ESCOLA
SUPERIOR
DE TECNOLOGIA
E GESTÃO

P.PORTO

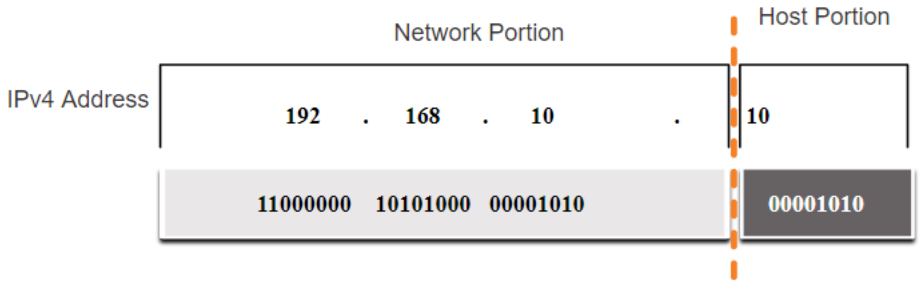
REDES DE COMPUTADORES I – Endereçamento IP

Sumário

1. IPv4 subnetting
2. IPv6 concepts
3. Virtual IP (VIP)
4. Subinterfaces

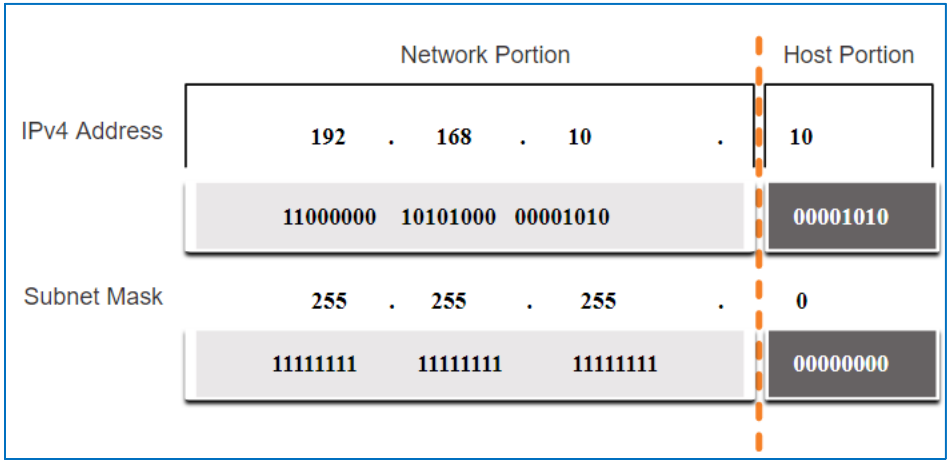
Subnetting

- Subnetting is the process of dividing a larger IP (Internet Protocol) network into smaller, more manageable subnetworks, also known as subnets. It's a crucial part of IP addressing and network management, as it allows organizations to optimize their network performance, security, and control.



Subnetting

- Subnet Mask



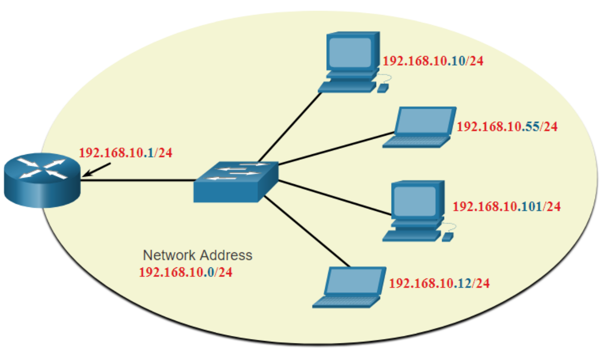
Subnetting

- Prefix Length

Subnet Mask	32-bit Address	Prefix Length
255.0.0.0	11111111.00000000.00000000.00000000	/8
255.255.0.0	11111111.11111111.00000000.00000000	/16
255.255.255.0	11111111.11111111.11111111.00000000	/24
255.255.255.128	11111111.11111111.11111111.10000000	/25
255.255.255.192	11111111.11111111.11111111.11000000	/26
255.255.255.224	11111111.11111111.11111111.11100000	/27
255.255.255.240	11111111.11111111.11111111.11110000	/28
255.255.255.248	11111111.11111111.11111111.11111000	/29
255.255.255.252	11111111.11111111.11111111.11111100	/30

Subnetting

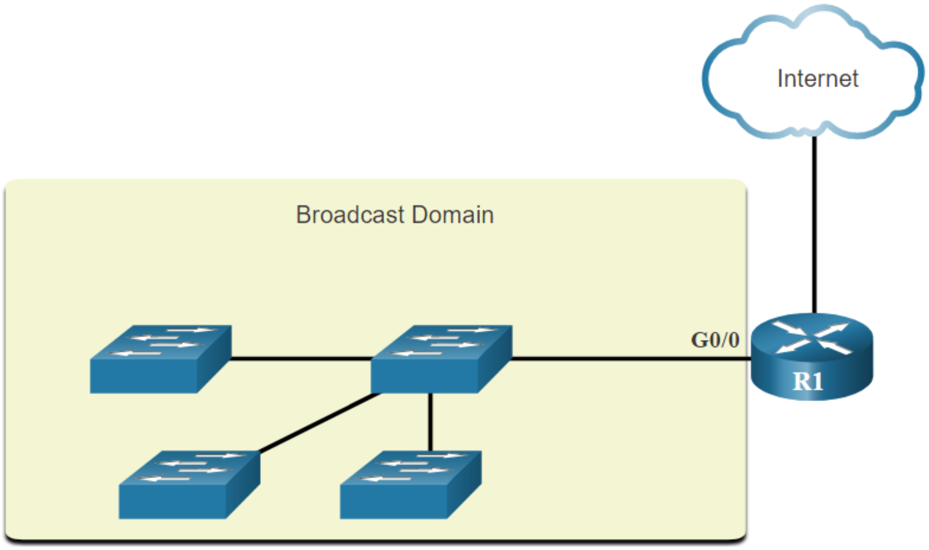
- Network, Host, and Broadcast Addresses



	Network Portion			Host Portion	Host Bits
Subnet mask 255.255.255.0 or /24	255 11111111	255 11111111	255 11111111	0 00000000	
Network address 192.168.10.0 or /24	192 11000000	168 10100000	10 00001010	0 00000000	All 0s
First address 192.168.10.1 or /24	192 11000000	168 10100000	10 00001010	1 00000001	All 0s and a 1
Last address 192.168.10.254 or /24	192 11000000	168 10100000	10 00001010	254 11111110	All 1s and a 0
Broadcast address 192.168.10.255 or /24	192 11000000	168 10100000	10 00001010	255 11111111	All 1s

Purpose of Subnetting

- Broadcast Domains



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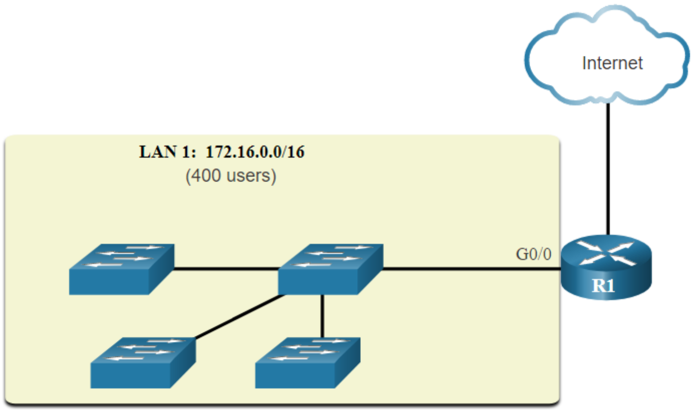

