Lesson 10: Configuring IPv4 and IPv6 Addressing

MOAC 70-410: Installing and Configuring Windows Server 2012

Microsoft
Official Academic Course

WILEY

Overview

- Exam Objective 4.1: Configure IPv4 and IPv6 Addressing
- IPv4 Addressing
- IPv6 Addressing
- Planning an IP Transition

IPv4 Addressing

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IPv4 Addressing

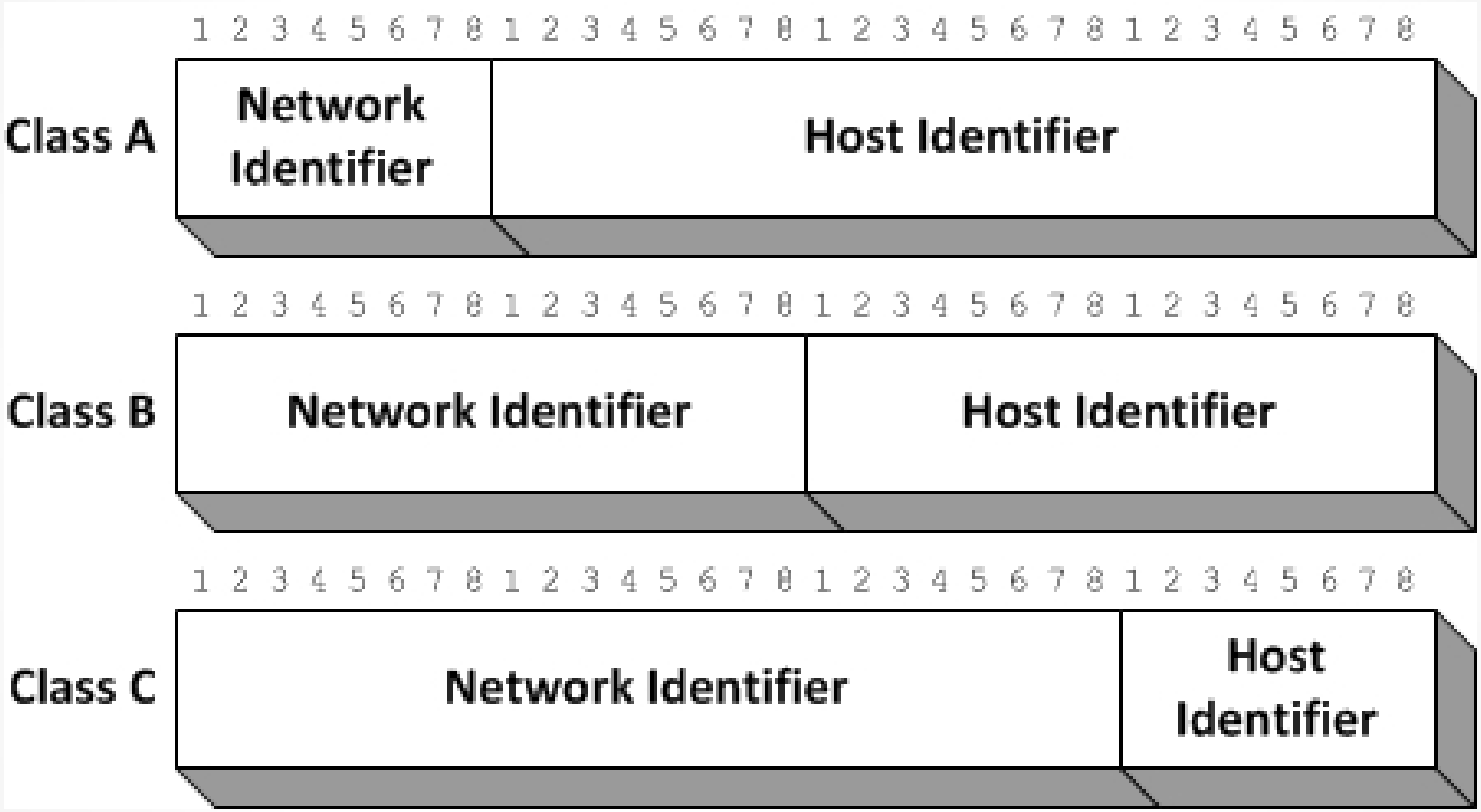
- **IP Address**
  - 32-bit address
  - Four 8-bit decimal values between 0 and 255 separated by periods (octets)
- **Subnet Mask**
  - 32-bit value of 0's and 1's
  - 1's designate network bits, 0's are host bits

