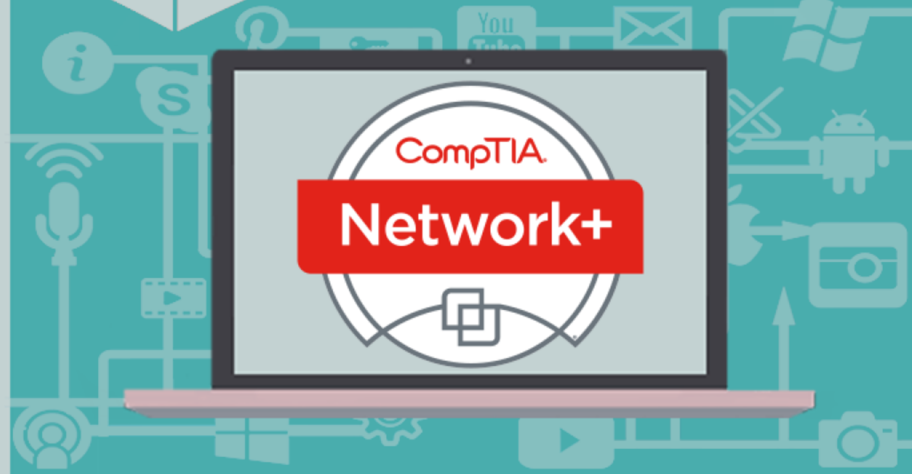
IPv4 Addressing

CompTIA Network+ (N10-007)

Internet Protocol Version 4 (IPv4) Addressing



- Written in *dotted-decimal* notation
  - 10.1.2.3
  - 172.21.243.67
- Each IPv4 address is divided into 4 separate numbers and divided by dots
- Each of these division are call octets due to having 8 bits assigned
- 32-bits in length

	1st Octet	2nd Octet	3rd Octet	4th Octet
Dotted-Decimal	192	168	1	4
Binary Digits	11000000	10101000	00000001	00000100

IPv4 Addressing

- IPv4 address is divided into network and host portions
- Subnet mask defines the network portion
  - Network portion if a binary 1
  - Host portion if binary 0

IP Address (In Decimal)	**192**	**168**	**1**	**4**
IP address	11000000	10101000	00000001	00000100
Subnet mask	255	255	255	0
Subnet mask	11111111	11111111	11111111	00000000
	Network bits	*Network bits*	*Network bits*	*Host bits*

Classes of IP Addresses

- Default subnet mask assigned by first octet
  - Classful Masks if using default subnet mask

- Defines the Class of IP Address

Address Class	Value in First Octet	Classful Mask (Dotted Decimal)	Classful Mask (Prefix Notation)
Class A	1 – 126	255.0.0.0	/8
Class B	128 – 191	255.255.0.0	/16
Class C	192 – 223	255.255.255.0	/24
Class D	224 – 239	n/a	n/a

Notice that 127 is skipped between Class A and Class B,
It is a reserved block for the loopback address (127.0.0.1)

Routable IPs

- Publically routable IP addresses are globally managed by ICANN
  - Internet Corporation for Assigned Names and Numbers
    - ARIN, LACNIC, AFNIC, APNIC, and RIPE NCC
- Public IP’s must be purchased before use through your Internet Service Provider

Private IPs

- Private IP’s can be used by anyone
- Not routable outside your local area network
- Network Address Translation (NAT) allows for routing of private IPs through a public IP

Address Class	Address Range	Default Subnet Mask
Class A	10.0.0.0 – 10.255.255.255	255.0.0.0
Class B	172.16.0.0 – 172.31.255.255	255.255.0.0
Class C	192.168.0.0 – 192.168.255.255	255.255.255.0

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Specialized IPs

- Loopback addresses (127.x.x.x range)
  - Refers to the device itself and used for testing
  - Most commonly used as 127.0.0.1

- Automatic Private IP Addresses (APIPA)
  - Dynamically assigned by OS when DHCP server is unavailable and address not assigned manually
  - Range of 169.254.x.x

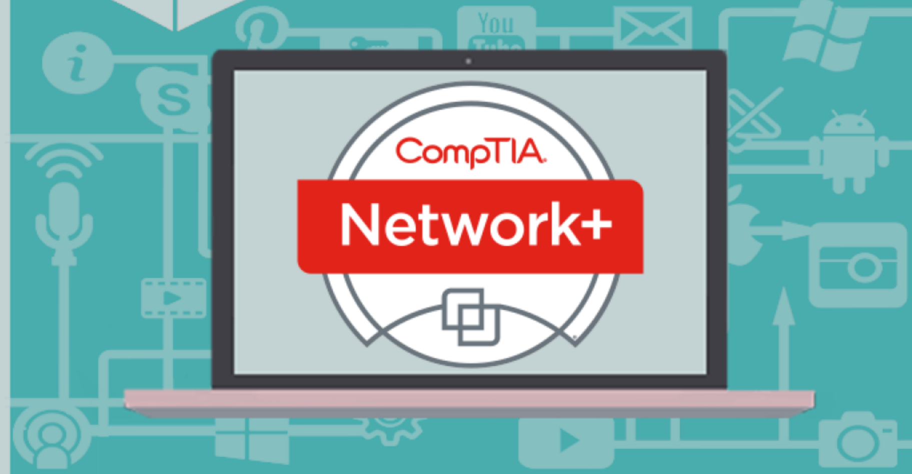
Description	Address Class	Address Range	Default Subnet Mask
Loopback	Class A	127.0.0.1 – 127.255.255.255	255.0.0.0
APIPA	Class B	169.254.0.0 – 169.254.255.255	255.255.0.0