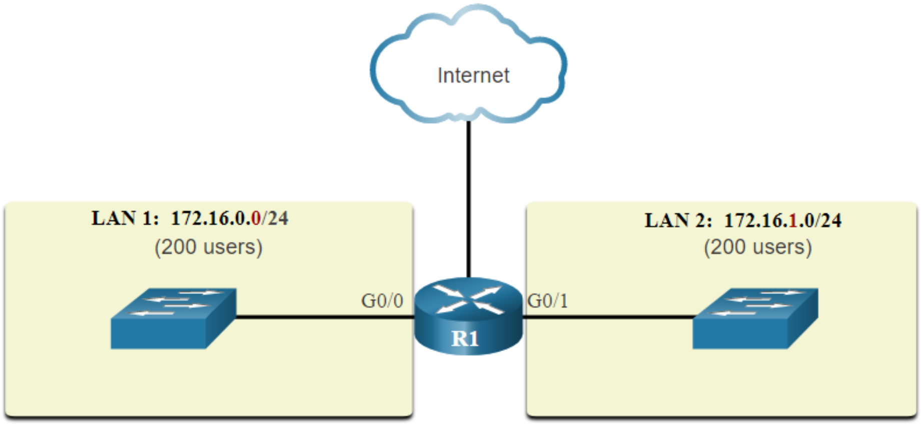

Purpose of Subnetting

- Improved network performance
- Enhanced Security
- Easier network management
- Efficient IP address utilization
- Scalability
- Organized network hierarchy
- Network isolation for different departments or functions

Purpose of Subnetting

Address Class	Assignable IP Addresses
Class A	16,777,214 (2^{24}–2)
Class B	65,534 (2^{16}–2)
Class C	254 (2^{8}–2)

Purpose of Subnetting

- variable-length subnet masking (VLSM) The process of assigning various subnetwork IDs in a network to issue the appropriate number of IP addresses.

Subnet Octet Value	Number of Contiguous Left-Justified Ones
0	0
128	1
192	2
224	3
240	4
248	5
252	6
254	7
255	8

Purpose of Subnetting

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252	6
254	7
255	8

LAB

- Subnet an IPv4 Network
  - 11.5.5 Packet Tracer – Subnet an IPv4 Network

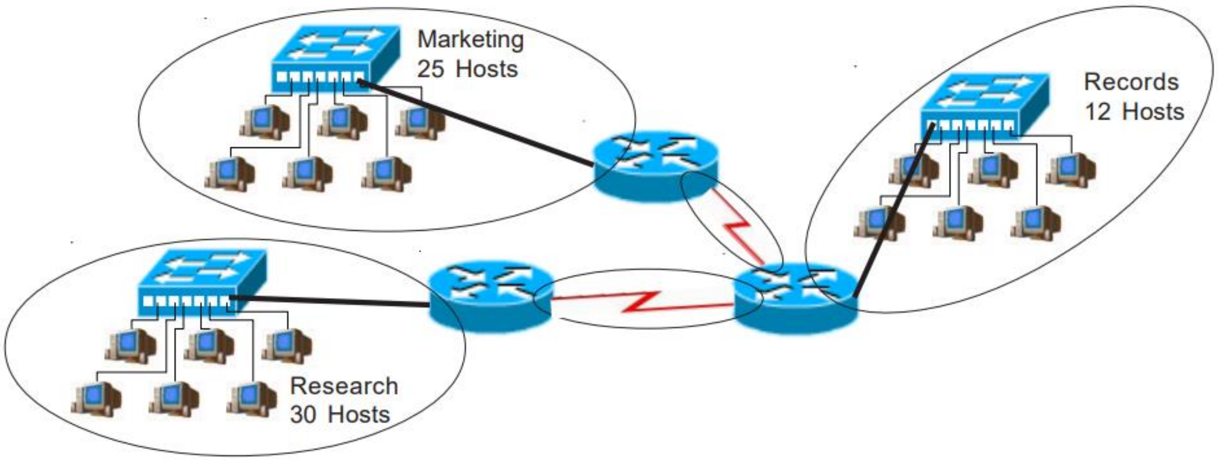
Calculating the Number of Created Subnets

- **borrowed bits** Bits added to a classful subnet mask
- Number of created subnets = 2^S
  - Calculating the Number of Available Hosts = 2^H-2

Borrowed Bits	Number of Subnets Created (2^s, Where ***s*** Is the Number of Borrowed Bits)
0	1
1	2
2	4
3	8
4	16

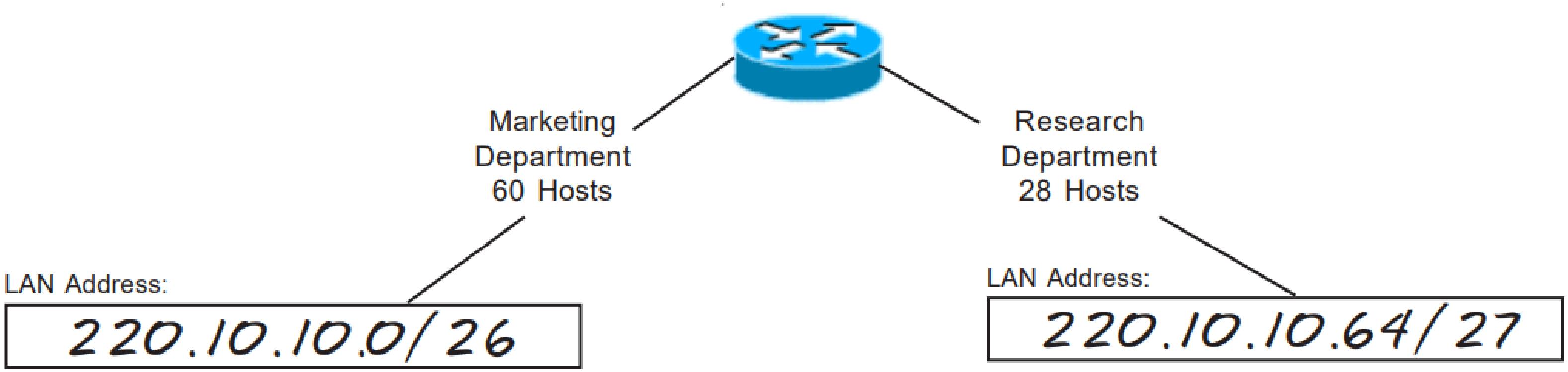
Exercise

- IP Address: 192.168.1.0
- five subnets
- two containing 30 hosts, one containing 12 hosts, and two serial connections that only req
- uire two usable addresses each



