

**Introducing the IPv6 Standard**  
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The newest Internet addressing scheme is called **IPv6**. It is also referred to as a classless IP addressing scheme because there is no need for a subnet mask based on network class. Windows Vista, Windows 7 and Microsoft Server 2008 automatically configure IPv6 addresses in addition to a default IPv4 address. While IPv6 is still not fully implemented, it is now incorporated into all modern operating systems, and is important that all network and computer technicians to learn and understand.

The original reason for development of a new IP address system was the rapid development of the Internet and the almost immediate shortage of available IP addresses. Today, almost all electronic communication equipment uses the internet and some form of an Internet address. The development of the IPv6 standard has also led to other network addressing improvements. We will now look at some of the advantages to using IPv6 and more details about it.

### **Some Advantages of IPv6**

The IPv4 standard still remains primarily the same as when it was finalized in 1980. The Internet has long outgrown the old standard. IPv6 provides many advantages and improvements when compared to the limitations of IPv4. The major improvements include a much larger pool of Internet and network addresses, reduced broadcast traffic, better security, and improved quality of service.

**Note:** The IPv6 standard is still evolving and not fully implemented at this time. IPv6 standards can be modified in the future. While all information is accurate at the time of this writing, changes may occur in the future. You should check reliable references for latest changes concerning IPv6.

### **Number of Possible IPv6 Addresses**

The main reason IPv6 was implemented was to increase the number of available Internet addresses. IPv4 address is equal to **32-bits** or approximately 4,000,000,000 (4 billion). When the IPv4 standard was developed, it was thought that the total number of IPv4 addresses was inexhaustible.

IPv6 uses **128-bit** addresses (or over 340,000,000,000,000,000,000,000,000,000,000,000) possible addresses. As you can see, the possible number of unique addresses seems inexhaustible once more. Only time will tell.

## **Reduced Broadcast Traffic**

IPv4 utilizes Address Resolution Protocol (ARP) to resolve IPv4 addresses to Media Access Control (MAC) addresses. A unique MAC address is assigned to each network adapter card. IPv6 uses Neighbor Discovery (ND) protocol carried inside a series of Internet Control Message Protocol (ICMP) packets on the local area network system. Basically, ND will eventually replace ARP broadcasts, which will significantly reduce network traffic on the local area network. At this time the implementation of both IPv6 and IPv4 by default does not result in total reduced local area network traffic.

## **Improved Security**

IPv6 incorporates IPsec to provide better security than IPv4. IPsec is not a single protocol, but rather a collection of protocols used to encrypt and authenticate each and every packet that utilizes an IP address over the Internet. The reason IPv6 has improved security is the fact that IPsec is mandatory for use with IPv6 while it is only optional for IPv4. There will be much more about IPsec in Chapter 15-Network Security (in the *new edition* of Networking Fundamentals, by Richard M. Roberts).

## **Better Quality of Service**

Used in this case, “quality of service” refers to the ability of a protocol to deliver certain packets in a timely fashion. For example, a long text document can have delays between packets that do not affect the content of the text document. But, packets that contain video or audio, such as a telephone conversation, must not have delays between the packets. A long delay between packets can result in a choppy conversation with parts of speech missing. IPv4 does have a quality of service feature, but when using security such as IPsec, the delivery of packets is slowed down. The IPv6 standard significantly improves quality of service and does not let IPsec security cause long delays between packets, thus insuring a better quality of service.

## **Support for Network Discovery**

ICMPv6 Internet Control Message Protocol Version 6 is designed to exchange messages between network neighboring nodes on the same link. This is the basis of the network discovery protocol which allows a computer system to identify other devices connected together in the same section (subnet) of a local area network. Network discovery allows for automatic configuration of network devices and the discovery of router devices attached to the local area network.

## The IPv6 Address

Modern computer equipment and software readily accepts IPv6 addresses and uses them to communicate across a network. The IPv6 standard uses a total address length of 128 bits.

The 128 bits are divided into 8 units of 16 bits. These units can be represented as a 4-digit hexadecimal number separated by colons. See **Figure 1**, below. The IPv6 address is assigned to network interface cards and equipment in a similar fashion as the IPv4 standard.

### Figure 1

The 128-bit IPv6 address is divided into eight 16-bit blocks each separated by a colon.

**FE80:0000:0000:4DE1:F01B:80FA:CCA3**

A single 16-bit block containing all zeros can be expressed as a single zero.

**FE80:0:0:4DE1:F01B:80FA:CCA3**

A series of 16-bit blocks containing only zeros can be expressed as a simple double colon.

**FE80::4DE1:F01B:80FA:CCA3**

↑  
Double Colon ::

Only one double colon can be used in an IPv6 address.

