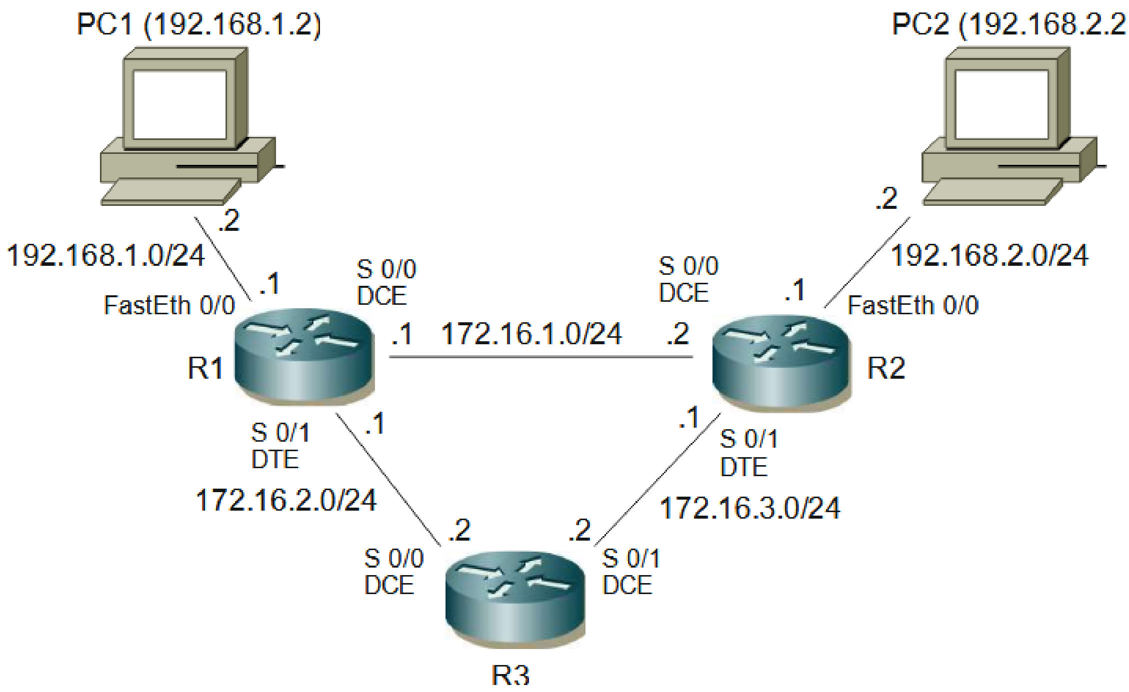

Figure 2: Routers Configuration

14.1 Router Configuration Activities

- **Hostname Assignment**:
  - Set unique hostnames (R1, R2, R3) on all routers
  - Verified using `show running-config`
- **Interface Configuration**:
  - Configured IP addresses on all FastEthernet and Serial interfaces
  - Set clock rates (64000) on DCE interfaces

  - Enabled interfaces with `no shutdown` command
  - Verified status with `show ip interface brief`

- **Static Routing Implementation**:
  - Added primary static routes for direct paths
  - Configured backup routes with higher administrative distance (AD=10)
  - Implemented asymmetric routing for return traffic
  - Verified with `show ip route` and `traceroute`

- **Connectivity Testing**:
  - Performed ping tests between all adjacent interfaces
  - Verified serial line protocols with `show controllers`
  - Tested end-to-end connectivity between PC1 and PC2

14.2 Router Configuration Commands

```
! R1 Configuration
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 no shutdown
exit

interface Serial0/0
 ip address 172.16.1.1 255.255.255.0
 clock rate 64000
 no shutdown
exit

interface Serial0/1
 ip address 172.16.2.1 255.255.255.0
 no shutdown
exit

! Static routes on R1
ip route 192.168.2.0 255.255.255.0 172.16.1.2  ! Primary path to PC2 via
    R2
ip route 192.168.2.0 255.255.255.0 172.16.2.2  ! Backup path to PC2 via
   R3

! R2 Configuration
interface FastEthernet0/0
 ip address 192.168.2.1 255.255.255.0
 no shutdown
exit

