BIRZEIT UNIVERSITY

Faculty of Engineering and Technology
Electrical and Computer Engineering Department
ENCS4130 – Computer Network Laboratory

Experiment No. 11

Internet Protocol Version 6 (IPv6) Configuration

■ Objectives

(a) Learn how to configure IPv6 addressing.

(b) Understand static IPv6 routing.

(c) Understand dynamic IPv6 routing using RIPng.

■ Requirements

(a) Cisco Packet Tracer software.

(b) Three Routers.

(c) Three switches.

(d) Two servers (Web and DNS servers).

(e) Five PCs.

11.1 Introduction

You have probably heard that the world is running out of IP addresses. According to the number resource organization (NRO), as of February 3, 2011, the free pool of IPv4 addresses was officially depleted.

IPv6 addresses are 128 bits long, allowing for approximately 3.4×10^{38} unique addresses. Unlike IPv4, IPv6 addresses are written in hexadecimal and separated by colons. Each group contains four hexadecimal digits. Leading zeros in each group can be omitted. For example:

AA76:0000:0000:0000:0012:A322:FE33:2267

Can be shortened to:

AA76:0:0:0:12:A322:FE33:2267

Additionally, one sequence of consecutive zero groups can be replaced with a double colon (**::**) for further simplification:

AA76::12:A322:FE33:2267

Important: A double colon may appear only once in an IPv6 address. For example:

AA76:0000:0000:0012:A322:0000:0000:2267

Can be written as either:

AA76::12:A322:0:0:2267

or

AA76:0:0:12:A322::2267

But not:

AA76::12:A322::2267

(Using two double colons in one address is invalid.)

11.1.1 IPv6 Address Types

- **Unicast:** A unicast address ***identifies a single unique interface*** on a network. Packets sent to a unicast address are *delivered to exactly one destination interface.*
  - **Global Unicast:** Similar to public IPv4 addresses. These start with **2000::/3** .
  - **Link-Local:** Similar to private IPv4 addresses; not routable beyond the local link. These start with **FE80::/10** . Useful for temporary or isolated LAN setups.
- **Multicast:** A multicast address ***identifies a group of interfaces***, typically on different devices. Packets sent to a multicast address are *delivered to all interfaces* that belong to the specified multicast group.
- **Anycast:** An anycast address is ***assigned to multiple interfaces***, usually on different devices. Packets sent to an anycast address are *delivered to the nearest interface* (in terms of routing distance) among those that share the same address.

- **Reserved Addresses:** Reserved IPv6 addresses serve special purposes.
  - **::1** is the **loopback address**, used by a device to send packets to itself.
  - **::** is the **unspecified address**, used when a device does not yet have an assigned address.
  - IPv4-mapped IPv6 addresses (e.g., **::FFFF:192.0.2.1**) are special reserved addresses used to represent IPv4 addresses within an IPv6 environment. They enable interoperability between IPv6-only applications and IPv4 systems by allowing IPv4 addresses to be embedded in IPv6 format.

11.1.2 Configuring Cisco Routers with IPv6

A) Configuring a Router Interface

To assign an IPv6 address to an interface:

```
Router(config)# interface <type> <slot>/<port>
Router(config-if)# ipv6 address <ipv6-prefix>/<prefix-length>
```

> Important:
>
> An interface can have **multiple** IPv6 addresses assigned, and it can also be configured with both IPv4 and IPv6 addresses simultaneously.

B) Enabling IPv6 Routing

IPv6 routing is disabled by default. To enable it:

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

C) Static IPv6 Routing

To configure a static route:

```
Router(config)# ipv6 route <ipv6-prefix>/<prefix-length>
                <next-hop-ipv6-address>
```

This list describes each component of the command:

- `ipv6 route`: The command used to create the static route.
- `IPV6-PREFIX`: The network you're placing in the routing table.
- `PREFIX-LENGTH`: The subnet mask being used on the network.
- `IPV6-NEXT-HOP-ADDRESS`: The address of the next-hop router that will receive the packet and forward it to the remote network. This is a router interface on a directly connected network.

This command tells the router to forward packets destined for `<ipv6-prefix>/<prefix-length>` to the next-hop address specified.

D) Dynamic IPv6 Routing: RIPng

Routing Information Protocol next generation (RIPng) is similar to RIPv2 but designed for IPv6. Key features include:

- Distance-vector routing protocol
- Maximum hop count: 15
- Uses **link-local** addresses for next-hop resolution, not global addresses

Unlike RIPv2, RIPng is enabled **per interface**, not globally via a **network** command. When enabled, a new RIPng process starts automatically.

```
Router(config)# interface <type> <slot>/<port>
Router(config-if)# ipv6 rip <rip-id> enable
```

The `<rip-id>` is a tag that names the RIPng process (can be numeric or textual).