Special address ranges never assigned by an administrator or DHCP server

Identifying Network and Hosts in IPv4

- Class A network address example:
  - IP Address: 114.56.20.33
    Subnet Mask: 255.0.0.0
- Class B network address example:
  - IP Address: 147.12.38.81
  - Subnet Mask: 255.255.0.0
- Class C network address example:
  - IP Address: 214.51.42.7
  - Subnet: 255.255.255.0

Network | Host



IPv4 Data Flows

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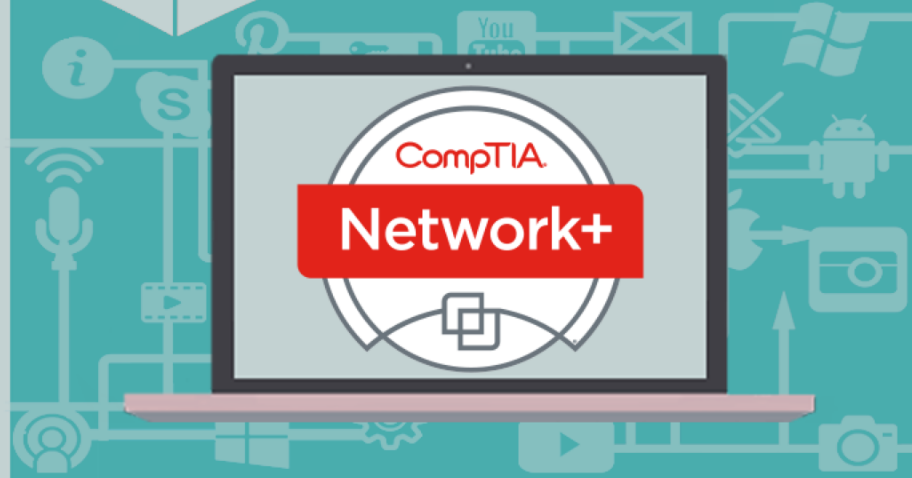
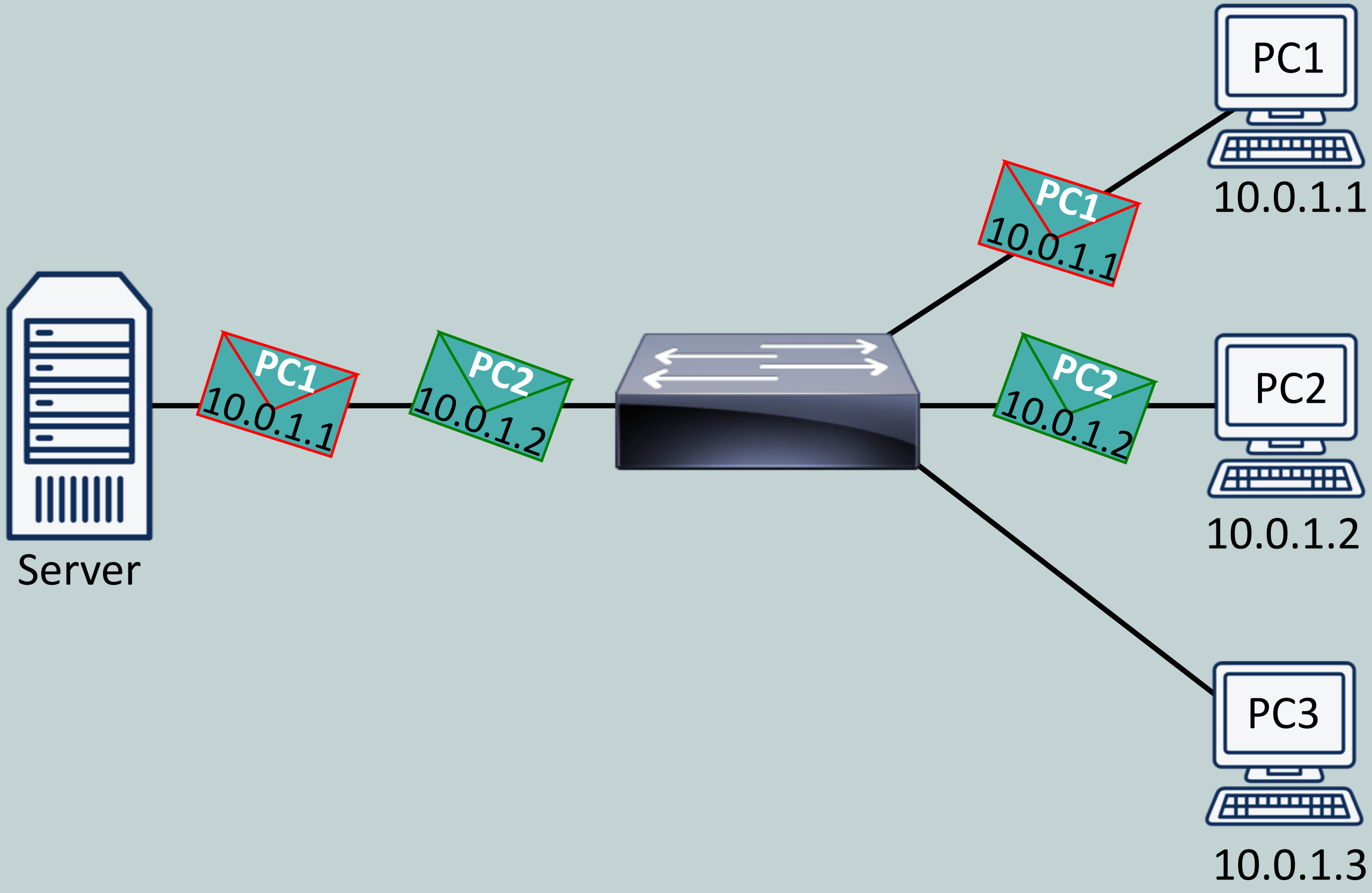
Data Flows