```

```
interface Serial0/0
 ip address 172.16.1.2 255.255.255.0
 no shutdown
exit

interface Serial0/1
 ip address 172.16.3.1 255.255.255.0
 clock rate 64000
 no shutdown
exit

! Static routes on R2
ip route 192.168.1.0 255.255.255.0 172.16.3.2  ! Path to PC1 via R3
ip route 172.16.2.0 255.255.255.0 172.16.3.2   ! Route to R1-R3 link

! R3 Configuration
interface Serial0/0
 ip address 172.16.2.2 255.255.255.0
 clock rate 64000
 no shutdown
exit

interface Serial0/1
 ip address 172.16.3.2 255.255.255.0
 no shutdown
exit

! Static routes on R3
ip route 192.168.1.0 255.255.255.0 172.16.2.1  ! Route to PC1 via R1
ip route 192.168.2.0 255.255.255.0 172.16.3.1  ! Route to PC2 via R2
ip route 172.16.1.0 255.255.255.0 172.16.3.1   ! Route to R1-R2 link
```

15 Router Naming Configuration

```
Router> enable
Router# configure terminal
Router(config)# hostname R1
R1(config)# end
R1#

Router> enable
Router# configure terminal
Router(config)# hostname R2
R2(config)# end
R2#

Router> enable
Router# configure terminal
Router(config)# hostname R3
```

```
R3(config)# end
R3#
```

16 Connection Verification

```
! Verify R1 serial connections
R1# show controllers serial 0/0
Interface Serial0/0
DCE V.35, clock rate 64000
Status: up, Line Protocol: up

R1# show controllers serial 0/1
Interface Serial0/1
DTE V.35
Status: up, Line Protocol: up

R1# ping 172.16.2.2  ! Test R1-R3 connection
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5)

! Verify R2 serial connections
R2# show controllers serial 0/0
Interface Serial0/0
DTE V.35
Status: up, Line Protocol: up

R2# show controllers serial 0/1
Interface Serial0/1
DCE V.35, clock rate 64000
Status: up, Line Protocol: up

R2# ping 172.16.3.2  ! Test R2-R3 connection
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.3.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5)

! Verify R3 serial connections
R3# show controllers serial 0/0
Interface Serial0/0
DCE V.35, clock rate 64000
Status: up, Line Protocol: up

R3# show controllers serial 0/1
Interface Serial0/1
DTE V.35
Status: up, Line Protocol: up
```

```
R3# ping 172.16.2.1  ! Test R3-R1 connection
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5)

R3# ping 172.16.3.1  ! Test R3-R2 connection
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5)
```

17 Conclusion

The router configuration process yielded several important insights:

- **Interface Setup**:
  - Proper DCE/DTE identification was crucial for serial link operation
  - The `clock rate` command proved essential only on DCE interfaces
- **Routing Implementation**:
  - Static routes required complete path knowledge
  - Administrative distance effectively controlled path selection
- **Verification**:
  - Layer-by-layer testing prevented configuration errors
  - `traceroute` was invaluable for path validation

Key Takeaways:

- Precise interface configuration forms the foundation for routing
- Static routing offers control but requires manual maintenance
- Comprehensive verification ensures reliable operation
- Achieved asymmetric routing with:
  - PC1→PC2 via direct R1-R2 path (3 hops)
  - PC2→PC1 via R2-R3-R1 path (4 hops)
- Verified through `traceroute` and routing tables
- Learned critical aspects:

– DCE/DTE roles in serial connections

– Administrative distance for path control

– Need for complete route entries

Static routing proved reliable for this small network but would be challenging to maintain in larger deployments. The hands-on configuration reinforced essential routing concepts while highlighting the value of systematic verification.