E) Configuring a DHCPv6 Pool

To configure a DHCPv6 pool that provides clients with an IPv6 prefix and a DNS server:

```
Router(config)# ipv6 dhcp pool <pool-name>
Router(config-dhcp)#address prefix <ipv6-prefix>/<prefix-len>
Router(config-dhcp)#dns-server <dns-ipv6-address>
```

> Important:
>
> This configuration defines a DHCPv6 pool that can be bound to an interface. Clients receive IPv6 configuration parameters such as the prefix and DNS server address.

F) Binding DHCPv6 Pool to an Interface

After creating the DHCPv6 pool, you need to bind it to the desired interface and enable IPv6 router advertisements with the appropriate flags.

```
Router(config)# interface <type> <slot>/<port>
Router(config-if)#ipv6 nd other-config-flag
Router(config-if)#ipv6 dhcp server <pool-name>
```

The `ipv6 nd other-config-flag` command sets the ”Other Configuration” (O) flag in router advertisements to inform clients that additional configuration (e.g., DNS) is available via DHCPv6.

G) DNS AAAA Records

`AAAA` records in DNS map domain names to IPv6 addresses. They enable IPv6-capable devices to resolve hostnames to their corresponding IPv6 addresses, providing full DNS functionality in IPv6 networks.

11.1.3 Cisco Discovery Protocol (CDP)

CDP is a proprietary **Layer 2 protocol** developed by Cisco Systems. It allows Cisco devices to automatically discover and exchange information with directly connected Cisco devices. Because CDP operates at Layer 2, it functions independently of Layer 3 protocols such as IPv4 or IPv6. CDP is widely used in *network management*, *troubleshooting*, and *device inventory*.

CDP-enabled devices **periodically send advertisement messages** to a **multicast MAC address** (`01:00:0C:CC:CC:CC`). These messages contain useful information such as the device ID (e.g., hostname), IP address, operating system version, platform (e.g., model or hardware type), active interfaces, and device capabilities (e.g., router, switch, IP phone). Neighboring Cisco devices that are also CDP-enabled receive these messages, extract the data, and store it in a local cache.

A) Monitoring CDP

Network administrators can view CDP cached information using diagnostic commands.

- To displays a summary of directly connected Cisco devices:

```
Router# show cdp neighbors
```

- To show detailed information about each neighboring device:

```
Router# show cdp neighbors detail
```

B) Disabling CDP

Although CDP is enabled by default on most Cisco interfaces, it can be disabled when not needed, either per interface or globally.

- To disable CDP on a specific interface:

```
Router(config)# interface <type> <slot>/<port>
Router(config-if)# no cdp enable
```

- To disable CDP globally:

```
Router(config)# no cdp run
```

CDP should be disabled on interfaces where device discovery is not required, especially on interfaces connected to untrusted networks, to enhance security.

11.2 Procedure

In this lab we will connect three routers and several PCs to different networks using both IPv6 and IPv4 IPs. This will require configuring routing protocols between the routers. For IPv6, we will configure static routing and dynamic routing (RIPng), and for IPv4 we will configure RIP routing.

The topology includes both DNS and Web servers. The DNS server will be configured to have both an A record (IPv4) and an AAAA record (IPv6) for the Web server. The IPv6 addresses on PC0 and PC1 will be dynamically assigned using DHCPv6 within the network `2001:11AA::/64`.

11.2.1 Building the Topology

Construct the network topology shown in Figure 1, which consists of the following devices:

- Routers: Use **2811 IOS 15**.
- Switches: Use **Switch-PT**.
- Servers and PCs: From "*End Devices*", use **Server-PT** and **PC-PT**.
- Use the "**Automatically Choose Connection Type**" to connect devices.
- For **Router1**, you may need to add an extra interface as shown in Figure 2:
  1. Click the router, go to the Physical tab, and turn it off using the power switch.
  2. Insert the **NM-2FE2W** module into an empty slot.
  3. Turn the router back on.