- Unicast
  - Data travels from a single source device to a single destination device
- Multicast
  - Data travels from a single source device to multiple (but specific) destination devices
- Broadcast
  - Data travels from a single source device to all devices on a destination network

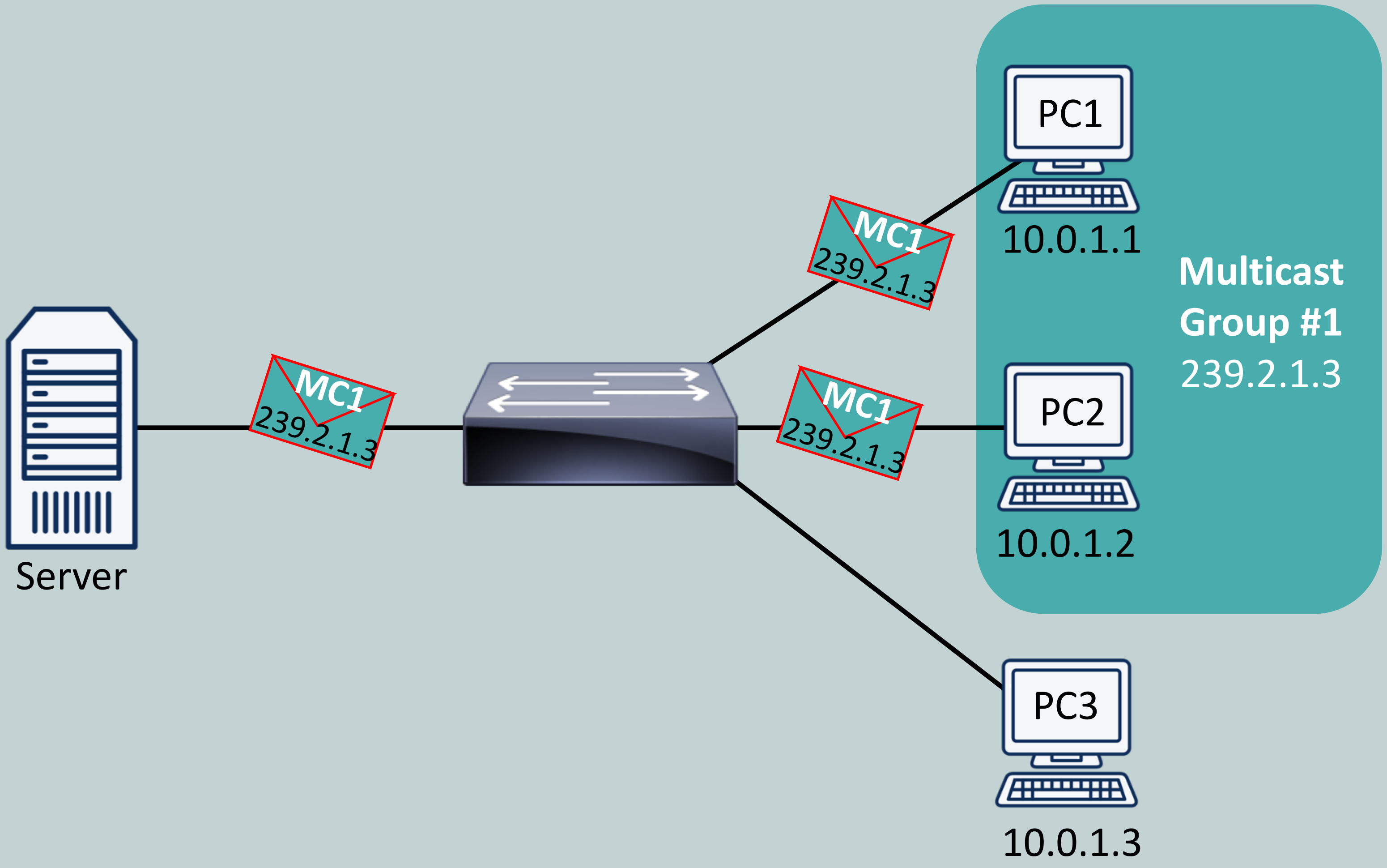


Unicast



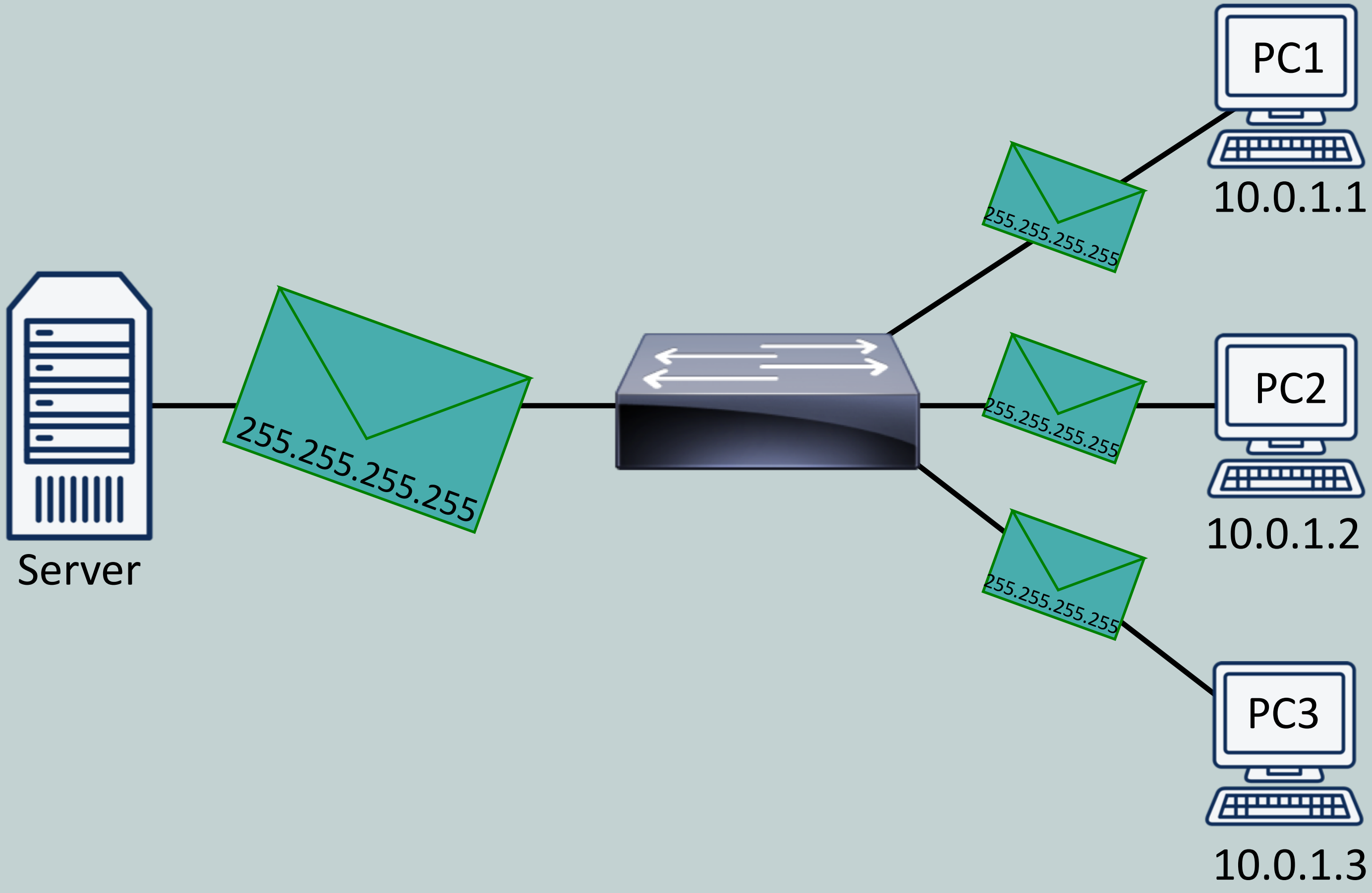
Data travels from a single source device to a single destination device

Multicast