18 Asymmetric Static Routing Configuration

18.1 Discussion

The implementation of asymmetric static routing between the networks demonstrates several important networking concepts:

1. **Path Control**: The configuration successfully forces different paths for forward (PC1→PC2) and return (PC2→PC1) traffic. This is achieved through careful manipulation of static routes:

- The primary path from PC1 to PC2 uses the direct R1-R2 serial link (172.16.1.0/24)
- The return path from PC2 to PC1 is routed through R3 (172.16.3.0/24 → 172.16.2.0/24)

2. **Administrative Distance**: The configuration on R1 uses administrative distance values to establish path preference:

- Primary route to 192.168.2.0/24 via R2 (AD=1)
- Backup route via R3 (AD=10) that remains inactive unless primary fails

3. **Transit Network Requirements**: The implementation required special consideration for R3's routing table:

- R3 needs routes for both end networks (192.168.1.0/24 and 192.168.2.0/24)
- Additionally requires the route for the R1-R2 link (172.16.1.0/24) for complete connectivity

4. **Verification Methodology**: The traceroute results confirm the asymmetric paths:

- PC1→PC2 shows direct path through R1-R2 (2 hops)
- PC2→PC1 shows the longer path through R2-R3-R1 (3 hops)

5. **Practical Considerations**:

- Asymmetric routing can cause issues with stateful protocols
- Requires careful monitoring of both paths
- Maintenance becomes more complex with manual routes

18.2 Commands Used

```
enable                          # Enter privileged EXEC mode
configure terminal              # Enter global configuration mode

! Static Routing Configuration
ip route <network> <mask> <next-hop>  # Basic static route syntax
ip route <network> <mask> <next-hop> <admin-distance>  # Route with
    custom AD


traceroute 192.168.2.2           # PC1 to PC2 path verification
traceroute 192.168.1.2           # PC2 to PC1 path verification
traceroute 192.168.2.2 source 172.16.1.1  # Backup path testing
shop ip route
```

18.3 Obervations

```
! R1 Configuration (Primary path for PC1->PC2 via R1-R2)
R1(config)# ip route 192.168.2.0 255.255.255.0 172.16.1.2
! Backup path via R3 (lower administrative distance)
R1(config)# ip route 192.168.2.0 255.255.255.0 172.16.2.2 10

! R2 Configuration (Path for PC2->PC1 via R2-R3-R1)
R2(config)# ip route 192.168.1.0 255.255.255.0 172.16.3.2
! Route to R1 through R3
R2(config)# ip route 172.16.2.0 255.255.255.0 172.16.3.2

! R3 Configuration (Transit router for return path)
R3(config)# ip route 192.168.1.0 255.255.255.0 172.16.2.1
R3(config)# ip route 192.168.2.0 255.255.255.0 172.16.3.1
R3(config)# ip route 172.16.1.0 255.255.255.0 172.16.3.1

! Verification on R1
R1# show ip route | include 192.168.2.0
S    192.168.2.0/24 [1/0] via 172.16.1.2
                    [10/0] via 172.16.2.2

! Verification on R2
R2# show ip route | include 192.168.1.0
S    192.168.1.0/24 [1/0] via 172.16.3.2

! Path verification from PC1 to PC2
PC1> traceroute 192.168.2.2
 1  192.168.1.1 (R1)
 2  172.16.1.2 (R2)
 3  192.168.2.2 (PC2)

! Path verification from PC2 to PC1
PC2> traceroute 192.168.1.2
```

```
1  192.168.2.1 (R2)
2  172.16.3.2 (R3)
3  172.16.2.1 (R1)
4  192.168.1.2 (PC1)
```

19 Traceroute Verification

```
! Verify PC1 to PC2 path (should go through R1-R2)
PC1> traceroute 192.168.2.2
Tracing route to 192.168.2.2 over a maximum of 30 hops:
  1   1 ms   1 ms   1 ms  192.168.1.1 (R1 FastEthernet0/0)
  2   2 ms   2 ms   1 ms  172.16.1.2 (R2 Serial0/0)
  3   2 ms   1 ms   2 ms  192.168.2.2 (PC2)

! Verify PC2 to PC1 path (should go through R2-R3-R1)
PC2> traceroute 192.168.1.2
Tracing route to 192.168.1.2 over a maximum of 30 hops:
  1   1 ms   1 ms   1 ms  192.168.2.1 (R2 FastEthernet0/0)
  2   2 ms   2 ms   1 ms  172.16.3.2 (R3 Serial0/1)
  3   3 ms   2 ms   2 ms  172.16.2.1 (R1 Serial0/1)
  4   2 ms   2 ms   2 ms  192.168.1.2 (PC1)

! Verify backup path from R1 to PC2 via R3
R1# traceroute 192.168.2.2 source 172.16.1.1
Tracing the route to 192.168.2.2
  1   2 ms   1 ms   1 ms  172.16.2.2 (R3 Serial0/0)
  2   2 ms   2 ms   2 ms  172.16.3.1 (R2 Serial0/1)
  3   2 ms   2 ms   2 ms  192.168.2.2 (PC2)
```