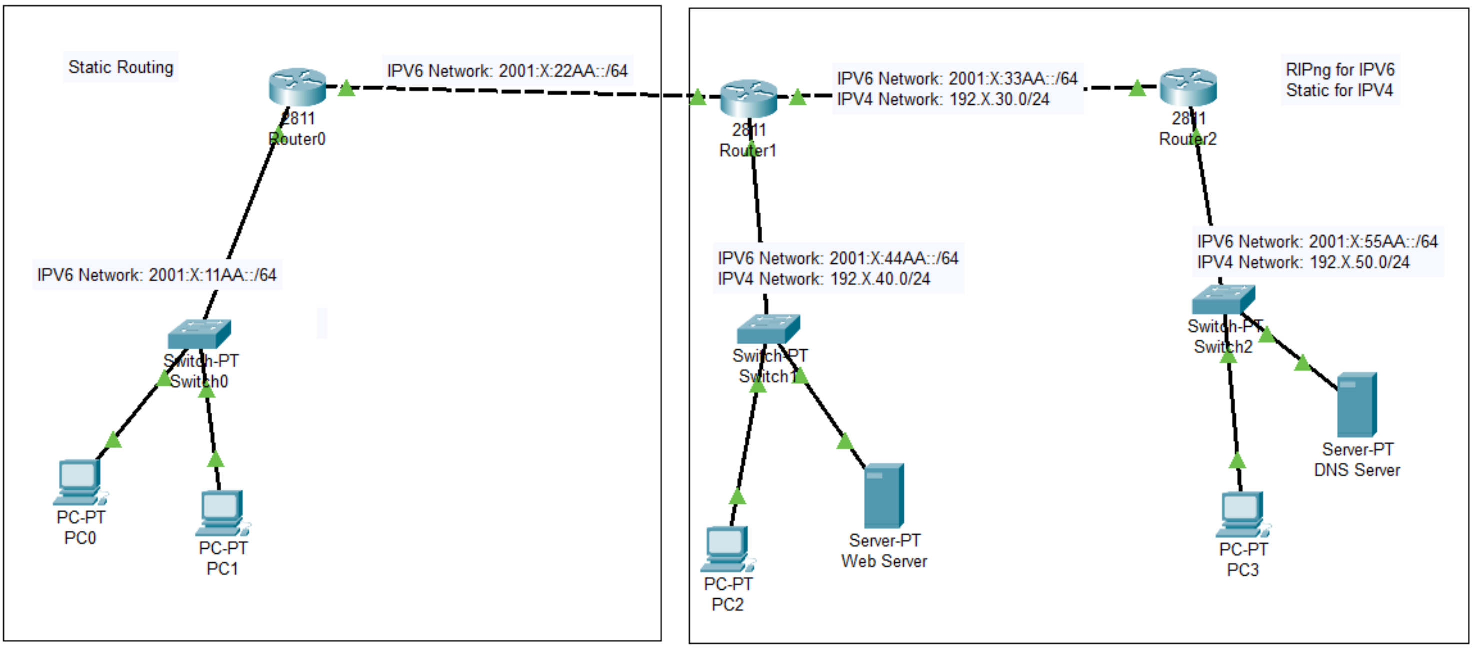

Figure 1: IPv6 topology.

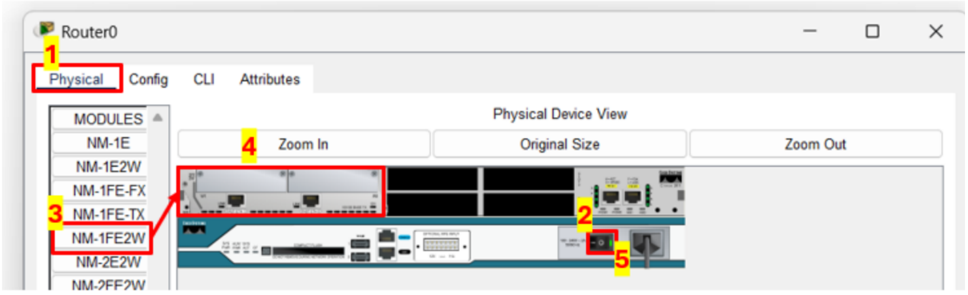

Figure 2: Adding the **NM-2FE2W** module to a router.

11.2.2 Configuring Servers

A) Web Server Configuration

- Click on the **Web Server**, go to the **Desktop** tab, and open **IP Configuration**.
  - Configure the IPv4 and IPv6 addresses as shown in Figure 3.