Network Host

Examples: IP Address **192.168.43.100**

Subnet Mask **255.255.255.0**

IPv4 Classful Addressing



The three IPv4 address classes

IPv4 Address Classes

IP Address Class	***Class A***	***Class B***	***Class C***
First bit values (binary)	0	10	110
First byte value (decimal)	0–127	128–191	192–223
Number of network identifier bits	8	16	24
Number of host identifier bits	24	16	8
Number of possible networks	126	16,384	2,097,152
Number of possible hosts	16,777,214	65,534	254

Classless Inter-Domain Routing

- Classful addressing was gradually phased out by a series of subnetting methods, including variable length subnet masking (VLSM) and, eventually, **Classless Inter-Domain Routing (CIDR)**.
- **CIDR** is a subnetting method that enables administrators to place the division between the network bits and the host bits anywhere in the address, not just between octets.

CIDR

CIDR notation: **192.168.43.0/26**

- Where the **/26** means 26 bits of the address are used as the network identifier
- In binary, the subnet mask translates to: **11111111.11111111.1111111.11000000** or **255.255.255.192** in decimal
- This would allow us to divide this address into **4 networks**, each with up to **62 hosts**

CIDR 192.168.43.0/26 Networks

Network Address	*Starting IP Address*	*Ending IP Address*	*Subnet Mask*
192.168.43.0	192.168.43.1	192.168.43.62	255.255.255.192
192.168.43.64	192.168.43.65	192.168.43.126	255.255.255.192
192.168.43.128	192.168.43.129	192.168.43.190	255.255.255.192
192.168.43.192	192.168.43.193	192.168.43.254	255.255.255.192

Public and Private IPv4 Addressing

- Registered IP addresses are not necessary for workstations that merely access resources on the Internet
- The three blocks of addresses allocated for private use are as follows:
  - 10.0.0.0/8
  - 172.16.0.0/12
  - 192.168.0.0/16

Using Network Address Translation (NAT)

- NAT is a network-layer routing technology that enables a group of workstations to share a single registered address.
- A NAT router is a device with two network interfaces, one connected to a private network and one to the Internet.
- When a workstation on the private network wants to access an Internet resource, it sends a request to the NAT router.
- The NAT router substitutes its own registered IP address for the workstation's private address, and sends the request on to the Internet server.
- The router then performs the same substitution in reverse and forwards the response back to the original unregistered workstation.

Using a Proxy Server

- Like NAT, a proxy server receives requests from clients on a private network, and forwards to the destination on the Internet, using its own registered address.
- The proxy server interposes additional functions into the forwarding process. These functions can include:
  - Filtering
  - Logging
  - Caching
  - Scanning
- Applications must be configured to use a proxy server.

IPv4 Subnetting

- Allows you to split one IP address range into multiple networks (e.g., you can take the 10.0.0.0/8 private IP address range and use the entire second octet as a subnet ID).
- This creates up to 256 subnets with up to 65,536 hosts.
- The subnet masks will be 255.255.0.0 and the network addresses will proceed as follows:
  - 10.0.0.0/16
  - 10.1.0.0/16
  - 10.2.0.0/16
  - …
  - 10.255.0.0/16
- When you are working on an existing network, the subnetting process is more difficult.

Calculate IPv4 Subnets

1. Determine how many subnet identifier bits you need to create the required number of subnets.
2. Subtract the subnet bits you need from the host bits and add them to the network bits.
3. Calculate the subnet mask by adding the network and subnet bits in binary form and converting the binary value to decimal.
4. Take the least significant subnet bit and the host bits, in binary form, and convert them to a decimal value.
5. Increment the network identifier (including the subnet bits) by the decimal value you calculated to determine the network addresses of your new subnets.