**FE80:0:0:0:A23D:0:0:CCA3**

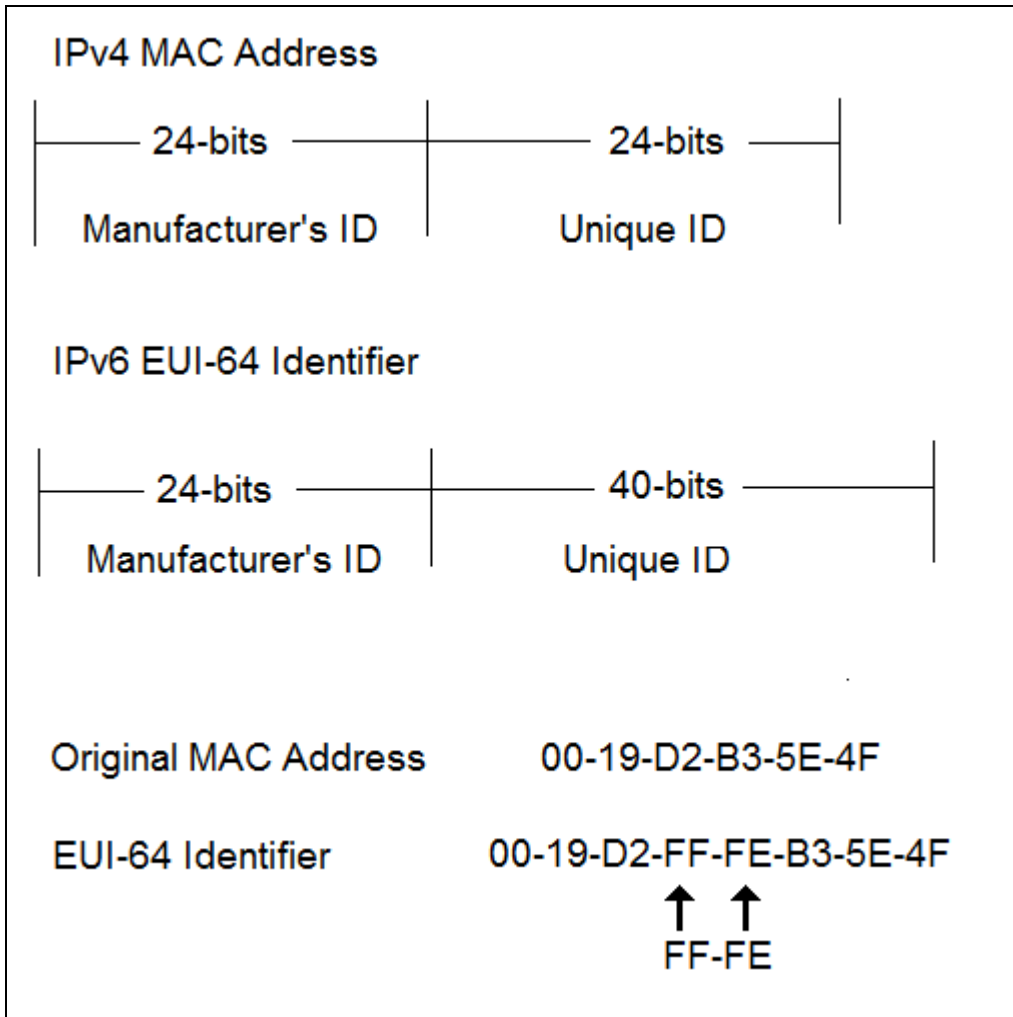
**FE80::A23D::CCA3**

↑ ↑  
Using a double colon more than once is illegal!

It is interesting to note that, with the development of the NAT protocol, the numbers of IP addresses are lasting longer than expected. By using the NAT protocol to translate private IP addresses on a home or office network, thousands, if not millions, of IP addresses are saved.

## IPv6 EUI-64 Identifiers

The original IEEE 802 MAC address consists of a 24-bit manufacturer's ID and a 24-bit unique ID associated with each network interface card. The IPv6 standard uses a 24-bit manufacturer's ID and a 40-bit unique ID to identify each network interface card. See **Figure 2** below.



**Figure 2**

The last 64-bits of an IPv6 address are the interface identifier. The interface identifier serves the same function as the IPv4 MAC address. Since the original MAC address is 48-bits and the newer IPv6 EUI-64 identifier is 64-bits, the original MAC address is modified to fit inside the 64-bit frame. The hexadecimal values "FF" and "FE" are inserted in the middle of the original 48-bit MAC address which results in a 64-bit EUI-64 identifier. For example, an original MAC address of 00-19-D2-B3-5E-4F would be expressed as 00-19-D2-FF-FE-B3-5E-4F after being converted to a EUI-64 identifier by inserting FF and FE into the center.

The EUI-64 identifiers were standard in Windows XP Service Pack 1 and later, and also in Windows Server 2003. Beginning with Windows Vista, and Server 2008, and Vista continuing in Windows 7, the EUI-64 no longer uses the original MAC address of the adapter. The EUI-64 is now randomly generated. This change was due to the fact that many people viewed the use of the MAC address incorporated into the EUI-64 as a security risk because the IPv6 address identifier portion of the IPv6 may be transmitted across the IPv6 portion of the Internet.

The use of the MAC address as part of the IPv6 address could definitively identify a computer or network device by the physical address being incorporated into the IPv6 address. For example, a network sniffer which is used to probe packets being exchanged over a network

could record all IPv6 addresses. Over time, the addresses could be associated with specific persons as they come and go from work, as well as indentify the days they leave early or are absent. Look at the **screen captures on page 6** comparing actual screen captures of a Windows 7 and Windows XP after the ipconfig/all command has been issued from the command prompt.

```

C:\Windows\system32\cmd.exe
C:\Users\Richard>ipconfig/all

Windows IP Configuration

    Host Name . . . . . : Richar7
    Primary Dns Suffix . . . . . :
    Node Type . . . . . : Hybrid
    IP Routing Enabled. . . . . : No
    WINS Proxy Enabled. . . . . : No
    DNS Suffix Search List. . . . . : hsd1.fl.comcast.net.

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix . : hsd1.fl.comcast.net.
    Description . . . . . : Intel(R) 82566DC-2 Gigabit Network Connec
tion
    Physical Address. . . . . : 00-1F-E2-57-DD-A6
    DHCP Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . . : Yes
    Link-local IPv6 Address . . . . . : fe80::55c7:254c:4bf7:712b%11(Preferred)
    IPv4 Address. . . . . : 192.168.1.100(Preferred)
    Subnet Mask . . . . . : 255.255.255.0
    Lease Obtained. . . . . : Wednesday, October 28, 2009 10:00:45 AM
    Lease Expires . . . . . : Thursday, October 29, 2009 10:00:44 AM
    Default Gateway . . . . . : 192.168.1.1
    DHCP Server . . . . . : 192.168.1.1
    DHCPv6 IAID . . . . . : 234889186
  