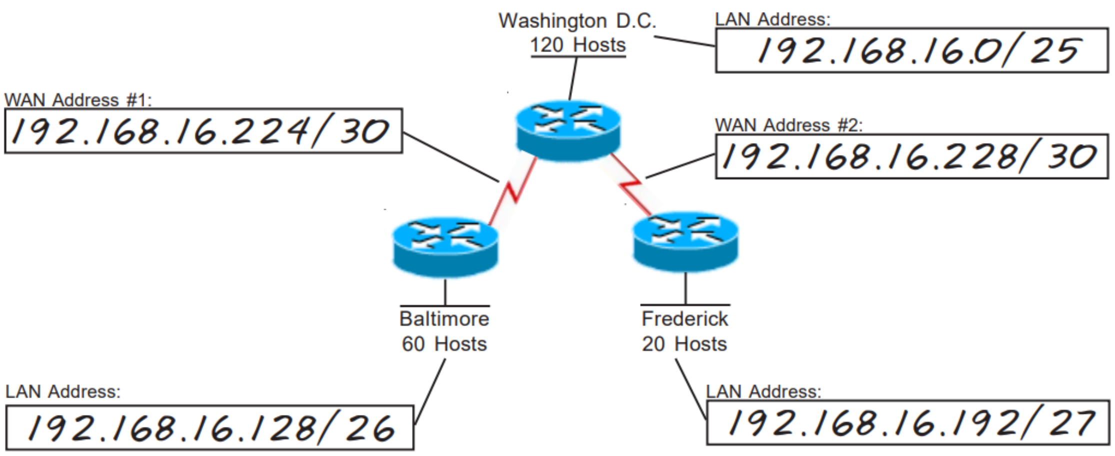
Exercise

- class C address 220.10.10.0



Exercise

- class C address 192.168.16.0

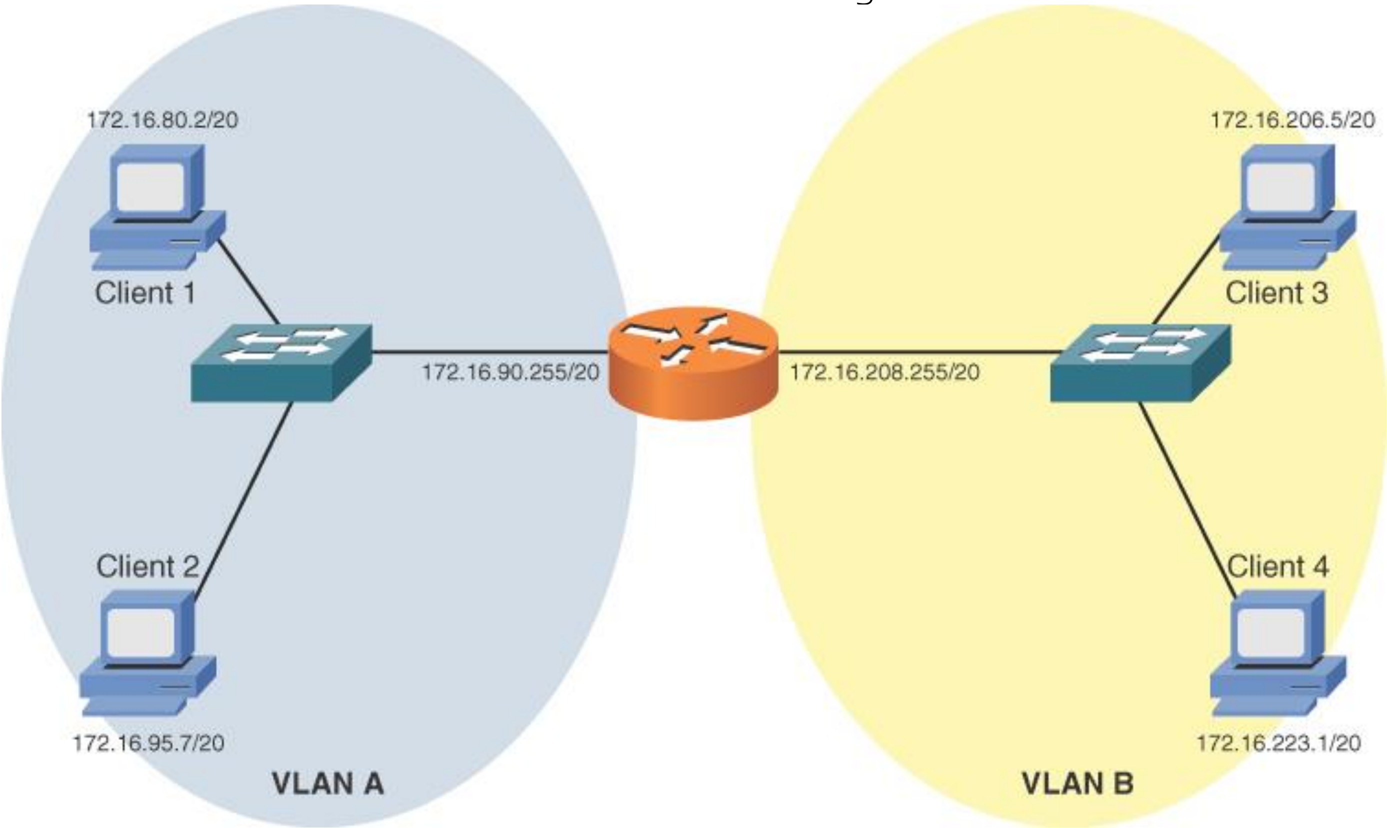


LAB

- Subnet an IPv4 Network
  - 11.7.5 Packet Tracer – Subnetting Scenario
  - 11.9.3 Packet Tracer – VLSM Design and Implementation Practice
  - 11.10.1 Packet Tracer – Design and Implement a VLSM Addressing Scheme

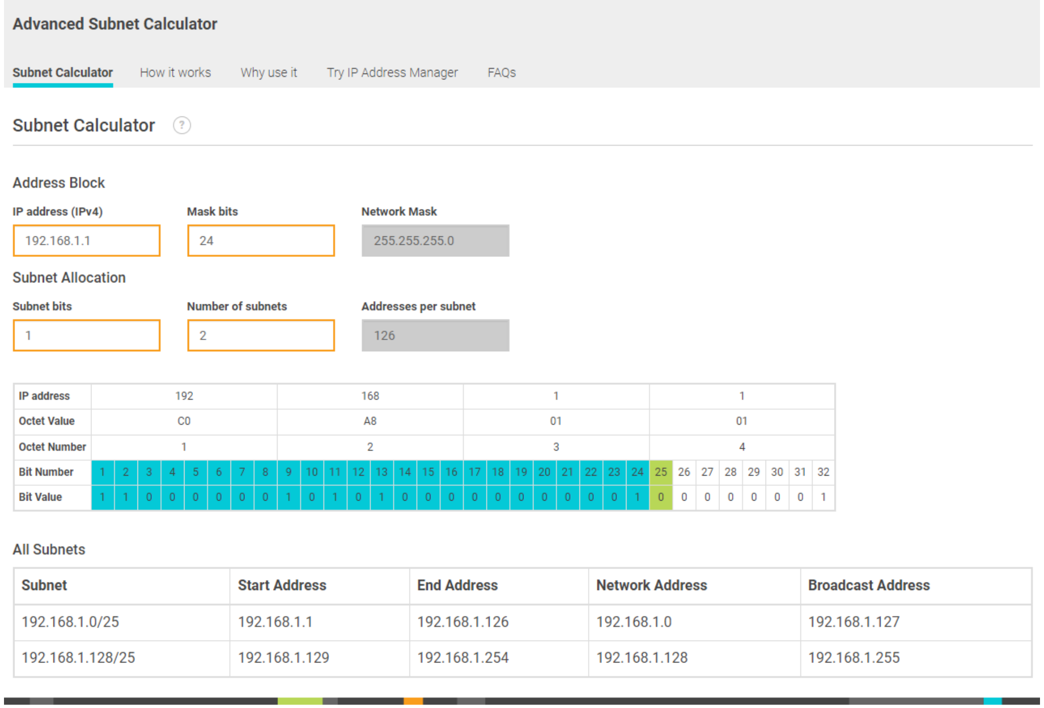
Exercise

- 172.16.0.0/16 network is subnetted using a 20-bit subnet mask. Notice that two VLANs (two subnets) are configured; however, one of the client PCs is assigned an IP address that is not in that PC's VLAN. Which client PC is assigned an incorrect IP address?