Supernetting

- Allows contiguous networks to be added to a routing table with one entry to reduce the size of Internet routing tables.
- For example:
  - 172.16.43.0/24
  - 172.16.44.0/24
  - 172.16.45.0/24
  - 172.16.46.0/24
  - 172.16.47.0/24
- Can all be expressed in one supernet address:
  - 172.16.40.0/21

Assigning IPv4 Addresses

To assign IPv4 addresses, there are three basic methods:

- Manual configuration
- Dynamic Host Configuration Protocol (DHCP)
- Automatic Private IP Addressing (APIPA)

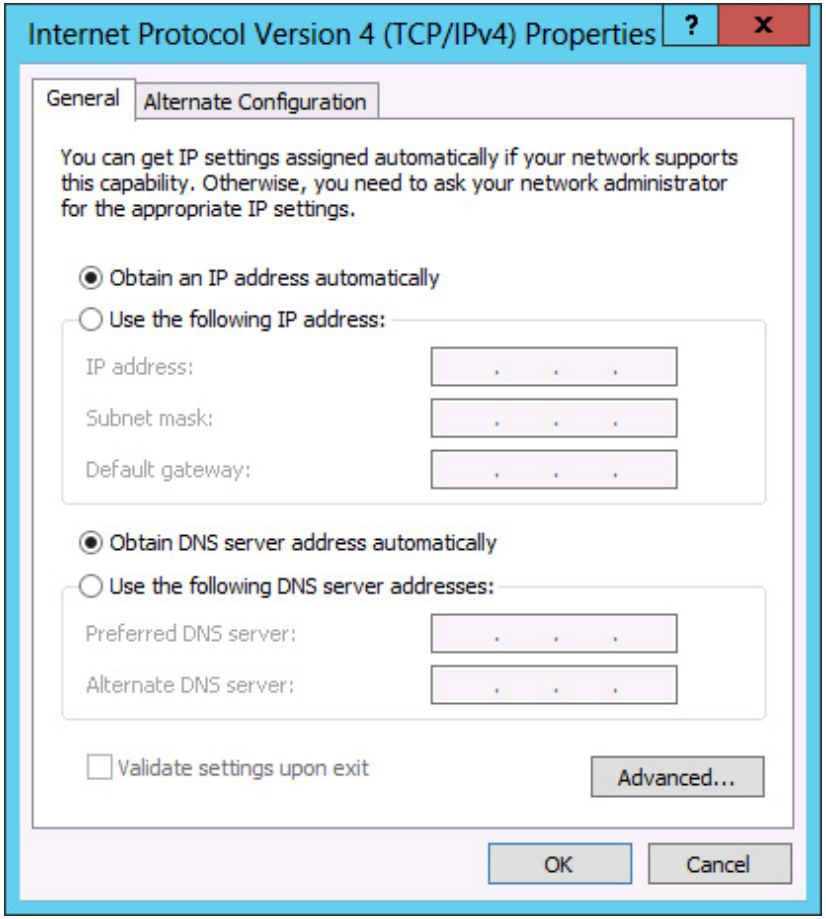
Manual IPv4 Address Configuration

- Manually enter IP address, subnet mask, default gateway and DNS servers.
- Use a GUI or command line.
- Not difficult, but it can be time consuming on a large network.
- Difficult to troubleshoot if information is entered incorrectly.

Dynamic Host Configuration Protocol (DHCP)

- Client computers are configured to Obtain an IP address automatically.
- DHCP Servers on the network contain a pool of addresses and other IPv4 configuration.
- Clients request configuration at boot up.
- DHCP Servers respond to the requests.
- IPv4 configurations are leased for a period of time and renewed as necessary.
- No addresses are duplicated.