```

Windows Vista, Windows 7 and Server 2008 generate a random IPv6 address and does not incorporate the MAC address.

```

C:\Documents and Settings\XPMUser>ipconfig/all

Windows IP Configuration

    Host Name . . . . . : VirtualXP-15718
    Primary Dns Suffix . . . . . :
    Node Type . . . . . : Mixed
    IP Routing Enabled. . . . . : No
    WINS Proxy Enabled. . . . . : No

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix . :
    Description . . . . . : Intel 21140-Based PCI Fast Ethernet
Adapter
    Physical Address. . . . . : 00-03-FF-56-DD-A6
    Dhcp Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . . : Yes
    IP Address. . . . . : 192.168.131.67
    Subnet Mask . . . . . : 255.255.255.0
    IP Address. . . . . : fe80::203:ffff:fe56:dda6%4
    Default Gateway . . . . . : 192.168.131.254
    DHCP Server . . . . . : 192.168.131.254
    DNS Servers . . . . . : 68.87.74.166
    . . . . . : 68.87.68.166
    . . . . . : fec0:0:0:ffff::1%1
    . . . . . : fec0:0:0:ffff::2%1
    . . . . . : fec0:0:0:ffff::3%1
    Lease Obtained. . . . . : Tuesday, October 27, 2009 9:56:37 AM
    Lease Expires . . . . . : Sunday, November 01, 2026 4:45:08 AM

Tunnel adapter Teredo Tunneling Pseudo-Interface:
  
```

Windows XP incorporates the Mac address into the IPv6 address.

## Win 7 IPv6 Identifier Labeled

You can compare the Windows XP MAC address to the Windows XP IPv6 address and see how the MAC address is incorporated into the IPv6 address. When comparing the Windows 7 IPv6 address to the Windows 7 MAC address, you can see there is no similarity because they are randomly generated.

### IPv6 Topography Terminology

IPv6 introduced new terminology to redefine the network topography. The new terms are used to classify portions of an organization's network. When using IPv6 addressing an organization could subdivide the organization network into subsections using subnet masks or subnets. IPv6 does not use a separate subnet mask, but rather incorporates the same function as a subnet mask into the complete IPv6 address. IPv6 classifies the scope or range of an IPv6 address by its prefix, such as FE80 and FEC0, which performs the same function as a separate subnet mask.

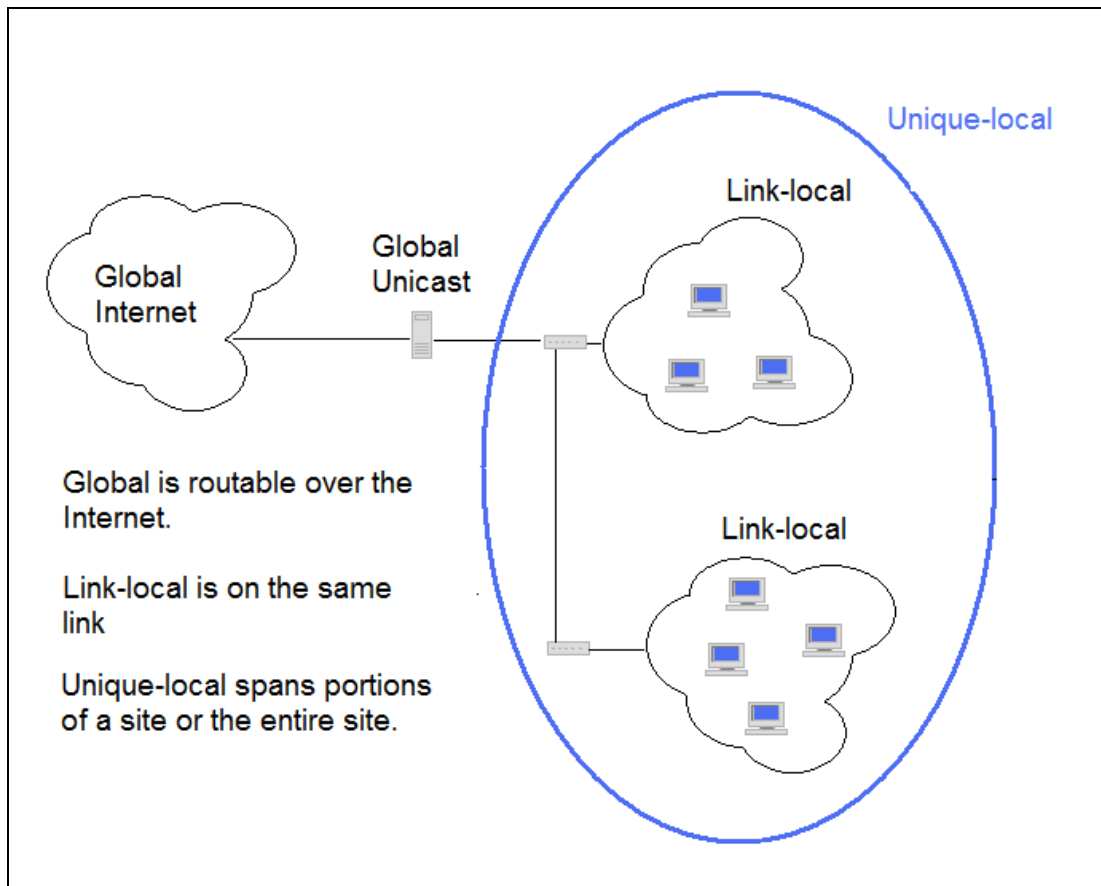
There are three terms used to describe the scope of the address, Global, Link-Local, and Unique-local. The term "unique-local" replaces the term "site-local" which was introduced earlier, but is no longer an approved term. IPv6 addresses can divide the organizational network into separate parts of the entire organization in much the same way as a separate subnet mask does for IPv4. This will limit communications to separate distinct portions of the entire network.

Unique-Local is the entire organizational site or a portion of the entire organization site. A router can forward unique local address packets to any portion of the organization site but not outside the organization network.

Link-Local is a portion of the organizational site. For example, the entire site might be the XYZ Corporation network. Within the XYZ Corporation is three smaller units such as payroll, sales, and management. Each of these three sub-units is referred to as Link-Local or portions of the entire XYZ corporation network. Routers will not forward packets with a Link-Local address, thus restricting packets to the link.

Global address is the Internet address used to identify the local network and is administered by the IANA.

Look at **Figure 3** on page 8.