Data travels from a single source device to multiple (but specific) destination devices

Broadcast



Data travels from a single source device to all devices on a destination network

Assigning IP Addresses

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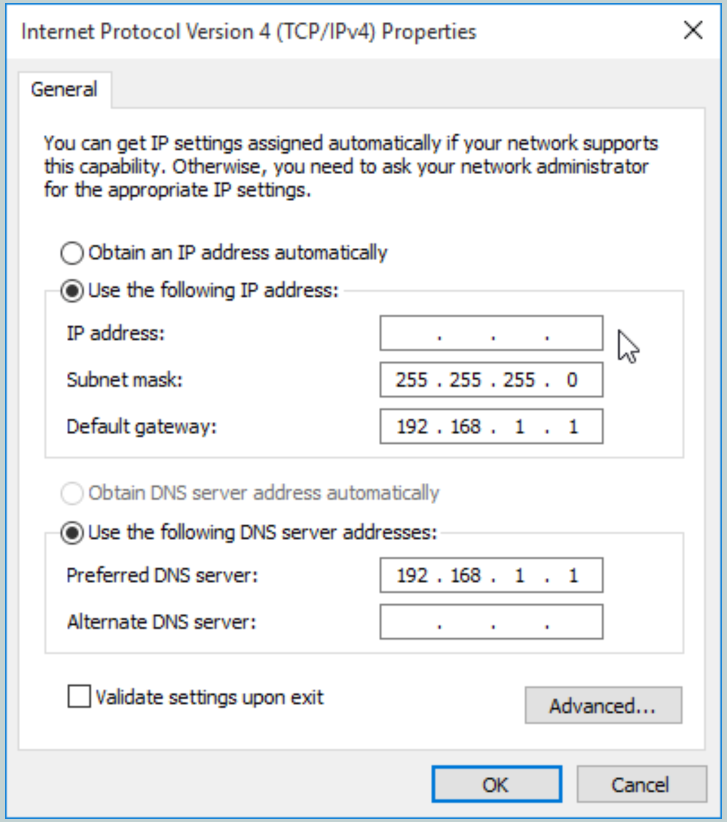
Assigning IP Addresses

- Static
  - Simple
  - Time-consuming
  - Prone to human errors
  - Impractical for large networks
- Dynamic
  - Quicker
  - Easier
  - Less confusing
  - Simplistic for large networks