Online Subnet Calculator

- https://www.solarwinds.com/free-tools/advanced-subnet-calculator



Advanced Subnet Calculator

Subnet Calculator | How it works | Why use it | Try IP Address Manager | FAQs

Subnet Calculator

Address Block

IP address (IPv4): 192.168.1.1
Mask bits: 24
Network Mask: 255.255.255.0

Subnet Allocation

Subnet bits: 1
Number of subnets: 2
Addresses per subnet: 126

IP address	192	168	1	1
Octet Value	C0	A8	01	01
Octet Number	1	2	3	4

Bit Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit Value	1	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

All Subnets

Subnet	Start Address	End Address	Network Address	Broadcast Address
192.168.1.0/25	192.168.1.1	192.168.1.126	192.168.1.0	192.168.1.127
192.168.1.128/25	192.168.1.129	192.168.1.254	192.168.1.128	192.168.1.255

Classless Interdomain Routing

- classless interdomain routing (CIDR) A process that involves shortening a classful subnet mask by removing right-justified 1s from a classful mask. As a result, CIDR allows contiguous classful networks to be aggregated. This process is sometimes called route aggregation.
  - 192.168.32.0/24
  - 192.168.33.0/24
  - 192.168.34.0/24
  - 192.168.35.0/24

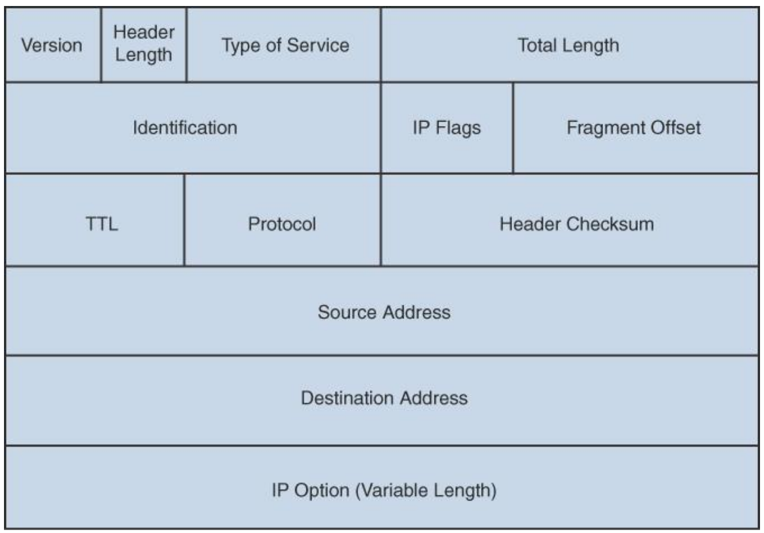
Network Address	1st Octet	2nd Octet	3rd Octet	4th Octet
192.168.32.0	11000000	10101000	001000 00	00000000
192.168.33.0	11000000	10101000	001000 01	00000000
192.168.34.0	11000000	10101000	001000 10	00000000
192.168.35.0	11000000	10101000	001000 11	00000000

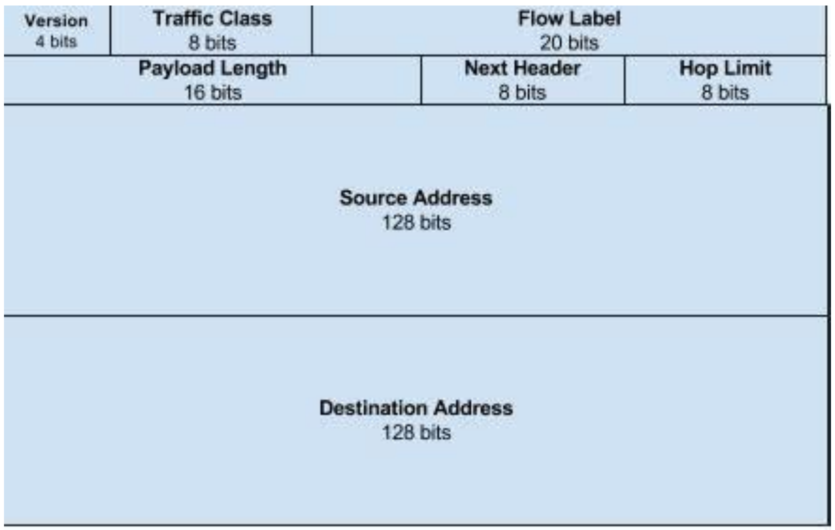
All Networks Have 22 Bits in Common

IP Version 6

- IPv4 is running out of addresses.
- IPv6 also included fixes for IPv4 limitations and other enhancements
- limited IPv4 address space, issues with NAT and the IoT
- IPv6 addresses are 128 bits in length and written in hexadecimal
- Simplified header:
    - The IPv4 header uses 12 fields.
    - The IPv6 header uses 5 fields.
- No broadcasts
- No fragmentation (performs MTU discovery for each session)
- Can coexist with IPv4 during a transition:
    - Dual stack (running IPv4 and IPv6 simultaneously on a network interface or device)
    - IPv6 over IPv4 (tunneling IPv6 over an IPv4 tunnel)

IP Version 6


Version
Header Length
Type of Service
Total Length
Identification
IP Flags
Fragment Offset
TTL
Protocol
Header Checksum
Source Address
Destination Address
IP Option (Variable Length)


Version
4 bits
Traffic Class
8 bits
Flow Label
20 bits
Payload Length
16 bits
Next Header
8 bits
Hop Limit
8 bits
Source Address
128 bits
Destination Address
128 bits