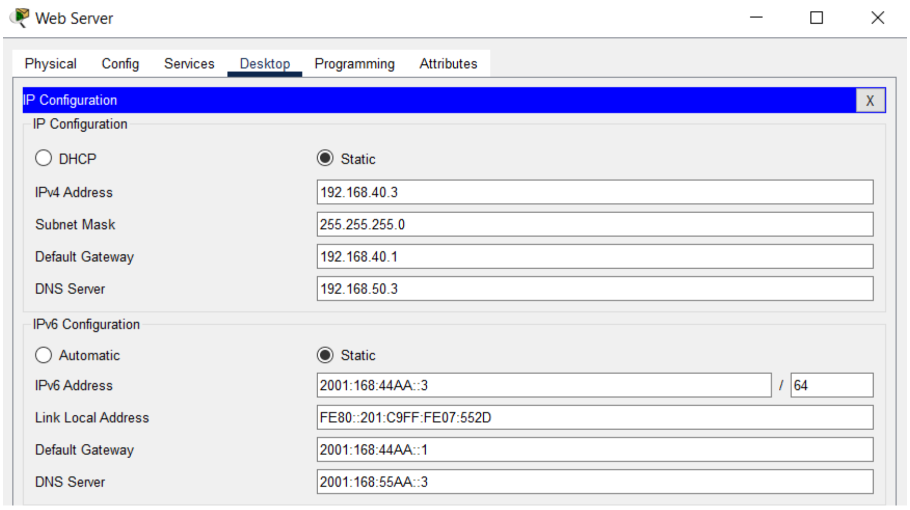

Figure 3: Web server configuration.

- Go to the **Services** tab and select **HTTP**.
- Ensure the HTTP service is **turned ON**.

B) DNS Server Configuration

- Click on the **DNS Server**, go to the **Desktop** tab, and open **IP Configuration**.
  - Configure the IPv4 and IPv6 addresses as shown in Figure 4.
- Go to the **Services** tab and select **DNS**.
- Ensure the DNS service is **turned ON**.
- Add the DNS records for the Web Server as shown in Figure 5.

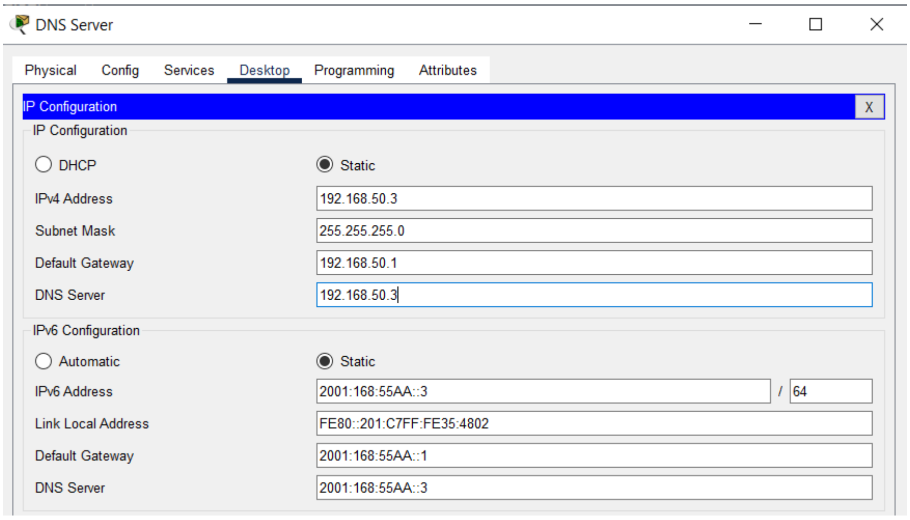

Figure 4: DNS server configuration.

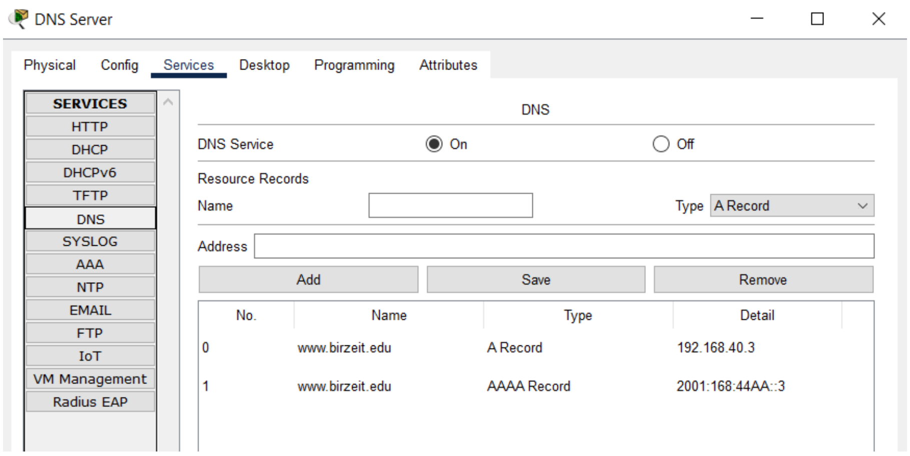

Figure 5: Configuring the DNS records for the web server.