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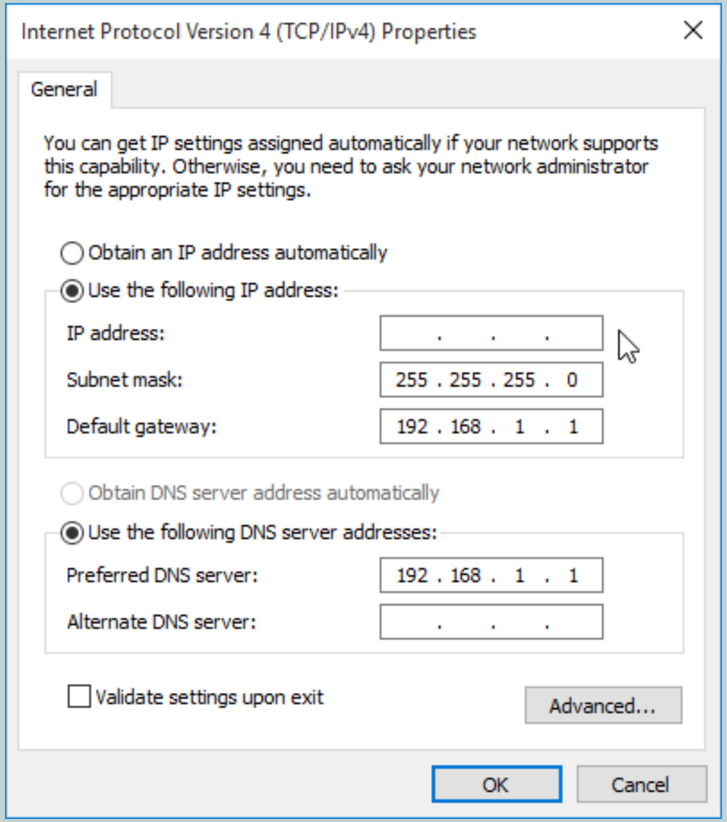
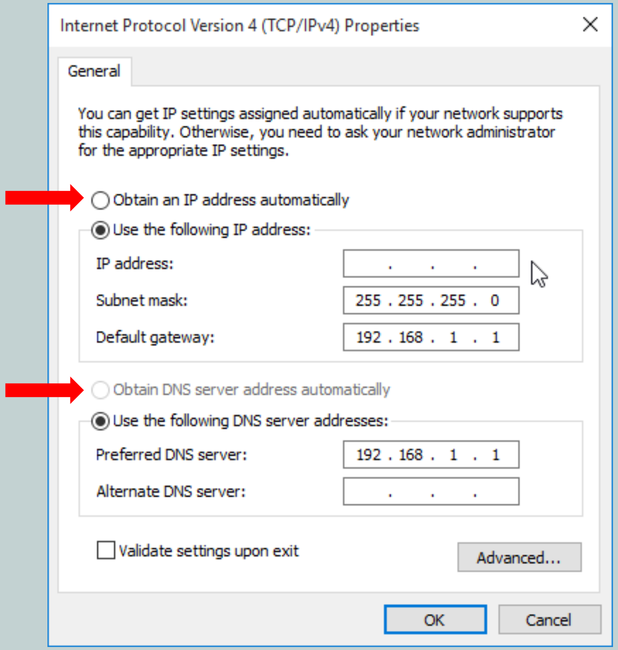
Components of an IP Address

- Information assigned from static or dynamic
  - IP Address
  - Subnet Mask
  - Default Gateway
  - Server addresses
    - DNS
      - Converts domain names to IP address
    - WINS (optional)
      - Converts NetBIOS computer name into an IP address



Dynamic Host Control Protocol (DHCP) Configuration

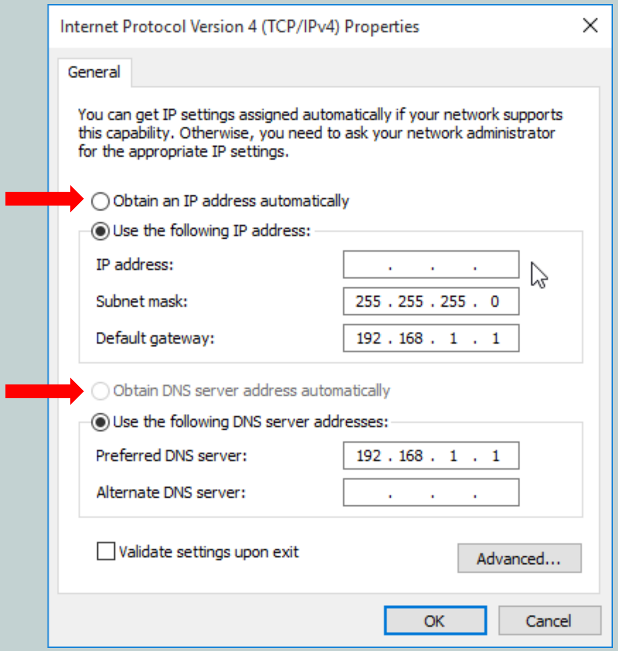
- Based on the older Bootstrap Protocol (BOOTP for short)
  - Required static database of IP and MAC to assign
- DHCP service assigns an IP from an assignable pool (scope)
- IP Address Management is a piece of software used to manage the IP's being assigned



Dynamic Host Control Protocol (DHCP)