IP Version 6

- IPv6 Address Structure

  XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX

  4 bits per digit × 4 digits per field × 8 fields = 128 bits in an IPv6 address

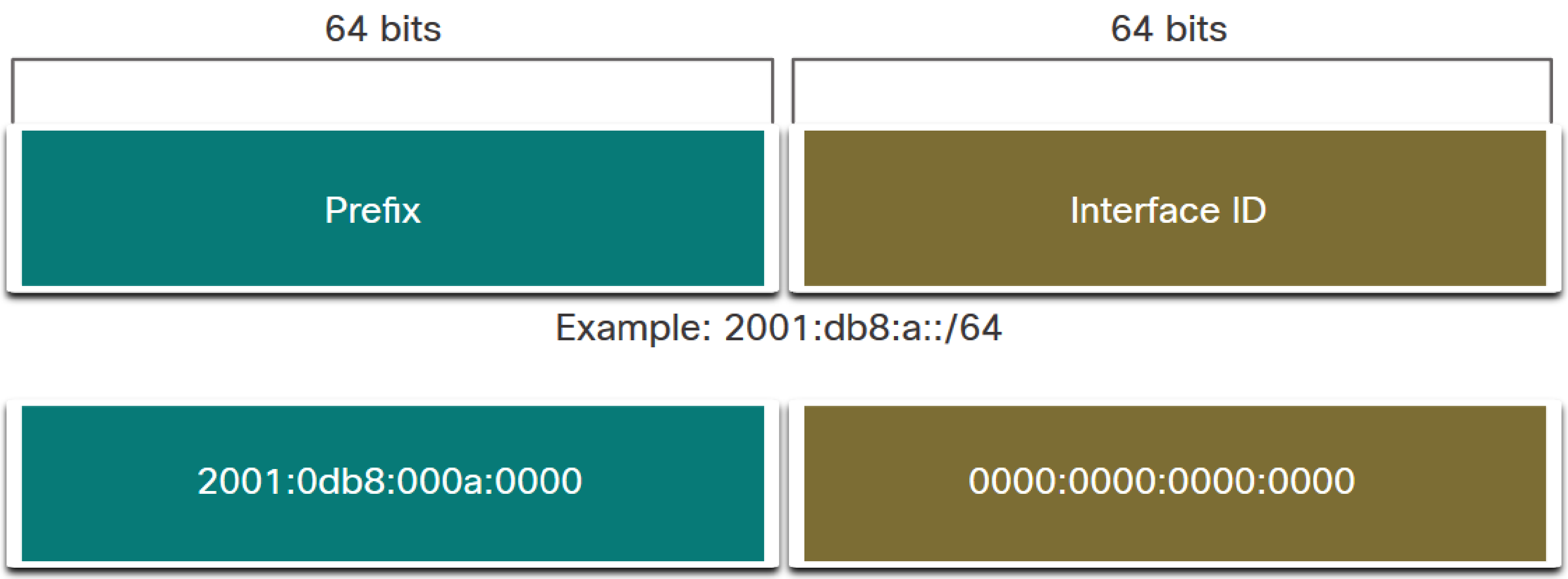
1. Leading 0s in a field can be omitted.
2. Contiguous fields containing all 0s can be represented with a double colon. (Note that this can be done only once for a single IPv6 address.)

   For example, consider the following IPv6 address:

   ABCD:0123:4040:0000:0000:0000:000A:000B

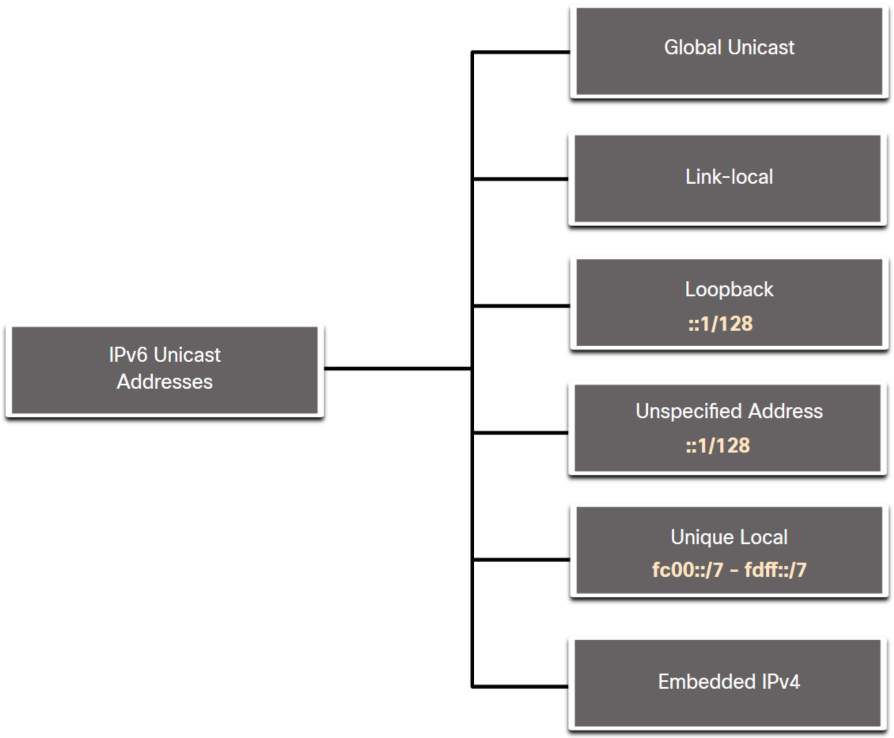
- Using the rules for abbreviation, the IPv6 address can be rewritten as follows:
- ABCD:123:4040::A:B

IPv6 Address Types



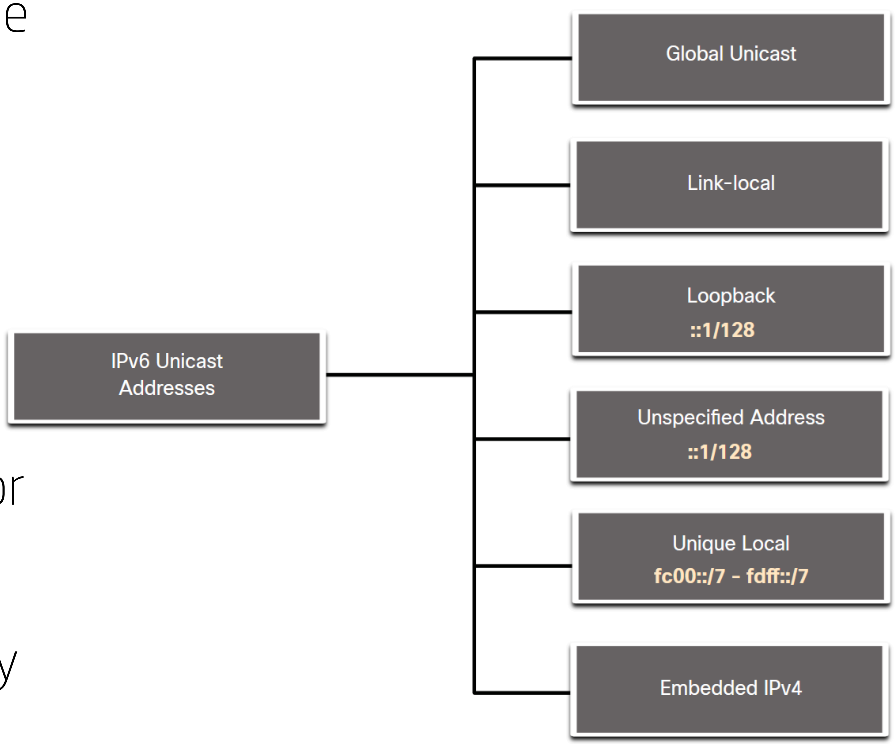
IPv6 Address Types

- **Global Unicast Address (GUA)** – This is similar to a public IPv4 address. These are globally unique, internet-routable addresses.
- **Link-local Address (LLA)** – Required for every IPv6-enabled device and used to communicate with other devices on the same local link. LLAs are not routable and are confined to a single link.