11.2.3 Configuring PC2 and PC3

This section covers how to assign **IPv4** and **IPv6** addresses to **PC2** and **PC3**.

A) IPv4 Configuration

- Click on the PC and navigate to the **Desktop** tab.
- Open the **IP Configuration** utility.
- In the **IPv4 Configuration** section, assign the IP address, subnet mask, default gateway, and IPv4 address of the DNS server.

B) IPv6 Configuration

- In the same **IP Configuration** window, scroll down to the **IPv6 Configuration** section, assign the IP address, subnet mask, default gateway, and IPv6 address of the DNS server.

Figure 6 shows the configurations for PC2, which requires both IPv4 and IPv6 connectivity.

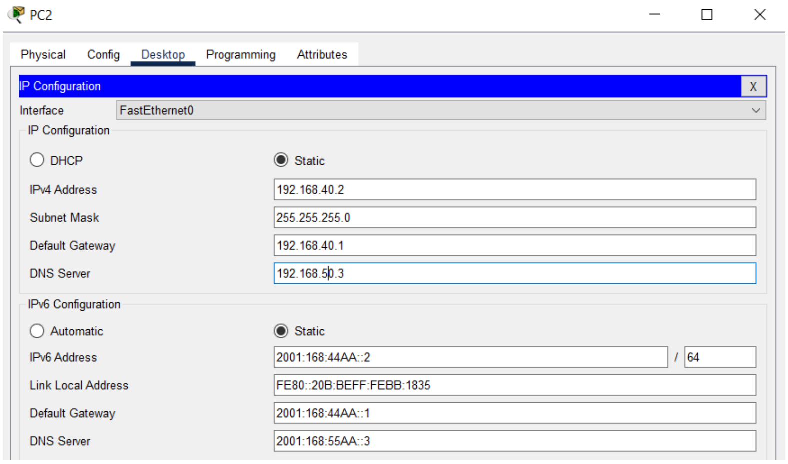

Figure 6: IPv4 and IPv6 configuration of PC2.

Repeat this configuration for **PC3** using the appropriate IPv4 and IPv6 addresses.

11.2.4 Router Interface Configuration

This section shows how to configure both **IPv4** and **IPv6** addresses on router interfaces.

A) Configuring IPv4 on Router Interfaces

To assign **IPv4** address `192.X.50.1/24` to **Router2** interface `FastEthernet0/1`, use the following commands:

```
Router2(config)# interface FastEthernet0/1
Router2(config-if)# ip address 192.X.50.1 255.255.255.0
Router2(config-if)# no shutdown
```

B) Configuring IPv6 on Router Interfaces

To configure an **IPv6** address `2001:X: 55AA::1/64` on **Router2** interface `FastEthernet0/1`, use the following commands:

```
Router2(config)# interface FastEthernet0/1
Router2(config-if)# ipv6 address 2001:X:55AA::1/64
Router2(config-if)# no shutdown
```

Repeat these steps for all required interfaces on **Router0**, **Router1**, and **Router2** using the appropriate IPv4 and IPv6 addresses.

11.2.5 Routing Configuration

A) Routing for IPv6 Networks

1. **Enabling IPv6 Routing**

To enable IPv6 routing on **Router2**, you must use the `ipv6 unicast-routing` global configuration command:

```
Router2(config)# ipv6 unicast-routing
```

Repeat this configuration for **Router0** and **Router1**.

2. **Configuring RIPng Routing Protocol**

   To enable RIPng on **Router2**'s `FastEthernet0/1` interface, first access the interface configuration mode, then enable RIPng using process ID `1`.

```
Router2(config)# interface Fa0/1
Router2(config-if)# ipv6 rip 1 enable
```

   Repeat for:

   - **Router2**: interface `Fa0/0`.
   - **Router1**: interfaces `Fa0/1` and `Fa1/0`.

3. **Configuring Static Routing**

   To configure a static route on **Router0** to reach the network `2001:44AA::/64`, use the following command:

```
Router0(config)# ipv6 route 2001:X:44AA::/64
                 2001:X:22AA::2
```

   Note:

   You must be able to ping the next-hop address before you add the route. If you enter an incorrect address, or if the interface to the next hop is down, the static route will show up in the router's configuration but not in the routing table.

   Repeat this process on **Router0** for all other remote networks. Similarly, configure static IPv6 routes on **Router1** and **Router2** to ensure full connectivity across the network.