Assigning IPv4 Addresses



The Internet Protocol Version 4 (TCP/IPv4) Properties sheet

Automatic Private IP Addressing (APIPA)

- A DHCP failover mechanism used by all current Microsoft Windows operating systems.
- If a system fails to locate a DHCP server on the network, APIPA takes over and automatically assigns an address on the 169.254.0.0/16 network to the computer.
- For a small network that consists of only a single LAN, APIPA is a simple and effective alternative to installing a DHCP server.

IPv6 Addressing

Lesson 10: Configuring IPv4 and IPv6 Addressing

IPv6 Addressing

- Designed to increase the size of the IP address space (128 bit), thus providing addresses for many more devices than IPv4
- Reduces the size of the routing tables because the size of the addresses provides for more than the two levels of subnetting currently possible with IPv4

Introducing IPv6

- IPv6 addresses use a notation called colon-hexadecimal format
- Eight 16-bit hexadecimal numbers, separated by colons: **XX:XX:XX:XX:XX:XX:XX:XX**
- Each X represents eight bits (or 1 byte), which in hexadecimal notation is represented by two characters, as in: **21cd:0053:0000:0000:e8bb:04f2:003c:c394**

Contracting IPv6 Addresses

- When an IPv6 address has two or more consecutive eight-bit blocks of zeroes, you can replace them with a double colon (but you can only use one double colon in any IPv6 address):
  21cd:0053::e8bb:04f2:003c:c394
- You can also remove the leading zeros in any block where they appear:
  21cd:53::e8bb:4f2:3c:c394

Expressing IPv6 Network Addresses

- No subnet masks in IPv6
- Network addresses use the same slash notation as CIDR:

  21cd:53::/64
- This is the contracted form for the following network address:

  21cd:0053:0000:0000/64

IPv6 Address Types

IPv6 supports three address types:

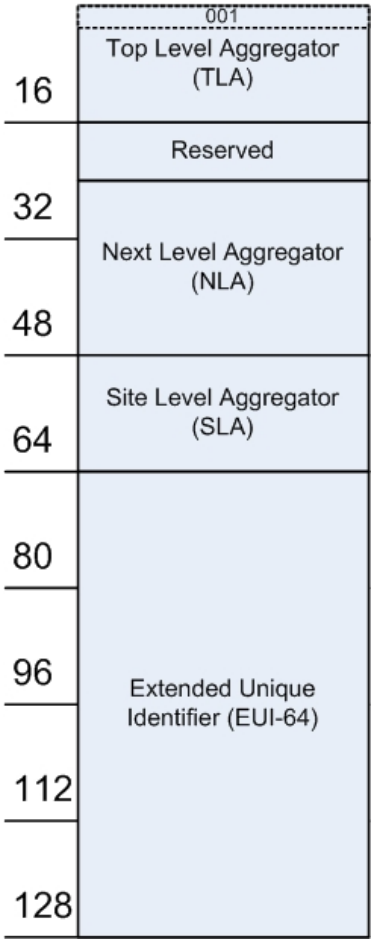
- **Unicast:** Provides one-to-one transmission service to individual interfaces, including server farms sharing a single address. IPv6 supports several types of unicast addresses, including global, link-local, and unique local.
- **Multicast:** Provides one-to-many transmission service to groups of interfaces identified by a single multicast address.
- **Anycast:** Provides one-to-one-of-many transmission service to groups of interfaces, only the nearest of which (measured by the number of intermediate routers) receives the transmission.

Original Global Unicast Addresses

The equivalent of a registered IPv4 address, routable worldwide and unique on the Internet. It consists of the following elements:

- **Format prefix (FP):** An FP value of 001 identifies the address as a global unicast.
- **Top Level Aggregator (TLA):** A 13-bit globally unique identifier allocated to regional Internet registries by the IANA.
- **Reserved:** An 8-bit field that is currently unused.
- **Next Level Aggregator (NLA):** A 24-bit field that the TLA organization uses to create a multilevel hierarchy for allocating blocks of addresses to its customers.
- **Site Level Aggregator (SLA):** A 16-bit field that organizations can use to create an internal hierarchy of sites or subnets.
- **Extended Unique Identifier (EUI-64):** A 64-bit field, derived from the network interface adapter's MAC address, identifying a specific interface on the network.