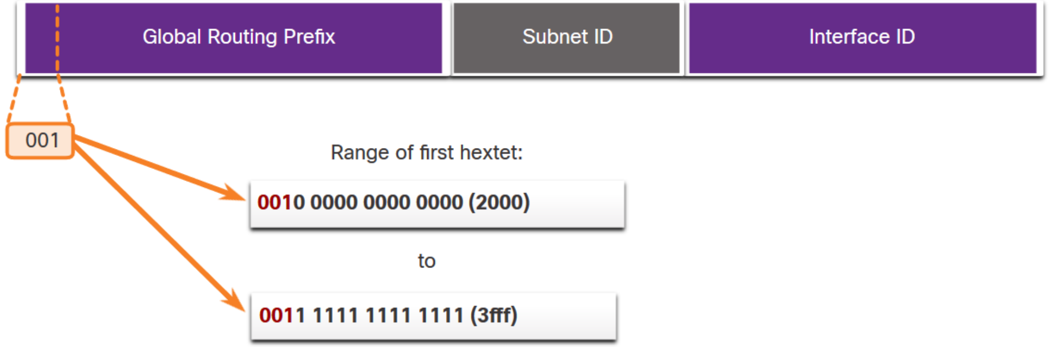
IPv6 Address Types

- The IPv6 unique local addresses (range fc00::/7 to fdff::/7) have some similarity to RFC 1918 private addresses for IPv4, but there are significant differences:
- Unique local addresses are used for local addressing within a site or between a limited number of sites.
- Unique local addresses can be used for devices that will never need to access another network.
- Unique local addresses are not globally routed or translated to a global IPv6 address.



IPv6 GUA

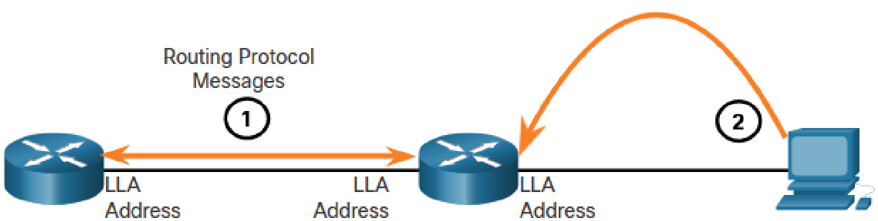
- IPv6 global unicast addresses (GUAs) are globally unique and routable on the IPv6 internet.
  - Currently, only GUAs with the first three bits of 001 or 2000::/3 are being assigned.
  - Currently available GUAs begins with a decimal 2 or a 3 (This is only 1/8th of the total available IPv6 address space).



IPv6 LLA

•An IPv6 link-local address (LLA) enables a device to communicate with other IPv6-enabled devices on the same link and only on that link (subnet).

- Packets with a source or destination LLA cannot be routed.
- Every IPv6-enabled network interface must have an LLA.
- If an LLA is not configured manually on an interface, the device will automatically create one.
- IPv6 LLAs are in the fe80::/10 range.



1. Routers use the LLA of neighbor routers to send routing updates.
2. Hosts use the LLA of a local router as the default-gateway.

IPv6 GUA and LLA Static Configuration

- The command to configure an IPv6 GUA on an interface is: **ipv6 address** *ipv6-address/prefix-length*.
- The example shows commands to configure a GUA on the G0/0/0 interface on R1

```
R1(config)# interface gigabitethernet 0/0/0
R1(config-if)# ipv6 address 2001:db8:acad:1::1/64
R1(config-if)# no shutdown
R1(config-if)# exit
```

IPv6 GUA and LLA Static Configuration

- LLAs can be configured manually using the **ipv6 address** *ipv6-link-local-address* **link-local** command.
- The example shows commands to configure a LLA on the G0/0/0 interface on R1

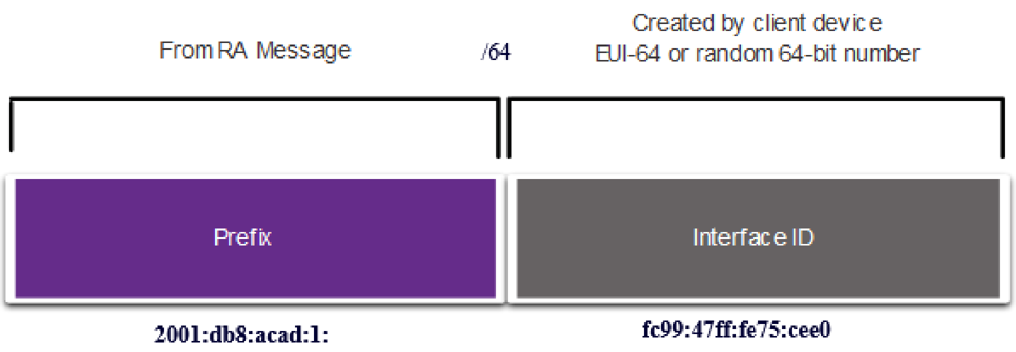
```
R1(config)# interface gigabitethernet 0/0/0
R1(config-if)# ipv6 address fe80::1:1 link-local
R1(config-if)# no shutdown
R1(config-if)# exit
```

IPv6 Dynamic Addressing for IPv6 GUAs

- Devices obtain GUA addresses dynamically through Internet Control Message Protocol version 6 (ICMPv6) messages.
  - Router Solicitation (RS) messages are sent by host devices to discover IPv6 routers
  - Router Advertisement (RA) messages are sent by routers to inform hosts on how to obtain an IPv6 GUA and provide useful network information such as:
    - Network prefix and prefix length
    - Default gateway address
    - DNS addresses and domain name
  - The RA can provide three methods for configuring an IPv6 GUA :
    - SLAAC
    - SLAAC with stateless DHCPv6 server
    - Stateful DHCPv6 (no SLAAC)

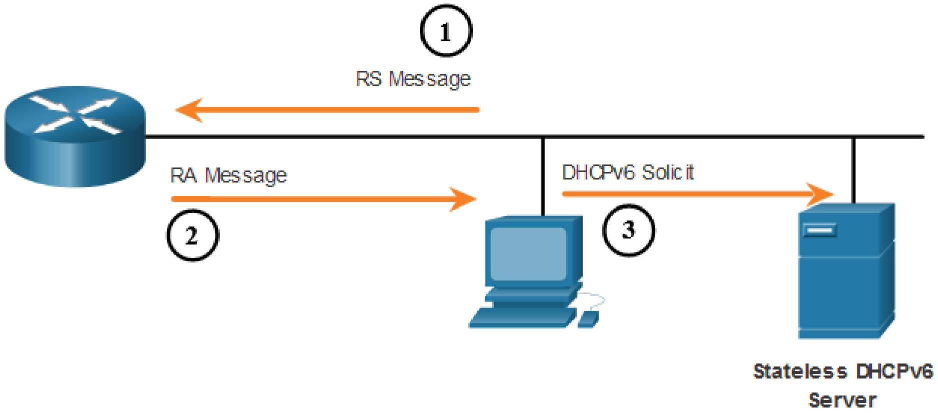
IPv6 Dynamic Addressing SLAAC

- SLAAC allows a device to configure a GUA without the services of DHCPv6.
- Devices obtain the necessary information to configure a GUA from the ICMPv6 RA messages of the local router.
- The prefix is provided by the RA and the device uses either the EUI-64 or random generation method to create an interface ID.