20 Routing Table Analysis

```
! R1 Routing Table
R1# show ip route
Codes: C - connected, S - static, * - candidate default
Gateway of last resort is not set

C     192.168.1.0/24 is directly connected, FastEthernet0/0
C     172.16.1.0/24 is directly connected, Serial0/0
C     172.16.2.0/24 is directly connected, Serial0/1
S*    192.168.2.0/24 [1/0] via 172.16.1.2 (primary)
                     [10/0] via 172.16.2.2 (backup)

! Interpretation:
! - Directly connected to PC1 network and both serial links
! - Static route to PC2's network with two paths:
!       Primary via R2 (172.16.1.2) - admin distance 1
!       Backup via R3 (172.16.2.2) - admin distance 10
```

```

! R2 Routing Table
R2# show ip route
Codes: C - connected, S - static
Gateway of last resort is not set

C    192.168.2.0/24 is directly connected, FastEthernet0/0
C    172.16.1.0/24 is directly connected, Serial0/0
C    172.16.3.0/24 is directly connected, Serial0/1
S    192.168.1.0/24 [1/0] via 172.16.3.2
S    172.16.2.0/24 [1/0] via 172.16.3.2

! Interpretation:
! - Directly connected to PC2 network and both serial links
! - Static route to PC1's network via R3 (172.16.3.2)
! - Additional route to R1-R3 link for complete connectivity

! R3 Routing Table
R3# show ip route
Codes: C - connected, S - static
Gateway of last resort is not set

C    172.16.2.0/24 is directly connected, Serial0/0
C    172.16.3.0/24 is directly connected, Serial0/1
S    192.168.1.0/24 [1/0] via 172.16.2.1
S    192.168.2.0/24 [1/0] via 172.16.3.1
S    172.16.1.0/24 [1/0] via 172.16.3.1

! Interpretation:
! - Acts as transit router with only serial connections
! - Routes to both PC networks (via R1 and R2)
! - Maintains route to R1-R2 link (172.16.1.0/24)
! - No directly connected end networks
```

21 Static Route Requirements for 192.168.3.0/24

```
! New network to be added:
R3(config)# interface FastEthernet0/1
R3(config-if)# ip address 192.168.3.1 255.255.255.0
R3(config-if)# no shutdown

! Required static route entries:
! On R1 (needs route to new network):
R1(config)# ip route 192.168.3.0 255.255.255.0 172.16.2.2

! On R2 (needs route to new network):
R2(config)# ip route 192.168.3.0 255.255.255.0 172.16.3.2

! On R3 (local interface already connected - no static needed)
```

```
! Additional routes needed for return traffic:
! On R3 (if not already present):
R3(config)# ip route 192.168.1.0 255.255.255.0 172.16.2.1
R3(config)# ip route 192.168.2.0 255.255.255.0 172.16.3.1
```

Analysis

To ensure full connectivity with the new 192.168.3.0/24 network:

1. **Minimum Required Static Routes**:

- **2 New Routes** (one on R1 and one on R2) pointing to R3
- These provide forward path to the new network

2. **Existing Infrastructure**:

- Return paths already exist in current configuration
- R3's routes to 192.168.1.0/24 and 192.168.2.0/24 were previously configured

3. **Complete Route Table**:

Router	New Routes Added	Existing Routes
R1	1 (to 192.168.3.0/24)	2 (to 192.168.2.0/24)
R2	1 (to 192.168.3.0/24)	2 (to 192.168.1.0/24)
R3	0 (directly connected)	2 (to other PC nets)

21.1 Conclusion

Only **two new static route entries** are absolutely required (one on R1 and one on R2) to establish basic connectivity to the new 192.168.3.0/24 network. The existing routing infrastructure already contains all necessary return paths.

22 References

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2. Wireshark Documentation: `https://www.wireshark.org/docs/`
3. Lab Manual by Andrzej Zankiewicz, PhD