Global Unicast Addresses



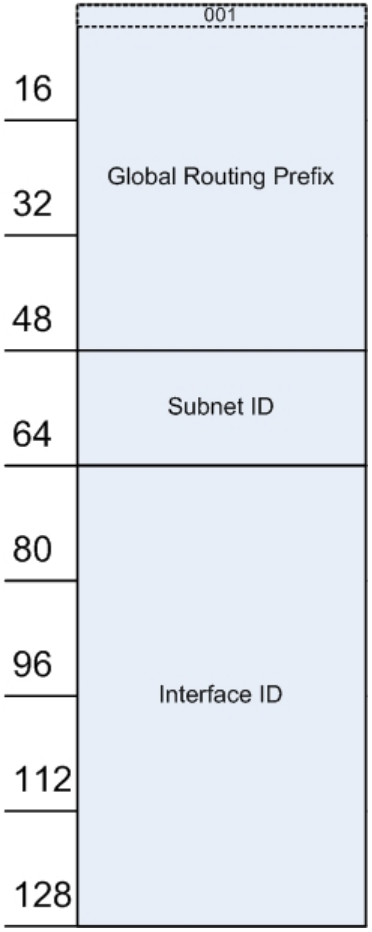
The original IPv6 global unicast address format

Current Global Unicast Addresses

The current official format for global unicast addresses consists of the following elements:

- **Global routing prefix:** A 48-bit field beginning with the 001 FP value, the hierarchical structure of which is left up to the RIR
- **Subnet ID:** Formerly known as the SLA, a 16-bit field that organizations can use to create an internal hierarchy of sites or subnets
- **Interface ID:** A 64-bit field identifying a specific interface on the network

Global Unicast Addresses



The current IPv6 global unicast address format

Subnet IDs

Organizations have a16-bit subnet ID with which to create an internal subnet hierarchy, if desired. Here are some of the possible subnetting options:

- **One-level subnet:** By setting all subnet ID bits to 0, all computers in the organization are part of a single subnet. This option is only suitable for smaller organizations.
- **Two-level subnet:** By creating a series of 16-bit values, you can split the network into as many as 65,536 subnets. This is the functional equivalent of IPv4 subnetting, but with a much larger subnet address space.
- **Multi-level subnet:** By allocating specific numbers of subnet ID bits, you can create multiple levels of subnets, sub-subnets, and sub-sub-subnets; suitable for an enterprise of almost any size.

Subnet ID Example

To support a large international enterprise, you could split the subnet ID as follows:

- **Country (4 bits):** Creates up to 16 subnets representing countries in which the organization has offices
- **State (6 bits):** Creates up to 64 sub-subnets within each country, representing states, provinces, or other geographical divisions
- **Office (2 bits):** Creates up to 4 sub-sub-subnets within each state or province, representing offices located in various cities
- **Department (4 bits):** Creates up to 16 sub-sub-sub-subnets within each office, representing the various departments or divisions.

To create a subnet ID for a particular office, it is up to the enterprise administrators to assign values for each field.

Interface IDs

- The interface ID contains a unique identifier for a specific interface on the network.
- The Institute for Electrical and Electronic Engineers (IEEE) defines the format for the 48-bit MAC address assigned to each network adapter by the manufacturer, as well as the EUI-64 identifier format derived from it.
- A privacy problem with this method of deriving interface IDs from the computer's hardware—the location of a mobile computer might be tracked based on its IPv6 address.
- Instead of using MAC addresses, Windows operating systems generate random interface IDs by default.