- Provides clients with
  - IP
  - Subnet mask
  - Default gateway
  - DNS server
  - WINS server
  - Other variables needed for VoIP

- Each IP is leased for a given amount of time and given back to the pool when lease expires (TTL)



Automatic Private IP Address (APIPA)

- Used when device does not have a static IP address and cannot reach a DHCP server
- Allows a network device to self-assign an IP address from the 169.254.0.0/16 network
- Designed to allow quick configuration of a LAN without need for DHCP
- Non-routable but allows for network connectivity inside the local subnet

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Zero Configuration (Zeroconf)

- Newer technology based on APIPA providing:
  - Assigning link-local IP addresses
    - Non-routable IP usable only on local subnet
  - Resolving computer names to IP addresses without the need for DNS server on local network
    - mDNS - Multicast Domain Name Server
  - Locating network services
    - Provides service discovery protocols
      - Service Location Protocol (SLP)
      - Microsoft’s Simple Service Discovery Protocol (SSDP)
      - Apple’s DNS-based Service Discovery (DNS-SD)

Computer Mathematics

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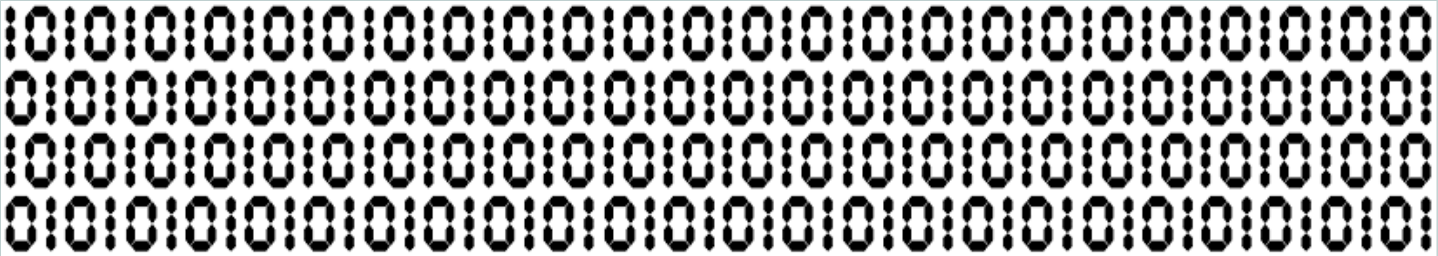
Computer Mathematics

- Humans count using Base-10 numbers
  - Decimals
  - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, …

- Computers and networks do not understand decimal numbers natively

- Process numbers using Base-2 numbers
  - Binary
  - 0, 1, 10, 11, …



Converting Binary to Decimal

- Use table to convert from binary to decimal
- Each number is a factor of 2
- Starting from the right and go to the left

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)

Converting Binary to Decimal

- Populate the table with the binary digits

- Add up any columns that contain a 1

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)

10010110

Converting Binary to Decimal

- Populate the table with the binary digits
- Add up any columns that contain a 1

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	0	1	0	1	1	0

10010110

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Converting Binary to Decimal

- Populate the table with the binary digits
- Add up any columns that contain a 1

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	0	1	0	1	1	0

10010110

→ 128 + 16 + 4 + 2

→ 150

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1							

$$\begin{array}{r} 167 \\ -128 \\ \hline \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1							

$$\begin{array}{r} 167 \\ -128 \\ \hline 39 \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0						

$$\begin{array}{r} 167 \\ -128 \\ \hline 39 \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1					

$$\begin{array}{r} 167 \\ -128 \\ \hline 39 \end{array} \qquad \begin{array}{r} 39 \\ -32 \\ \hline 7 \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1	0				

$$\begin{array}{r} 167 \\ -128 \\ \hline 39 \end{array} \qquad \begin{array}{r} 39 \\ -32 \\ \hline 7 \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1	0	0			

$$\begin{array}{r} 167 \\ -128 \\ \hline 39 \end{array} \qquad \begin{array}{r} 39 \\ -32 \\ \hline 7 \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1	0	0	1		

$$\begin{array}{r} 167 \\ -128 \\ \hline 39 \end{array} \qquad \begin{array}{r} 39 \\ -32 \\ \hline 7 \end{array} \qquad \begin{array}{r} 7 \\ -4 \\ \hline 3 \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1	0	0	1	1	

$$\begin{array}{r} 167 \\ -128 \\ \hline 39 \end{array} \quad \begin{array}{r} 39 \\ -32 \\ \hline 7 \end{array} \quad \begin{array}{r} 7 \\ -4 \\ \hline 3 \end{array} \quad \begin{array}{r} 3 \\ -2 \\ \hline 1 \end{array}$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1	0	0	1	1	1

$$
\begin{array}{rrrrr}
167 & 39 & 7 & 3 & 1 \\
-128 & -32 & -4 & -2 & -1 \\
\hline
39 & 7 & 3 & 1 & 0
\end{array}
$$

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1	0	0	1	1	1

(Check Your Answer by Adding It Back Up)

Converting Decimal to Binary

- Use subtraction to convert decimal to binary

Convert 167 into decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	1	0	0	1	1	1

(Check Your Answer by Adding It Back Up)

$$128 + 32 + 4 + 2 + 1 = 167$$

Computer Mathematics Practice

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Computer Mathematics Practice

- You must be able to convert:

Binary → Decimal
Decimal → Binary

Converting Binary to Decimal

Convert 01101011
to decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)

Converting Binary to Decimal

Convert 01101011
to decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
0	1	1	0	1	0	1	1