B. Routing for IPv4 Networks

IPv4 networks use static routing to reach remote networks. To configure **Router1** with a static route to the `192.X.50.0/24` network via the next hop `192.X.30.2`, use the following command:

```
Router1(config)#ip route 192.X.50.0 255.255.255.0 192.X.30.2
```

Repeat a similar configuration on **Router2** to add a static route to the `192.X.40.0/24` network.

11.2.6 Configuring DHCPv6 Pool on Router0

This configuration defines a DHCPv6 pool on **Router0** that provides IPv6 clients with a network prefix and DNS server address. It also includes prefix lifetimes to control how long the information is valid.

```
Router0(config)# ipv6 dhcp pool POOL0
Router0(config-dhcp)# address prefix 2001:168:11AA::/64
Router0(config-dhcp)# dns-server 2001:168:55AA::3
Router0(config-dhcp)# exit
```

The pool is then bound to an interface. The "`other-config-flag`" tells clients to use DHCPv6 for options like DNS, while the actual prefix is still assigned via SLAAC.

```
Router0(config)# interface FastEthernet0/0
Router0(config-if)# ipv6 nd other-config-flag
Router0(config-if)# ipv6 dhcp server POOL0
```

11.2.7 Configuring IPv6 Addressing on PC0 and PC1 via DHCPv6

After configuring the DHCPv6 pool on **Router0**, you will now configure **PC0** and **PC1** to obtain their IPv6 addresses dynamically using DHCPv6.

- Click on **PC0** to open its configuration window.
- Navigate to the Desktop tab and open the IPv6 Configuration tool.
- Set the IPv6 Address Configuration method to DHCP.

Repeat these steps for **PC1**.

11.2.8 Displaying CDP Neighbor Information

To observe neighboring Cisco devices and their details, the following two commands are executed in privileged EXEC mode:

```
Router# show cdp neighbors
```

Figure 7 shows device IDs, local interfaces, capabilities, platform types, and the ports used to connect. This output gives a quick overview of Layer 2 connectivity between Cisco devices.

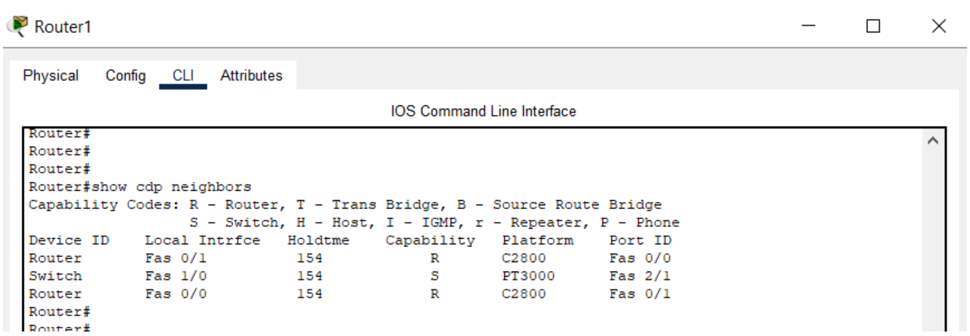

Figure 7: Output of `show cdp neighbors` command.

To obtain more detailed information about each neighboring device, the following command is used:

```
Router# show cdp neighbors detail
```

Figure 8 includes details such as IP addresses, device software versions, interfaces, duplex settings, and capabilities. This information is useful for troubleshooting, documentation, and inventory purposes.