**Figure 3**

\*\*The Global IPv6 address is the equivalent to the IPv4 Internet Address and can be routed.

\*\*The Link-Local IPv6 address identifies a portion of the site and is not routable.

\*\*The Unique-Local IPv6 address identifies a portion of a site or the entire site and is routable on the site, but not off the site.

The Global IPv6 serves as the Internet address and is used to communicate outside the confines of the corporation network. The site-local IPv6 address is used for the entire corporation network but not beyond the corporation network. The Link-local IPv6 address is used to limit a portion of the corporation network. The limit is bound by routers.

Note: The IEEE uses the term **interface** when describing the assignment of IPv6 addresses to a device rather than the term "node" which is commonly used to identify connections on a network. The main difference for the IEEE is the fact that a network node can only have one IP address assigned to it. In contrast to a node, an interface can have more than one IPv6 address assigned to it. This might seem like a trivial difference but look for the term as it will most likely appear on the CompTIA Network+ exam.

## Type of IPv6 Addresses

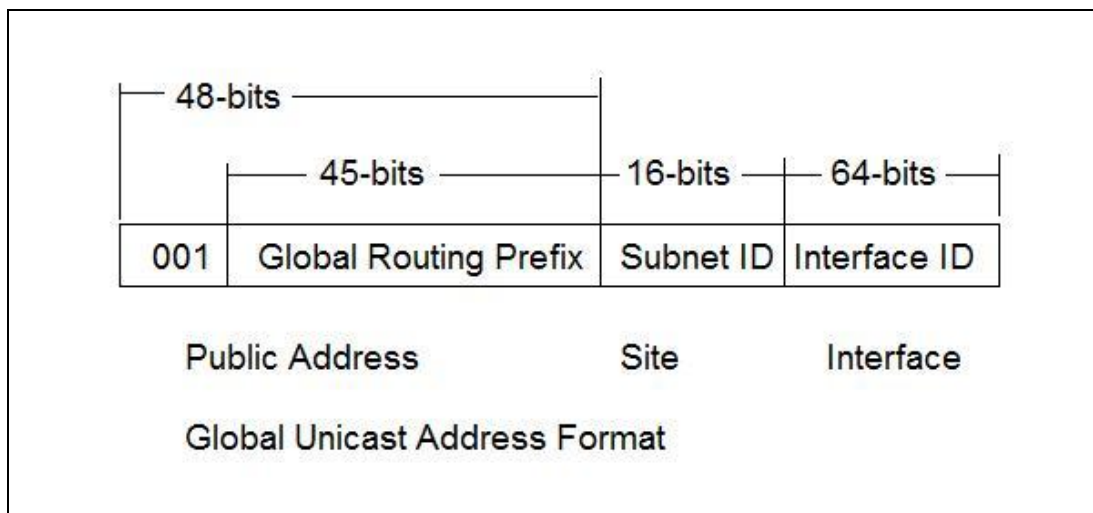
There are three broad classifications of IPv6 addresses - Unicast, Multicast, and Anycast. A Unicast address delivers packets to a single network address. A Multicast address delivers packets to multiple addresses, and is also referred to as many- to-one. Anycast delivers packets to the nearest interface and is used mainly for supporting router functions.

### Unicast Addresses

Unicast addresses are organized by scope of the address such as Global, Link-Local, Site-Local, Unique-local, and Special. Global is used for the IPv6 portion of the Internet and is similar in function as the IPv4 private IP address. Link-local is used on a local area network when there is no router or gateway available. Site-local serves the same function as local area network. The site-local can encompass part of the local area network or the entire local area network to include remote locations. Each of these Unicast address types will be now be discussed in more detail.

### Global Unicast IPv6 Address

Global Unicast IPv6 address serves the same function as IPv4 Public Addresses. A Global Unicast can broadcast to all IPv6 addresses in the IPv6 portion of the local area network, as well as to other Global IPv6 addresses across the IPv6 portion of the Internet. A Global Unicast IPv6 address is similar to an IPv4 public address. The Global Unicast address is unique and used for Internet addresses. The Global Internet address starts with 2000: or written as 2000:/3. The first three bits are set to 001. This is how an Internet address is identified and distinguished from other IPv6 addresses.