Link-Local Unicast Addresses

- In IPv6, systems that assign themselves an address automatically create a **link-local unicast address**, which is the equivalent of an APIPA address in IPv4.
- All link local addresses have the same network identifier: a 10-bit FP of 1111111010 followed by 54 zeroes, resulting in:

  fe80:0000:0000:0000/64
- In its more compact form, the link-local network address is:

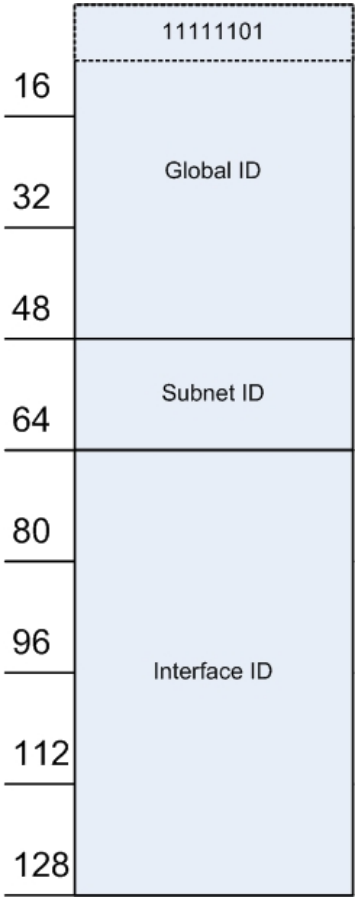
  fe80::/64

Unique Local Unicast Addresses

These are the same as private addresses in IPv4, with the following format:

- **Global ID:** A 48-bit field beginning with an 8-bit FP of 11111101 in binary, or fd00::/8 in hexadecimal. The remaining 40 bits of the global ID are randomly generated.
- **Subnet ID:** A 16-bit field that organizations can use to create an internal hierarchy of sites or subnets.
- **Interface ID:** A 64-bit field identifying a specific interface on the network.

Unique Local Unicast Addresses



The IPv6 unique local unicast address format

Special Addresses

- **Loopback address**: Any messages sent to it are returned back to the sending system.

  0:0:0:0:0:0:0:1 or **::1**

- **Unspecified address:** The address the system uses while requesting an address from a DHCP server.

  0:0:0:0:0:0:0:0

Multicast Addresses

Multicast addresses always begin with an FP value of **11111111**, in binary, or **ff** in hexadecimal. The entire multicast address format is as follows:

- **FP:** An 8-bit field that identifies the message as a multicast.
- **Flags:** A 4-bit field that specifies whether the multicast address contains the address of a rendezvous point (0111), is based on a network prefix (0010), and is permanent (0000) or transient (0001).
- **Scope:** A 4-bit field that specifies how widely routers can forward the address. Values include interface-local (0001), link-local (0010), site-local (0101), organization-local (1000), and global (1110).
- **Group ID:** A 112-bit field uniquely identifying a multicast group.