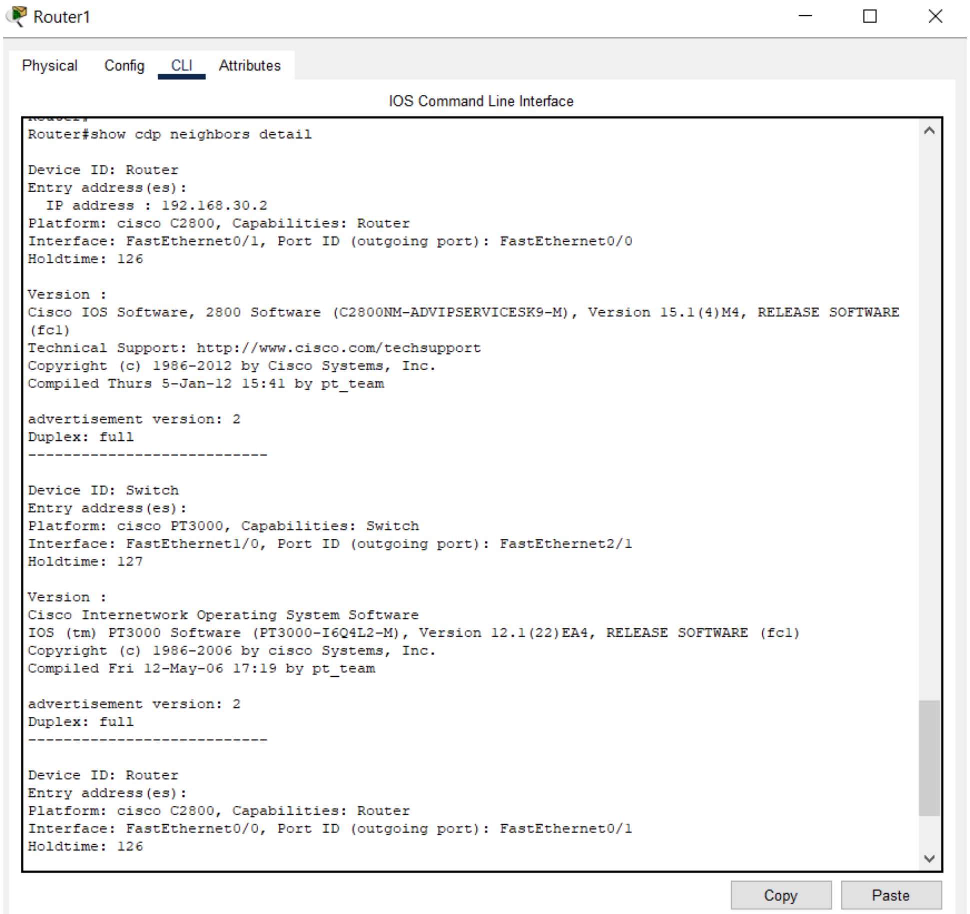

Figure 8: Output of `show cdp neighbors detail` command.

11.3 Verifying Your Configuration

1) Pinging from PC0 to Remote Networks

To verify basic network connectivity, `PC0` sends ICMP echo requests (ping) to devices in other networks.

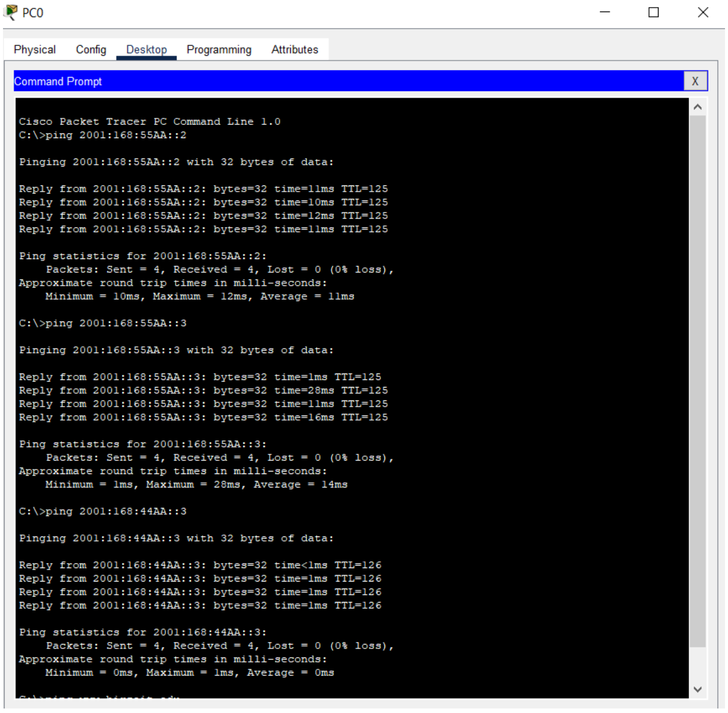

Figure 9: Successful ping from PC0 to remote networks

As shown in Figure 9, all pings are successful, indicating correct IP configuration and functional routing between networks.

2) HTTP Request from PC1 to Web Server Using Domain Name

`PC1` is configured with only IPv6 addressing. It sends an HTTP request to the web server using its domain name. The DNS server is configured with both A (IPv4) and AAAA (IPv6) records.