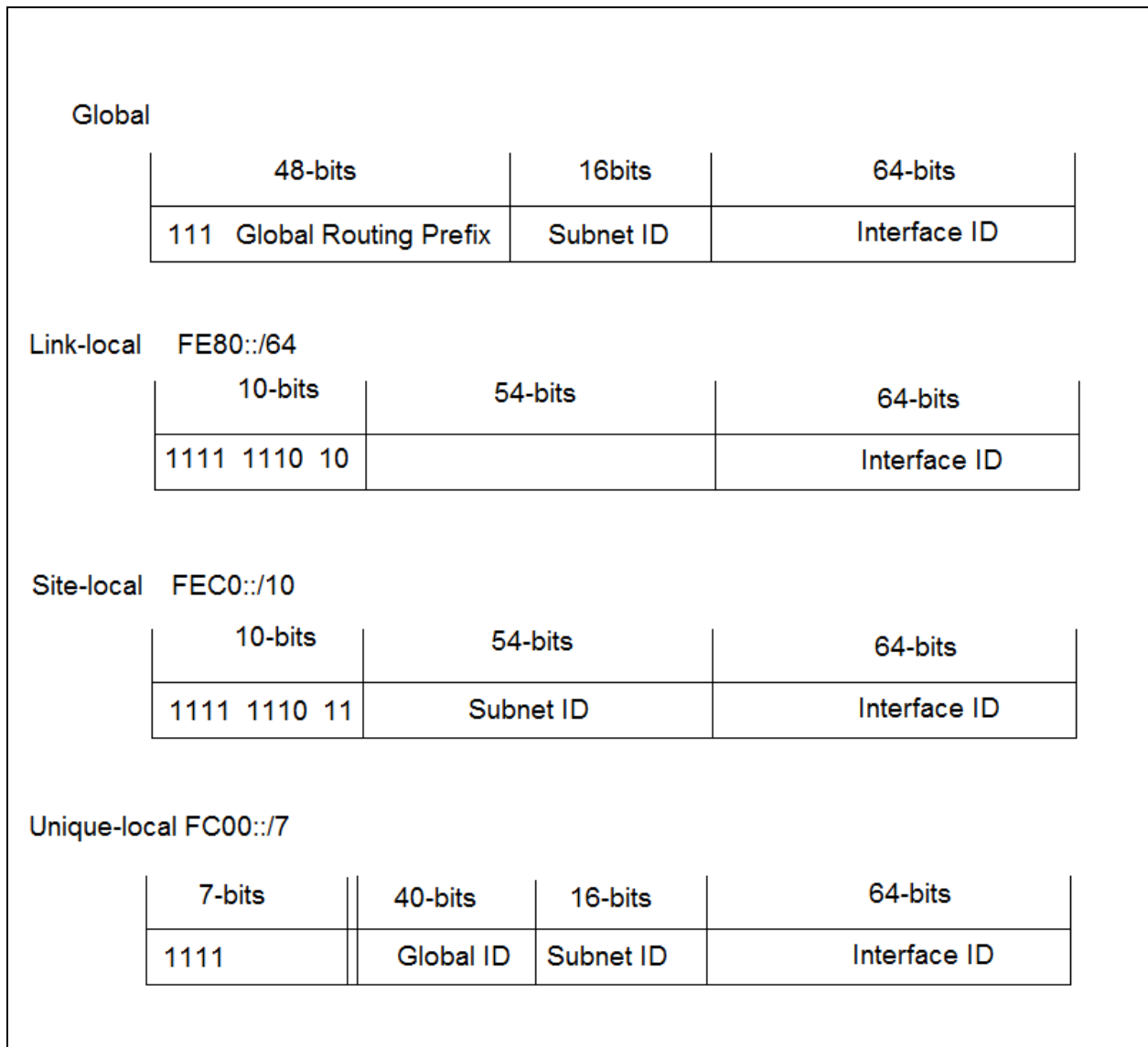
### Global Unicast Address Format

The Subnet ID is used to identify subnets or sections of a site network. The Interface ID is used to identify a specific interface or device on the subnet.



## Link-Local IPv6 Address

The Link-Local IPv6 address is used to communicate on the local area network and will not be forwarded by a router. The Link-Local addresses serve the same function as IPv4 APIPA address (169.254.xxx.xxx). The IPv6 link-Local address always starts with FE08 or FE08::/64. A Link-Local IPv6 is never forwarded beyond the local-link by an IPv6 capable router. Link-Local IPv6 addresses are automatically assigned without user intervention. Link-Local IPv6 addresses are required for the Network Discovery function. Without a Link-Local IPv6 address, Network Discovery will not function. This is why Microsoft operating systems configure a Link-Local address "FE08" automatically for network devices.



**Link Local Address Format**

Compare the Link-local, Site-local and Unique-local address format in the figure above. You will notice immediately that the link-local address does not have a subnet ID. This part of the IPv6 is usually filled with zeros (or simply ::). The Link-local address can be easily identified because it always starts with the prefix FE80. The Global, Site-local and Unique-local addresses do use a Subnet ID which makes them different from a link-local address. The subnet ID serves (in function) the same purpose as a separate subnet mask.

### Site-Local IPv6 Address

The Site-Local serves the same function as the IPv4 Public addresses (10.0.0.0, 172.16.0.0, and 192.168.0.0). Site-Local addresses always start with FEC0 or FEC0::/10. Site-Local IPv6 addresses are designed to be non-routable beyond the local area network, but are routable local-link sections of a local area network. Site-local IPv6 addresses are used for an organization with a defined geographic area such as a business, school, campus, or local area network or a portion of that organizations local area network. In contrast to Link-Local addresses, Site-Local must be assigned manually by user intervention.

### Unique-local IPv6 Address

Unique-local is a replacement for the Site-local address. Site-local is still valid, but is now considered “deprecated.” The term deprecated means that it is no longer being developed and will be replaced by Unique-local address. It is not automatically generated, and it has to be manually assigned. The Unique-local serves the same function as the Site-local address. The Unique-local address can represent the entire local area network or just a portion. The Unique-local address can also represent multiple locations, such as New York and Chicago, as long as the two locations are members of the same network. When you compare the site-local address to the unique-local address you see that a global ID is assigned to the address as well as a subnet ID. The unique-local address is easily identified by the prefix FC00.

**Note:** You will see the Unique-local address expressed as FC00::/7 or FC00::/8. The correct version is FC00/7. What has happened here, is the fact that there is a single bit that follows the first 7 bits of the unique-local address. This single bit is always set to binary 1, which results in the address being expressed as FC00::/8.

### IPv6 Loopback Address

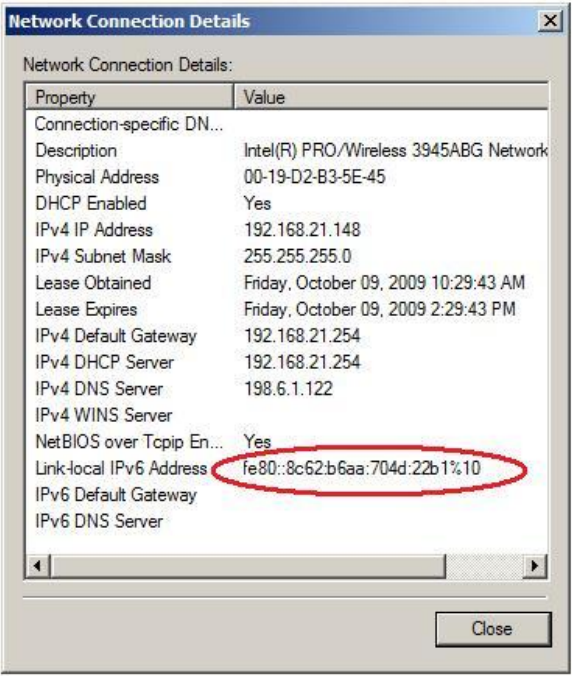
The IPv6 **loopback address** is the reserved IP address of the network interface card. It is used to test if an IP address is configured for the network interface card as well as test to see that the network interface card is functioning normally. The loopback address for IPv4 is 127.0.0.1. The loopback address for IPv6 is 0:0:0:0:0:0:0:1 (or ::1). Note that the double colon eliminates fields containing only zeros.