Anycast Addresses

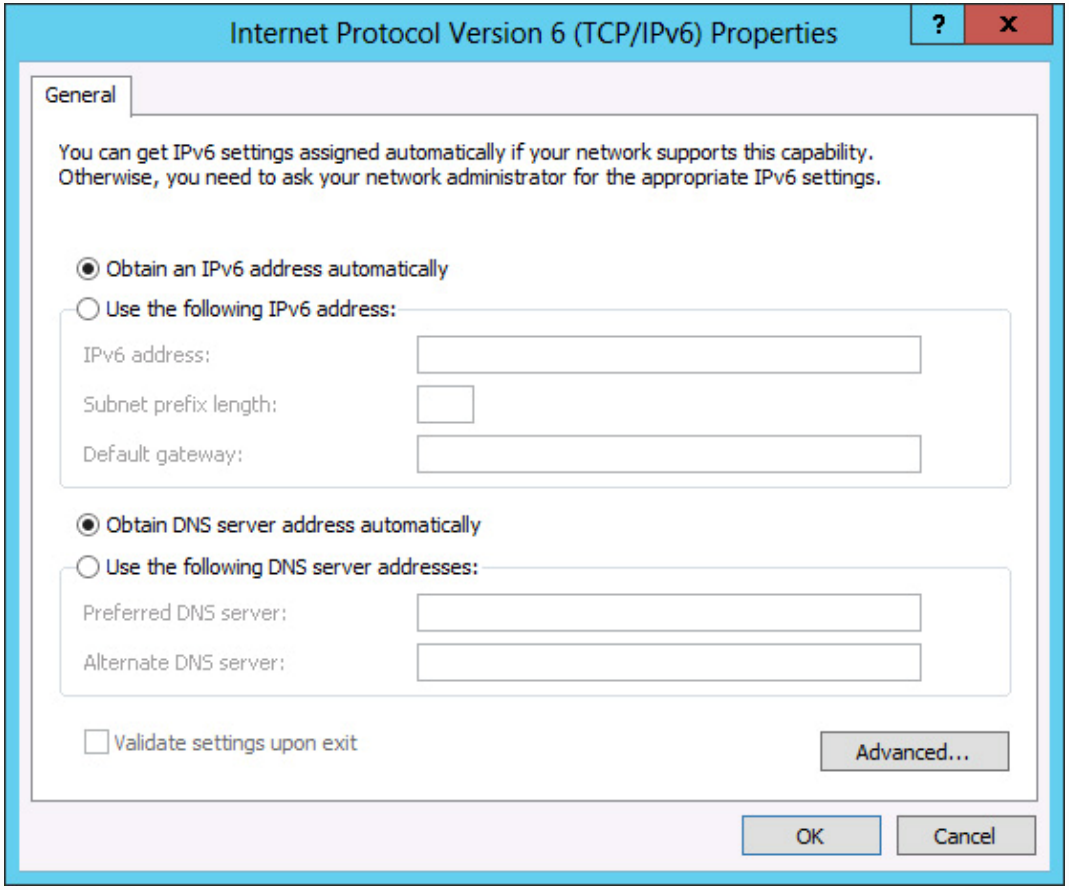
- Used to identify the routers within a given address scope and send traffic to the nearest router, as determined by the local routing protocols.
- Can be used to identify a particular set of routers in the enterprise, such as those that provide access to the Internet.
- To use anycasts, the routers must be configured to recognize the anycast addresses.

Assigning IPv6 Addresses

As with IPv4, a Windows computer can obtain an IPv6 address by three possible methods:

- **Manual allocation:** A user or administrator manually supplies an address and other information for each network interface.
- **Self-allocation:** The computer creates its own address using a process called stateless address autoconfiguration.
- **Dynamic allocation:** The computer solicits and receives an address from a Dynamic Host Configuration Protocol (DHCPv6) server on the network.

Assigning IPv6 Addresses



The Internet Protocol Version 6 (TCP/IPv6) Properties sheet

Planning an IP Transition

Lesson 10: Configuring IPv4 and IPv6 Addressing

Planning an IP Transition

- Administrators are reluctant to change from IPv4 to IPv6 because there is a lot to learn.
- IPv4 hardware is still functioning.
- The Internet is still mostly IPv4, but there is a gradual transition happening where there will be support for both IP versions.
- Currently, we must have mechanisms in place to transmit IPv6 traffic over IPv4 connections, but the situation will be reversed in the future.