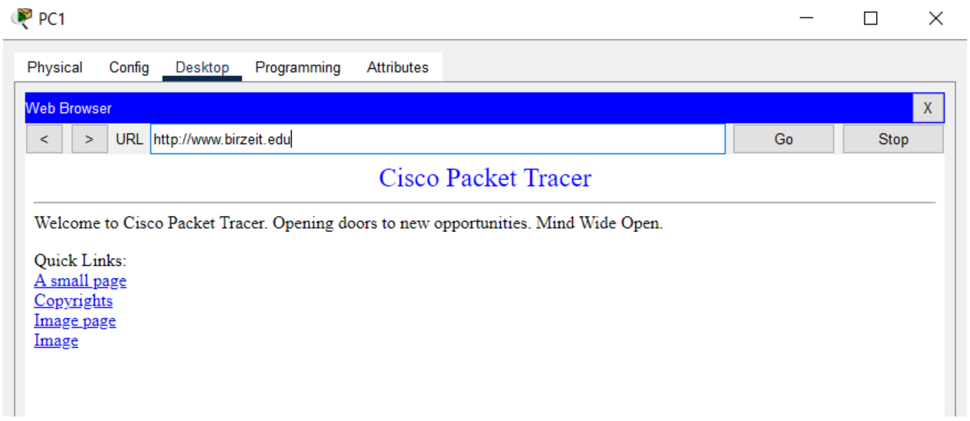

Figure 10: HTTP request from PC1 using IPv6 and domain name

Figure 10 shows a successful HTTP connection using the IPv6 path. Since PC1 only has an IPv6 address, the DNS query results in the use of the AAAA record to reach the web server.

3) HTTP Request from PC2 to the WebS Server using Domain Name

`PC2` is dual-stack (supports both IPv4 and IPv6). It sends an HTTP request to the web server using its domain name. The DNS has both A and AAAA records. In simulation mode, students can observe which record the DNS query resolves to.

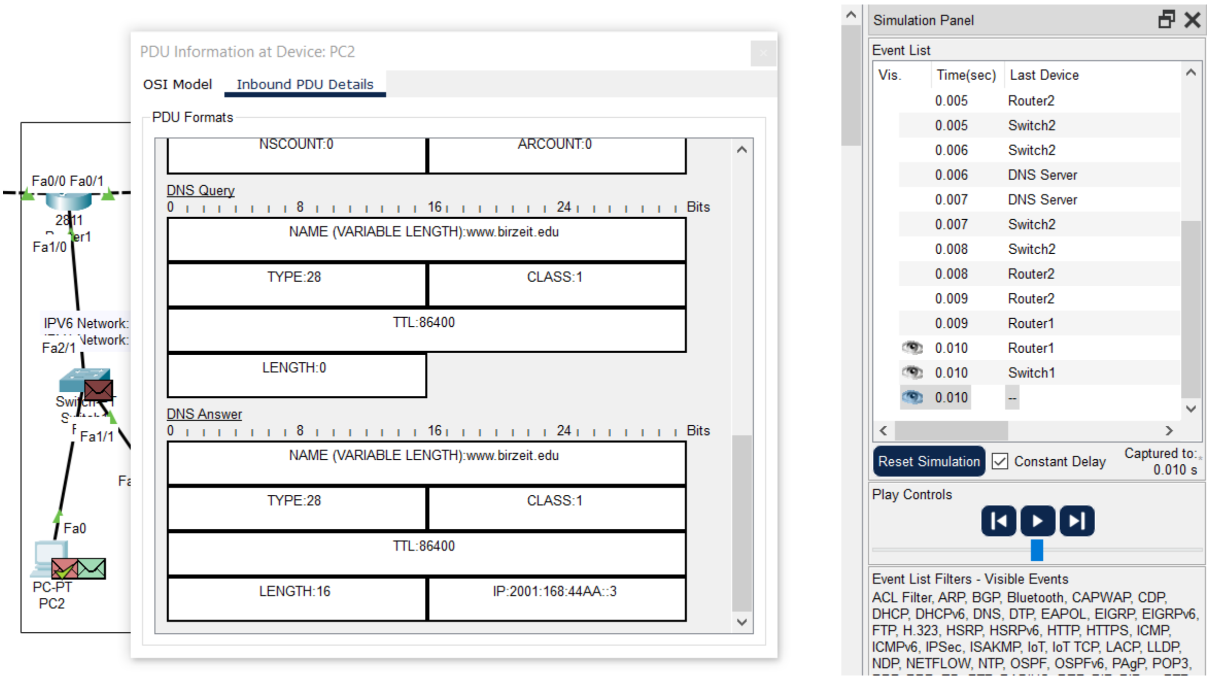

Figure 11: DNS resolution and HTTP request from PC2 (dual-stack)

Figure 11 shows that the DNS responded with the AAAA (IPv6) record. Modern dual-stack devices prioritize IPv6 when available, which explains why the IPv6 path was chosen. The HTTP request completes successfully over IPv6, verifying end-to-end connectivity and name resolution.

11.4 ToDo

This section will be provided by the instructor.