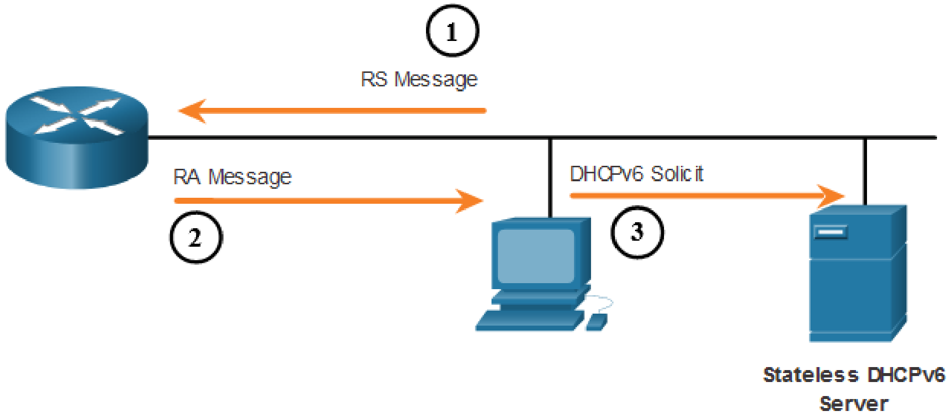
IPv6 Dynamic Addressing SLAAC Stateless DHCP

- An RA can instruct a device to use both SLAAC and stateless DHCPv6.
- The RA message suggests devices use the following:
  - SLAAC to create its own IPv6 GUA
  - The router LLA, which is the RA source IPv6 address, as the default gateway address
  - A stateless DHCPv6 server to obtain other information such as a DNS server address and a domain name



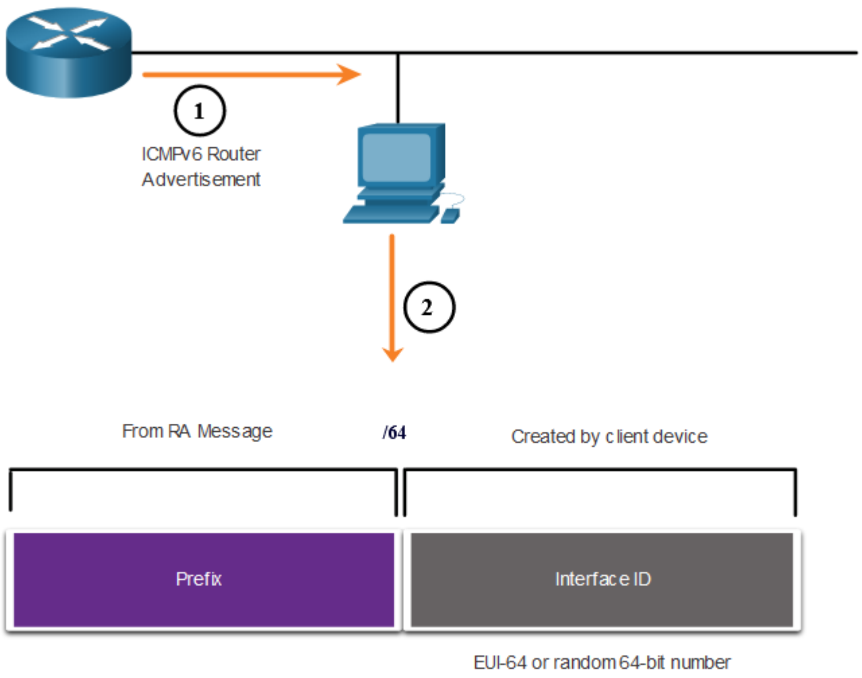
IPv6 Dynamic Addressing Stateful DHCPv6

- An RA can instruct a device to use stateful DHCPv6 only.
- Stateful DHCPv6 is similar to DHCP for IPv4. A device can automatically receive a GUA, prefix length, and the addresses of DNS servers from a stateful DHCPv6 server.
- The RA message suggests devices use the following:
  - The router LLA, which is the RA source IPv6 address, for the default gateway address.
  - A stateful DHCPv6 server to obtain a GUA, DNS server address, domain name and other necessary information.



IPv6 Dynamic Addressing EUI-64 Process

- When the RA message is either SLAAC or SLAAC with stateless DHCPv6, the client must generate its own interface ID.
- The interface ID can be created using the EUI-64 process or a randomly generated 64-bit number.



IPv6 Dynamic Addressing EUI-64 Process

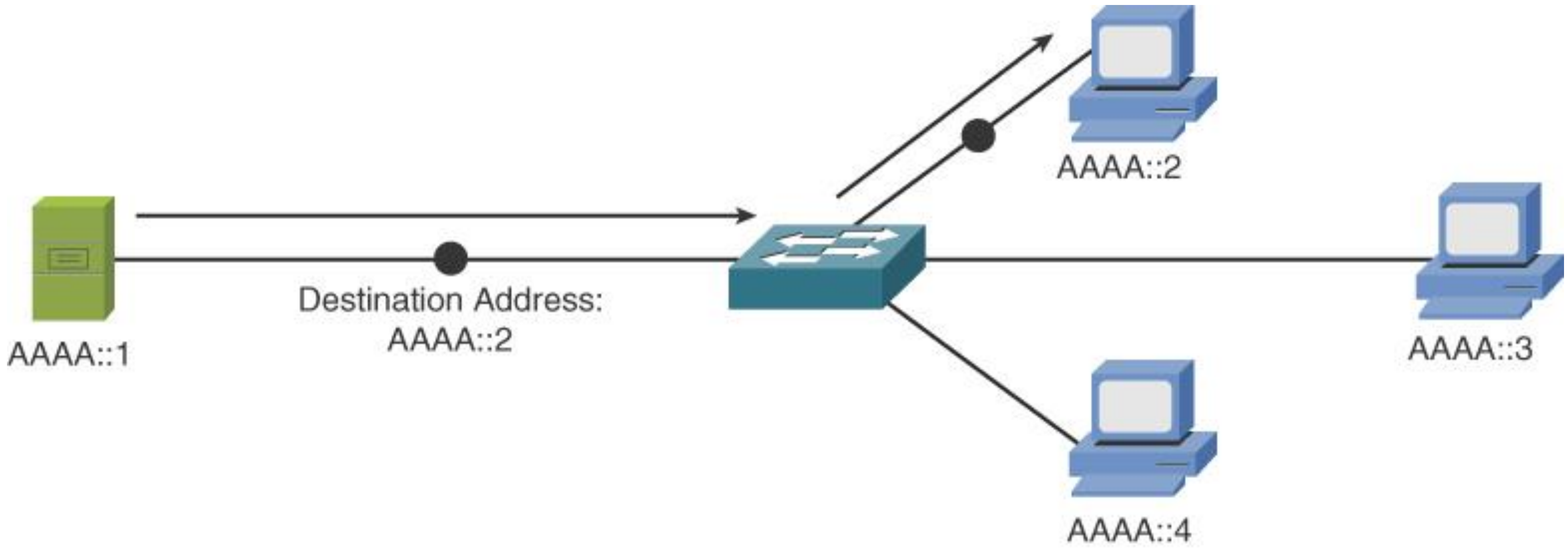
- The IEEE defined the Extended Unique Identifier (EUI) or modified EUI-64 process which performs the following:
  - A 16 bit value of fffe (in hexadecimal) is inserted into the middle of the 48-bit Ethernet MAC address of the client.
  - The 7th bit of the client MAC address is reversed from binary 0 to 1.
  - Example:

48-bit MAC	fc:99:47:75:ce:e0
EUI-64 Interface ID	fe:99:47:ff:fe:75:ce:e0

LAB

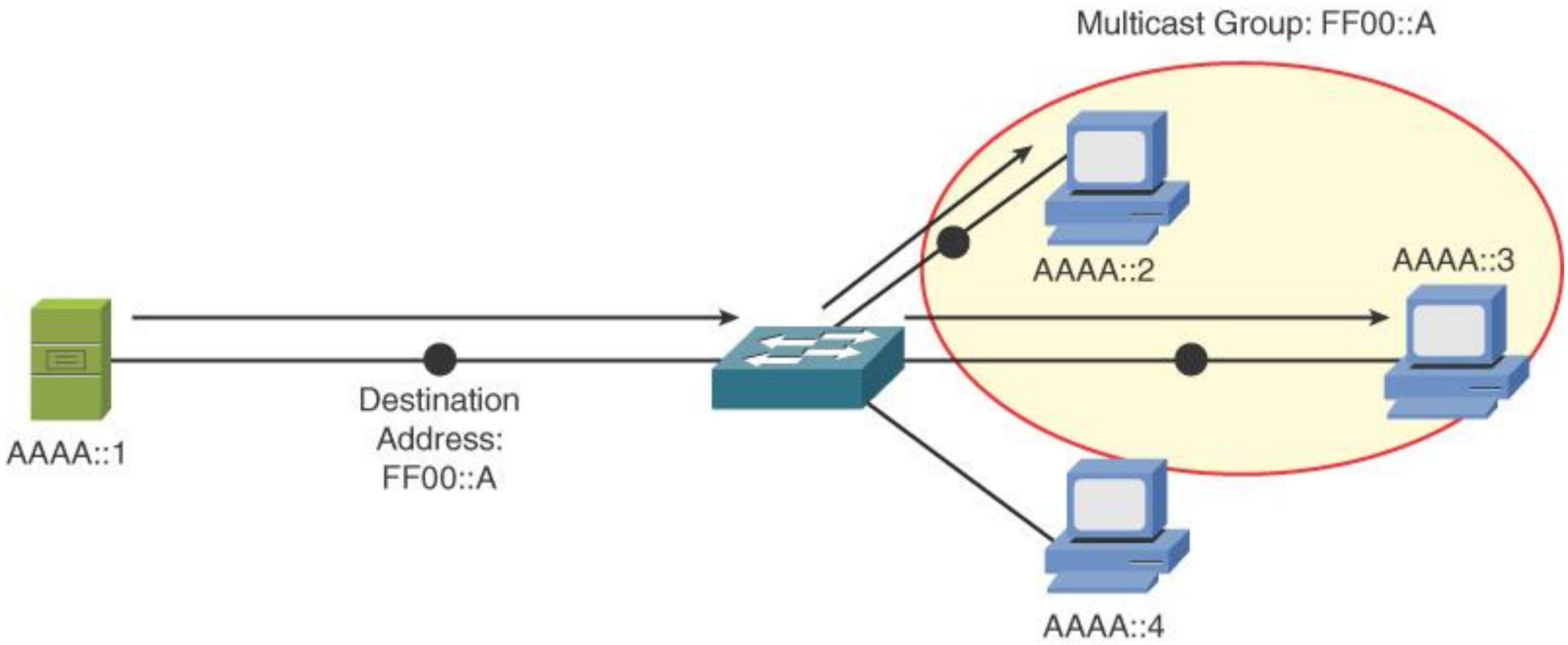
- IPv6
  - 12.6.6 Packet Tracer – Configure IPv6 Addressing
  - 12.9.1 Packet Tracer – Implement a Subnetted IPv6 Addressing Scheme
  - 13.2.6 Packet Tracer – Verify IPv4 and IPv6 Addressing

IPv6 Unicast

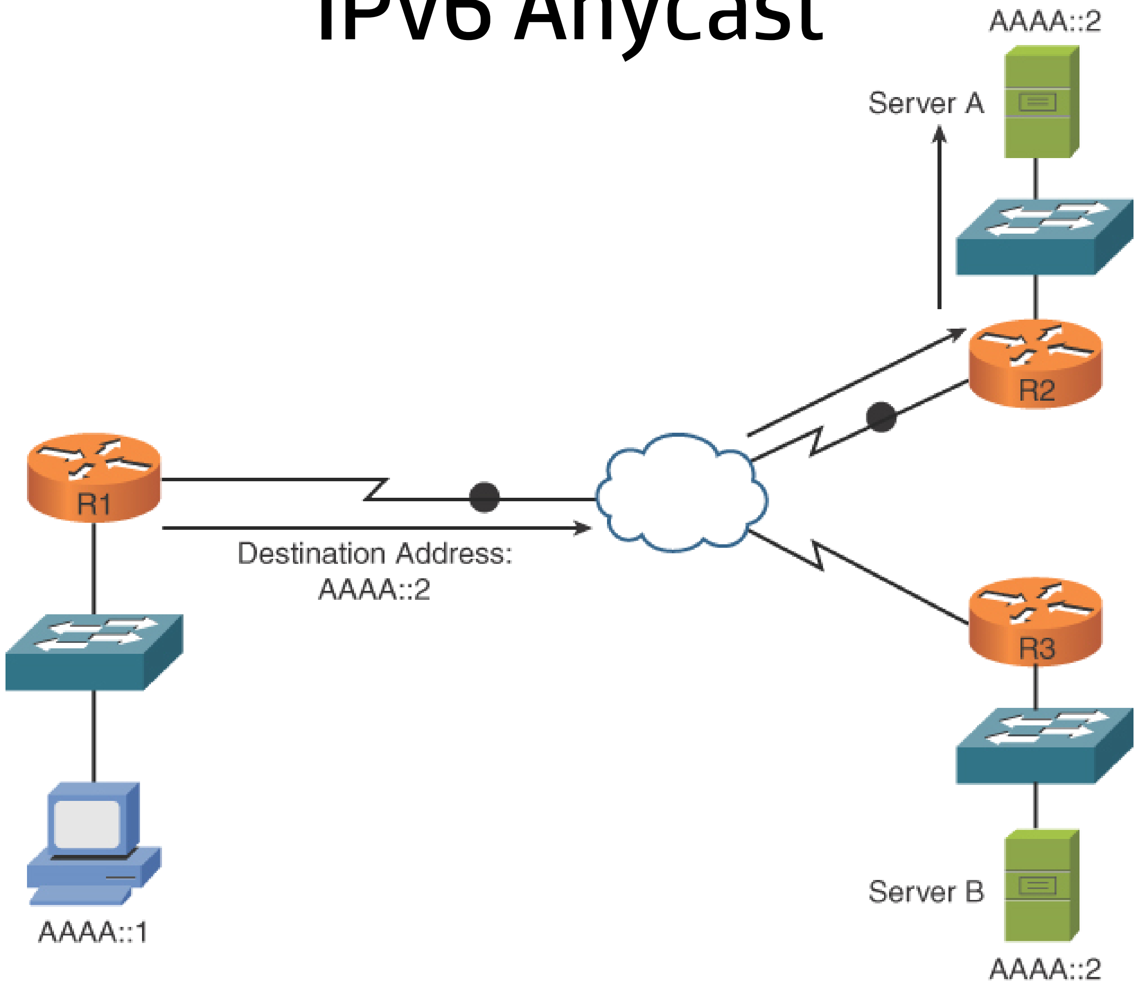


IPv6 Multicast

- IPv6 multicast addresses have the prefix ff00::/8



IPv6 Anycast



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