## IPv6 Unspecified Address

The IPv6 unspecified address is 0:0:0:0:0:0:0:0:, or simply a double colon :: to represent a string of zeros. It is the equivalent of the IPv4 address 0.0.0.0. The unspecified address is used when an interface is checking for its own duplicate address during the initial connection to the network. Because the identifier is randomly generated there is a possibility that two devices could have the same identifier. When a device first comes on the network, it identifies itself with an all zero address and looks to see if its own random address has already been assigned to another device. If no other device is using an address that matches the random address, then the randomly generated address will be used.

## Zone IDs for Local-Use Addresses

Zone IDs are used for Local-Use Addresses to indicate which zone on a local area network an IPv6 Site-Local address is used. Local-Use IPv6 addresses can be used more than once to identify computers connected on different zones within the same geographic local area network. Zone IDs are indicated by a percentage sign. Look at the screen capture below to see how a zone ID appears in the IPv6 address.



The screenshot shows a 'Network Connection Details' window with a table of properties and values. The 'Link-local IPv6 Address' property is circled in red, showing the value 'fe80::8c62:b6aa:704d:22b1%10'. To the right of the screenshot, text explains that 'fe80' indicates a Link-Local IPv6 address and '%10' indicates the Zone ID.

Property	Value
Connection-specific DN...	
Description	Intel(R) PRO/Wireless 3945ABG Network
Physical Address	00-19-D2-B3-5E-45
DHCP Enabled	Yes
IPv4 IP Address	192.168.21.148
IPv4 Subnet Mask	255.255.255.0
Lease Obtained	Friday, October 09, 2009 10:29:43 AM
Lease Expires	Friday, October 09, 2009 2:29:43 PM
IPv4 Default Gateway	192.168.21.254
IPv4 DHCP Server	192.168.21.254
IPv4 DNS Server	198.6.1.122
IPv4 WINS Server	
NetBIOS over Tcpip En...	Yes
Link-local IPv6 Address	fe80::8c62:b6aa:704d:22b1%10
IPv6 Default Gateway	
IPv6 DNS Server	

Link-Local IPv6 indicated by fe80  
Zone ID indicated by %10

## IPv6 Local Link Labeled

Zone ID is also referred to as a Scope ID. Numeric values used for the zone ID are selected by the sending network device and not the receiving network device. It is possible for a single computer to be identified by more than one zone ID.

## IPv6 Lifetimes

IPv4 addresses are leased for a definitive period of time. IPv6 addresses are configured with two lifetime values - a *valid* lifetime and a *preferred* lifetime. Valid lifetime is typically a week, while a preferred lifetime is one day. A valid lifetime has been validated by a router, and it can send and receive Unicast messages. A preferred life time is the period of time in which an interface can start new communication sessions.

## IPv6 Prefixes

An IPv6 prefix is the portion of the address that has a fixed value used to inform network devices as to what action to take concerning the packet based on the address prefix. For example FF00::/8 is a prefix indicating a multicast address.

Prefixes for IP addresses may be expressed using Class/less Inter-Domain Routing (CIDR), which is used to indicate what portion of the network IP address represents the subnet or network address. CIDR will be covered in much more detail in the next chapter. IPV6 has been designed not to use a separate subnet mask, but it does use a prefix which serves the same purpose as the IPv4 subnet mask. The IPv6 prefix is expressed as address/prefix for example FE80::/64 which mean that the first 64-bits represent the network address. You will see IPv6 addresses expressed in both forms, the entire IPv6 address or the CIDR when all that is really important to emphasize is the prefix.

Prefix	Address Type
2000::/3	Global Unicast
FE80::/10	Link-local Unicast
FC08::/10	Site-local Unicast
FD08::/8	Unique-local Unicast
FF00::/8	Multicast
FF01::1	Interface multicast local all nodes
FF02::1	Link-local multicast all nodes
FF01::2	Interface-local multicast all routers
FF02::2	Link-local multicast all routers
FF05::2	Site-local multicast all routers

**Common IPv6 Address Prefixes**

## Common IPv6 Multicast Address Prefixes

To see more a much more complete list of multicast IPv6 address prefixes look at the IANA organization website. <http://www.iana.org/assignments/ipv6-multicast-addresses/>

For more information on IANA IPV6 address use the following <http://www.iana.org/assignments/ipv6-address-space/>

### Comparison Chart for IPv4 and IPv6

IPv4	IPv6
32-bit / 4 byte address	128-bit / 16 byte address
ARP broadcast to discover nodes.	Network discovery replaces ARP.
Uses regular broadcasts to all nodes on local area network.	Replaces broadcasts with multicast to specific nodes.
Addresses are configured manually or through DHCP.	DHCP and or manual configuration is not required. IPv6 is configured automatically by computer.
IPsec optional	IPsec mandatory
Uses decimal numbers for address consisting of 0-255	Uses hexadecimal numbers consisting of 00 – FF
Uses a subnet mask to identify the network and host portions of an IPv4 address.	Does not use a separate subnet mask. Uses a prefix which provides similar function.
Assigned a single IPv4 address per single network adapter.	Can have more than one IPv6 address assigned to a single network adapter.

### IPv6 Transition Technologies

There are several technologies used to help in the transition from IPv4 to IPv6. Three of these technologies are **Teredo**, **6to4**, and **ISATAP**. These technologies are intended to be temporary until IPv6 is fully implemented and IPv4 is fully depreciated.

#### 6to4

The 6to4 address technology is designed to support network-to-network communications between routers. 6to4 solves compatibility issues between IPv6 and IPv4 addresses. For example; the IPv4 address 134.175.27.10 would be displayed as a 6 to 4 IPv6 address as 2002:86AF:1B0A. Each set of IPv4 decimal numbers is converted to IPv6 Hexadecimal pairs.