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Converting Binary to Decimal

Convert 01101011
to decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
0	1	1	0	1	0	1	1

→ 64 + 32 + 8 + 2 + 1

→ 107

Converting Binary to Decimal

Convert 10010100
to decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)

Converting Binary to Decimal

Convert 10010100
to decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	0	1	0	1	0	0

Converting Binary to Decimal

Convert 10010100
to decimal

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
1	0	0	1	0	1	0	0

➡ 128 + 16 + 4

➡ 148

Converting Decimal to Binary

Convert 49
to binary

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)

Converting Decimal to Binary

Convert 49
to binary

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
0	0	1	1	0	0	0	1

$$\begin{array}{r} 49 \\ -32 \\ \hline 17 \end{array} \qquad \begin{array}{r} 17 \\ -16 \\ \hline 1 \end{array} \qquad \begin{array}{r} 1 \\ -1 \\ \hline 0 \end{array}$$

Converting Decimal to Binary

Convert 49
to binary

128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
0	0	1	1	0	0	0	1

$$49 \rightarrow 00110001$$

Check Your Answer:

$$49 = 32 + 16 + 1$$

Subnetting

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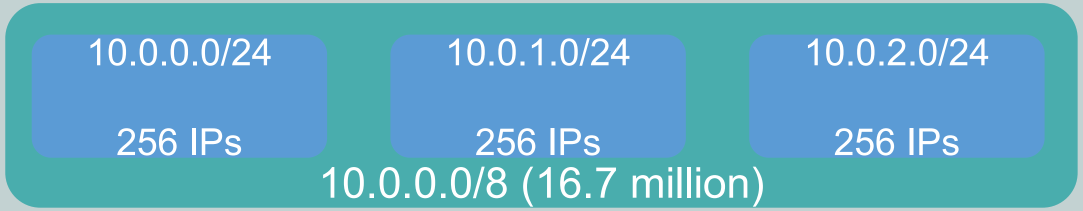
Subnetting

- Default classful subnet masks are rarely the optimal choice for a subnet size
- Subnets can be modified using subnet masks to create networks that are better scoped
- Creating a subnet involves borrowing bits from the original host portion and adding them to the network portion

Purpose of Subnets

- More efficient use of IP addresses than classful default
- Enables separation of networks for security
- Enables bandwidth control

Address Class	Default Subnet Mask	Assignable IP Calculation	Assignable IP Addresses
Class A	255.0.0.0	$2^{24} – 2 =$	16,777,214
Class B	255.255.0.0	$2^{16} – 2 =$	65,534
Class C	255.255.255.0	$2^{8} – 2 =$	254



Subnet Masks

Dotted-Decimal Notation	CIDR	Binary Notation
255.0.0.0	**/8**	11111111.00000000.00000000.00000000
255.255.0.0	**/16**	11111111.11111111.00000000.00000000
255.255.255.0	**/24**	11111111.11111111.11111111.00000000
255.255.255.128	/25	11111111.11111111.11111111.10000000
255.255.255.192	/26	11111111.11111111.11111111.11000000
255.255.255.224	/27	11111111.11111111.11111111.11100000
255.255.255.240	/28	11111111.11111111.11111111.11110000
255.255.255.248	/29	11111111.11111111.11111111.11111000
255.255.255.252	/30	11111111.11111111.11111111.11111100

Classful subnets for
Class A, B, and C in red

Subnetting Formulas

- Number of Created Subnets = 2^{s},
  where *s* is the number of borrowed bits

- Number of Assignable IP Addresses = $2^{h} - 2$,
  where *h* is the number of host bits

Classful vs Subnetted Networks

- Classful subnet (192.168.1.0/24)
  - 1 network (2^0), where *s* is the number of borrowed bits
  - 256 IPs (2^8), where *h* is the number of host bits

192	168	1	0
255	255	255	0
11111111	11111111	11111111	00000000
Network Bits			Host Bits

- Classless subnet (192.168.1.64/26)
  - 4 networks (2^2), where *s* is the number of borrowed bits
  - 64 IPs (2^6), where *h* is the number of host bits

192	168	1	64	0
255	255	255	192	0
11111111	11111111	11111111	11	000000
Network Bits			Sub	Host Bits

Calculating Number of Subnets

192.168.1.0/26

- Default mask is /24, so we *borrowed* 2 bits from the host space

$2^s = 2^2 = 4$,
which means there are four created subnets

192.168.1.0 to 192.168.1.63 (64 IPs)	192.168.1.64 to 192.168.1.127 (64 IPs)	192.168.1.128 to 192.168.1.191 (64 IPs)	192.168.1.192 to 192.168.1.255 (64 IPs)

192.168.1.0/24 (256 IPs)

Calculating Number of IPs

192.168.1.0/26

- Total bits are 32 and the mask is /26

32 – 26 = 6 host bits (h)

$$2^h - 2 = 2^6 - 2 = 64 - 2 = 62$$

62 assignable IPs in each subnet

192.168.1.0 to 192.168.1.63 (64 IPs)	192.168.1.64 to 192.168.1.127 (64 IPs)	192.168.1.128 to 192.168.1.191 (64 IPs)	192.168.1.192 to 192.168.1.255 (64 IPs)

192.168.1.0/24 (256 IPs)

Listing Subnets

192.168.1.0/26

- *Created 4 subnets of 62 usable IPs each*
- *Where does each network begin and end?*
- *Network ID (First IP)*
  0, 64, 128, 192
- *Broadcast (Last IP)*
  63, 127, 191, 255