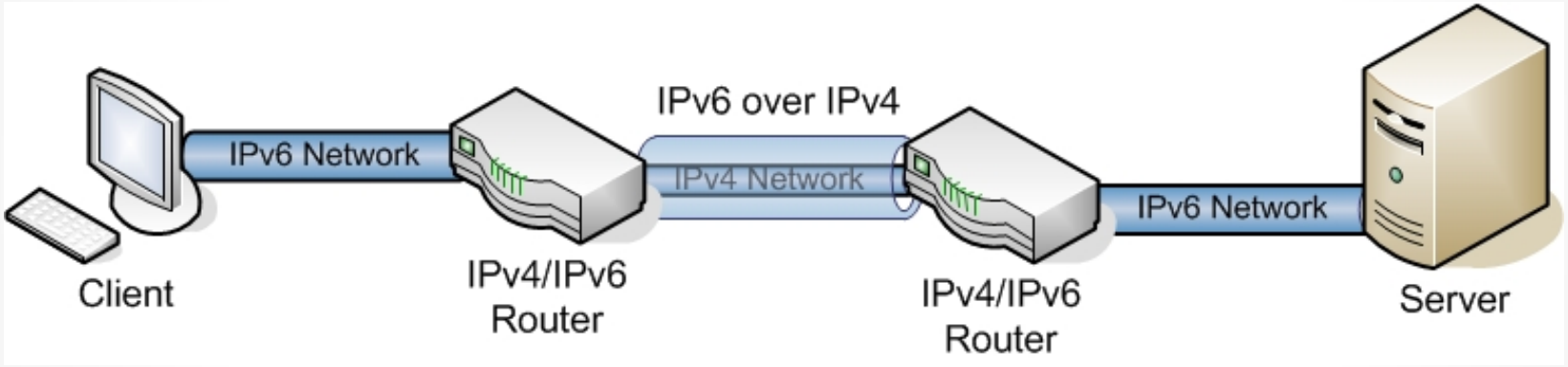
Using a Dual IP Stack

- The simplest way to transition is to run both IP versions.
- Windows has been doing this since Windows Server 2008 and Windows Vista.
- Use **ipconfig /all** to see IPv6 configuration.
- This allows us to communicate with IPv4 and IPv6 devices at the same time.

Tunneling

- **Tunneling** is the process by which a system encapsulates an IPv6 datagram within an IPv4 packet.
- Often used for router-to-router communication when communicating between two IPv6 networks over an IPv4 connection.

Tunneling



Two IPv6 networks connected by an IPv4 tunnel

Configuring Tunnels Manually

- It is possible to manually create semi-permanent tunnels that carry IPv6 traffic through an IPv4-only network. When a computer running Windows Server 2012 or Windows 8 is functioning as one end of the tunnel, you can use this command:

```
netsh interface ipv6 add v6v4tunnel "interface"
   localaddress remoteaddress
```

- In this command, *interface* is a friendly name you want to assign to the tunnel you are creating and *localaddress* and *remoteaddress* are the IPv4 addresses forming the two ends of the tunnel. An example of an actual command would be this:

```
netsh interface ipv6 add v6v4tunnel "tunnel"
   206.73.118.19 157.54.206.43
```

Configuring Tunnels Automatically

A number of mechanisms automatically create tunnels over IPv4 connections. These technologies are designed to be temporary solutions during the IPv4-to-IPv6 transition:

- **6to4**: Incorporates the IPv4 connections in a network into the IPv6 infrastructure by defining a method for expressing IPv4 addresses in IPv6 format and encapsulating IPv6 traffic into IPv4 packets.
- **ISATAP (Intra-Site Automatic Tunnel Addressing Protocol)**: An automatic tunneling protocol used by the Windows workstation operating systems that emulates an IPv6 link using an IPv4 network.
- **Teredo**: A mechanism that addresses the issue of NAT routers not supporting 6to4 by enabling devices behind non-IPv6 NAT routers to function as tunnel endpoints.

Lesson Summary

- The IPv4 address space consists of 32-bit addresses, notated as four 8-bit decimal values from 0 to 255, separated by periods (e.g., 192.168.43.100). This is known as dotted decimal notation, and the individual 8-bit decimal values are called octets or bytes.
- Because the subnet mask associated with IP addresses can vary, so can the number of bits used to identify the network and the host. The original Internet Protocol (IP) standard defines three address classes for assignment to networks, which support different numbers of networks and hosts.
- Because of its wastefulness, classful addressing was gradually made obsolete by a series of subnetting methods, including variable-length subnet masking (VLSM) and eventually Classless Inter-Domain Routing (CIDR). CIDR is a subnetting method that enables administrators to place the division between the network bits and the host bits anywhere in the address, not just between octets.

Lesson Summary

- When a Windows computer starts, it initiates the IPv6 stateless address autoconfiguration process, during which it assigns each interface a link-local unicast address.
- The simplest and most obvious method for transitioning from IPv4 to IPv6 is to run both, and this is what all current versions of Windows do.
- The primary method for transmitting IPv6 traffic over an IPv4 network is called tunneling—the process by which a system encapsulates an IPv6 datagram within an IPv4 packet.