Hex 86 = Decimal 134

Hex AF = Decimal 175

Hex 1B = Decimal 27

Hex 0A = Decimal 10

Hex IPv6 identifier address 86AF:1B0A = Decimal IPv4 134.175.27.10

The IPv6 Unicast 6to4 address always starts with 2002 or is represented by 2002::/16. The Global address is followed by a subnet ID and finally an interface ID. Look at the example below.

## **Sample Global Site Prefix:Subnet ID:Interface ID**

2002::WWXX:YYZZ

where WWXX:YYZZ corresponds to the original IPv4 address.

Octet 1 = WW; octet 2 = XX; octet 3 = YY; octet 4 = ZZ.

thus 2002::86AF:1B0A is equal to IPv4 address 134.175.27.10.F

6to4 is designed for router-to-router communication. In other words, for a 6to4 packet to be forwarded to another link in a network. A router must be designed to support 6to4 in order to be able to forward 6to4 packets.

## **ISATAP**

Intra-Site Automatic Tunneling Address Protocol (ISATAP) was developed jointly by Microsoft and Cisco Systems. ISATAP is designed to tunnel IPv6 addresses inside existing IPv4 packets at the link layer. ISATAP is designed as a node-to-node or node-to-router technology for existing IPv4 network devices without the need to upgrade network devices.

ISATAP is used to support Neighbor Discovery to identify computers and network devices, such as local routers. The main advantage of ISATAP over 6to4 is the fact that ISATAP is used to discover routers using the ICMPv6 protocol. ISATAP has been implemented in all versions of Windows, since Windows XP and server 2003.

## **Teredo**

Teredo is configured by default in Windows Vista, Windows 7, and is considered a last-resort technology when ISATAP cannot be used. Teredo functions as a network address translator similar to the NAT protocol. NAT devices are used to convert an IPv4 Internet site address to one or more private addresses. 6to4 requires a 6to4-enabled router at the edge of the network system that connects to the Internet while Teredo does not. Teredo creates a tunnel in similar fashion to 6to4 and allows incoming IPv6 traffic through a firewall designed for IPv4. This is especially important for small office systems and homes that use a router/gateway firewall system. Teredo was first implemented by Microsoft Windows XP after Service Pack 1 and has been continually refined.

You will see a reference to “automatic tunneling pseudo interface” and or reference to “tunneling” when you issue a “ipconfig/all” command on a Windows Vista or later computer.

## **Multicast Address**

A broadcast address sends packets to all network addresses, while a multicast sends packets to specific set of addresses. IPv4 uses broadcast and multicast addresses to distribute packets. IPv6 uses multicast addresses and does not use broadcast addresses. Multicast addressing is used for topology discovery, gateway discovery, and group discovery. A computer or network device can announce its presence to other computers and devices on the local-link using a

multicast address. For example, an IPv6 address with the prefix of FF02 is used to distribute a packet to all computers on a link-local.

The Link-layer Multicast Name Resolution (LLMNR) protocol uses both IPv4 and IPv6 for name resolution through multicast. The IPv4 multicast destination address is 224.0.0.252. The IPv6 multicast destination address is FF02::1:3. These two multicast addresses will not be forwarded by a router thus limiting the broadcast to the local-link. These two multicast destination addresses are used by the Link-layer Multicast Name Resolution protocol. LLMNR protocol is used by Windows Vista, Windows 7, and Server 2008 for name resolution using the multicast addresses in addition to NetBIOS Name Service (NBNS) protocol.

To learn much more about IPv6 please visit the Microsoft website at <http://technet.microsoft.com/en-us/network/bb530961.aspx> or conduct a web search using the key terms "TechNet Microsoft IPv6".

### **Keys Points Concerning 6to4, ISATAP, and Teredo**

6to4 is designed as a router-to-router tunneling address technology for connecting IPv6 host and sites across the IPv4 Internet.

ISATAP is designed as a host-to-host and host-router technology supporting Unicast IPv6 tunneling over an IPv4 network.

Teredo is designed to support IPv6 tunneling across the IPv4 Intranet when hosts are located behind a network address translator (NAT) device.

### **Windows XP and IPv6**

IPv6 is not configured by default in Windows XP. To install IPv6 simply type and enter "***ipv6 install***" from the command prompt. To remove IPv6 type and enter "***ipv6 uninstall***" from the command prompt. Windows XP uses Ping6.exe and Tracert6.exe from the command prompt to ping and trace the route of an IPv6 address.

Windows XP incorporated the MAC address directly into the IPv6. Now, a randomly generated number is used in place of the MAC address for the interface portion of the IPv6 address. Microsoft offers advanced support for Windows XP and IPv6. You can download the "Advanced Networking Pack for Windows XP" from the Microsoft website for free. It consists of a software package with complete Windows XP support for the latest IPv6 protocols and technologies.

### **Duplicate IPv4**

A static IP address is configured manually rather than using a DHCP server to automatically issue an IPv4 address to a workstation. You cannot manually configure a duplicate IPv4

address. Windows Vista and Windows XP will generate a warning message and will not allow you to complete the task of configuring a duplicate IPv4 addresses. Windows 7 will not generate a warning, but will automatically assign an Automatic Private IP Address (APIPA) which is an IPv4 address that starts with 169.254. A duplicate IPv4 address is not a concern when IPv6 is configured by default because all exchanges of packets are performed on the Link-local section of a network by using IPv6 addresses.

## **Disabling IPv6**

IPv6 is configured by default in Windows Vista, and Windows 7 as well as Server 2008. You can disable IPv6 through the Network Connection Properties dialog box. Some administrators may be tempted to disable IPv6 because they feel that the network will be overloaded by the fact that they are exchanging both IPv4 and IPv6 packets across the network. Most exchanges of packets in the Link-local part of the network are duplicate functions of IPv4 and IPv6.

Microsoft has designed several features that take advantage of IPv6 and these features will be adversely affected by disabling IPv6. Some of the new Windows 7 features depend on IPv6 are "HomeGroup" and "Direct Access," as well as some earlier features such as "Remote Assistance", "Windows Mail" and "Network Discovery".

Most modern networks, both home and office are using network adapters that are rated at 100MB and higher, and these can easily handle the increase in network traffic without adversely affecting the network.

Although not fully implemented yet, **IPv6 is here to stay.**



## Summary

- The three broad classifications of IPv6 addresses are Unicast, Multicast, and Anycast.
- Site-local IPv6 addresses always start with FEC0 and are routable .
- Link-Local IPv6 addresses always start with FE80 and are non-routable.
- Unique-local IPv6 address begin with “fd00” and are routable only within the private network.
- Unicast 6to4 addresses are used to support communication between IPv6 and IPv4 addresses on an IPv4 network system.
- The first half of a unicast address is the network identifier and the second half is the interface identifier.
- Unicast 6to4 always starts with 2002:.
- Four advantages of IPv6 are: a larger pool of Internet addresses, better security through mandatory IPsec, better quality of service, and reduced number of network broadcasts.
- IPv6 does not use a subnet mask.
- IPv6 uses an interface identifier the same way IPv4 uses a MAC address.
- IPv6 interfaces identifiers are now randomly generated.
- Link-layer Multicast Name Resolution (LLMNR) protocol uses both IPv4 and IPv6 for name resolution through multicast.
- A single network adapter can have more than one IPv6 address assigned.

### Websites For More Information About IPv6.

Microsoft TechNet website provides a rich assortment of information about IPv6 at the following address. <http://technet.microsoft.com/en-us/network/bb530961.aspx> or conduct a search using the keywords “Microsoft TechNet IPv6 ” or “bb530961”.

IANA organization for assignment of IP addresses both IPv4 and IPv6.  
<http://www.iana.org/numbers/>

3COM PDF file Understanding IP Addresses; Everything You Ever Want to Know. (76 Pages in PDF format) [http://www.3com.com/other/pdfs/infra/corpinfo/en\\_US/501302.pdf](http://www.3com.com/other/pdfs/infra/corpinfo/en_US/501302.pdf) or use key terms “ 3com Understanding IP Addresses” in your search.

## Review Questions

1. What are the three broad classifications of IPv6 addresses?
2. Which IPv6 address type is similar in function to the IPv4 public addresses?
3. Which IPv6 address type serves the same function as IPv4 APIPA?
4. How is a MAC address converted to a EUI 64-bit address?
5. How many bytes are represented by an IPv6 address?
6. How many bits are represented by an IPv6 address?
7. How many bytes are represented by an IPv4 address?
8. How many bits are represented by an IPv4 address?
9. What type of numbers is used to compose an IPv6 address?
10. What special character is used to separate the sections of an IPv6 address?
11. How was the original EUI-64 identifier created from an existing MAC address?
12. How is the EUI-64 identifier generated today?
13. Which IPv6 address type fills the subnet portion of the address with all zeros?
14. Which operating systems configure IPv6 by default?
15. A small section of a local area network limited by a router is referred to \_\_\_\_\_ in IPv6 terminology?
16. Which type of IPv6 address is the equivalent to an IPv4 Internet public address?
17. What is the prefix for an IPv6 link-local address?
18. Which operating systems, first, randomly generate the interface identifier used in IPv6?
19. What is the loopback for IPv6?
20. What is the purpose of LLMNR?
21. What is the LLMNR multicast destination addresses for IPv6?
22. What is the LLMNR multicast destination address for IPv4?
23. What are the three transition technologies used to implement IPv6?
24. What will happen if you disable IPv6?

## Review Questions Answers

1. What are the three broad classifications of IPv6 addresses? **Unicast, Multicast, and Anycast.**
2. Which IPv6 address type is similar in function to the IPv4 public addresses? **Global Unicast**
3. Which IPv6 address type serves the same function as IPv4 APIPA? **The Link-Local addresses serve the same function as IPv4 APIPA address.**
4. How is a MAC address converted to an EUI 64-bit address? **Insert FFFE into the middle of the MAC address and it becomes the interface identifier.**
5. How many bytes are represented by an IPv6 address? **16 bytes.**
6. How many bits are represented by an IPv6 address? **128 bits.**
7. How many bytes are represented by an IPv4 address? **4 bytes.**
8. How many bits are represented by an IPv4 address? **32 bits.**
9. What type of numbers is used to compose an IPv6 address? **Hexadecimal.**
10. What special character is used to separate the sections of an IPv6 address? **The colon ":".**
11. How was the original EUI-64 identifier created from an existing MAC address? **By inserting FF and FE into the center of the MAC address.**
12. How is the EUI-64 identifier generated today? **Randomized.**
13. Which IPv6 address type fills the subnet portion of the address with all zeros? **Link-local.**
14. Which operating systems configure IPv6 by default? **Windows Vista, Windows 7, and Server 2008.**
15. A small section of a local area network limited by a router referred \_\_\_\_\_ to in IPv6 terminology? **The link-local.**
16. Which type of IPv6 address is the equivalent to an IPv4 Internet public address? **Global.**
17. What is the prefix for an IPv6 link-local address? **Fe80.**
18. Which operating systems first randomly generate the interface identifier used in IPv6? **Windows Vista, Windows 7, and Server 2008.**
19. What is the loopback for IPv6? **Ping ::1**
20. What is the purpose of LLMNR? **LLMNR protocol is used by Windows Vista, Windows 7, and Server 2008 for name resolution using the multicast addresses.**
21. What is the LLMNR multicast destination addresses for IPv6? **"FF02::1:3".**
22. What is the LLMNR multicast destination address for IPv4? **224.0.0.252.**
23. What are the three transition technologies used to implement IPv6? **Teredo, 6to4, and ISATAP.**
24. What will happen if you disable IPv6? **Some services will no longer work correctly, such as HomeGroup, Direct Access, Remote Assistance, Windows Mail, and Network Discovery.**

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