192.168.1.0 to 192.168.1.63 (64 IPs)	192.168.1.64 to 192.168.1.127 (64 IPs)	192.168.1.128 to 192.168.1.191 (64 IPs)	192.168.1.192 to 192.168.1.255 (64 IPs)

192.168.1.0/24 (256 IPs)

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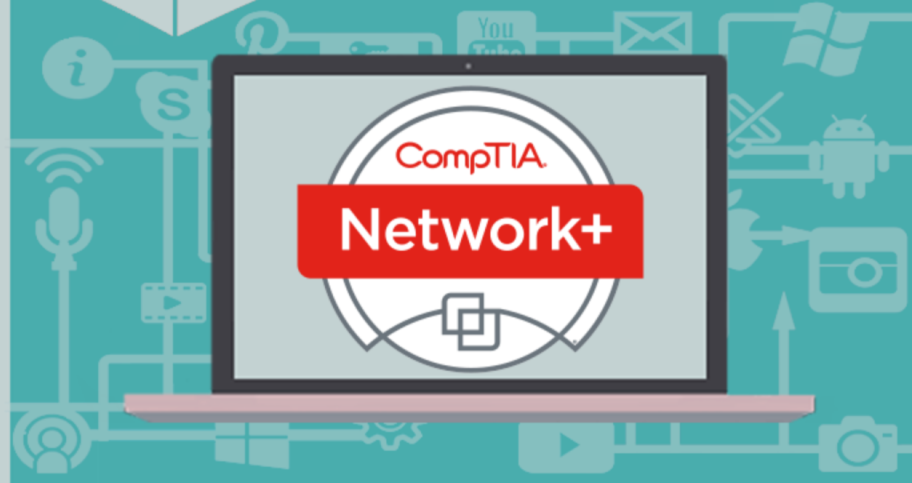

Classless Interdomain Routing (CIDR)

192.168.1.0/26

- Instead of advertising multiple individual routes, the routes can be summarized and advertised as a single route

- Used to summarize contiguous networks
  - Called *route aggregation*

Network Address	1st Octet	2nd Octet	3rd Octet	4th Octet
192.168.32.0	11000000	10101000	00000001	11000000
192.168.33.0	11000000	10101000	00000001	11000000
192.168.34.0	11000000	10101000	00000001	11000000
192.168.35.0	11000000	10101000	00000001	11000000

Variable-Length Subnet Masking (VLSM)

- Allows subnets of various sizes to be used
- Requires a routing protocol that supports it
  - RIPv2, OSPF, IS-IS, EIGRP, and BGP
- Basically it is subnetting subnets
- Without VLSM, all subnets would have to be the same size

10.0.0.0/24	10.0.1.0/25	10.0.1.128/25
256 IPs	128 IPs	128 IPs

10.0.0.0/8 (16.7 million)

Subnetting Exam Tip

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128
/24	1	256
/23	128	2
/22	64	4
/21	32	8
/20	16	16
/19	8	32
/18	4	64
/17	2	128

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

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Memorize smaller chart for the exam

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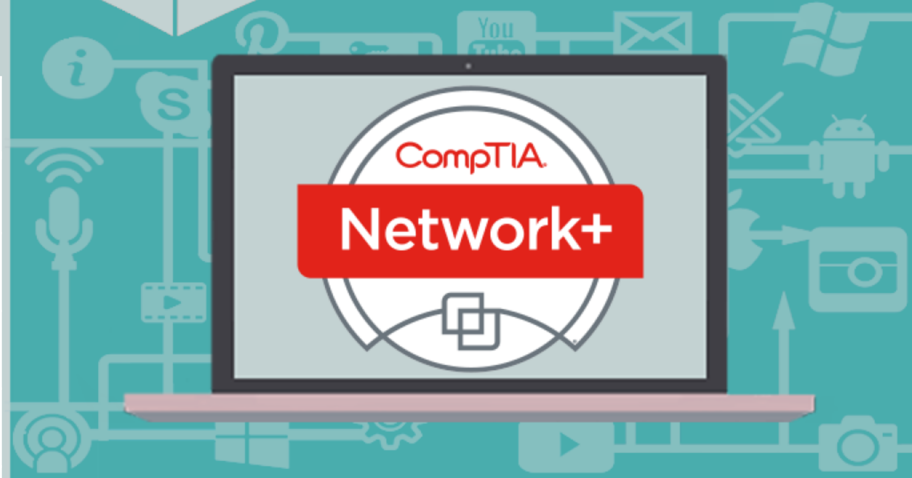

Subnetting Practice

CompTIA Network+ (N10-007)

Subnetting Practice #1

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

You are the network administrator for DionTraining.com. We decided to locate a small branch office in another city. To support the new location, you will need to subnet the private IP address range given to you into several smaller networks to service each department.

The new office location has been assigned the range of 10.10.10.0/24.

When you set up the new network, you need to configure separate subnets for each department in the new office. You should allocate the addresses using CIDR notation and provide each department the minimum number of IP addresses that will meet their needs.

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The departments at the new location will require these number of computers in their subnets:

54 – IT

32 – Instructors

5 – Sales

3 – Administrative

X – Unused

- When complete, summarize the remaining available IPs in their own subnet using CIDR notation.

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- If you have memorized the table, this problem becomes quite simple.
- First, we round up our department numbers to the next highest multiple of 2. Remember, the numbers provided are for the computers, we still need to add 2 IPs to account for the network and broadcast IPs:

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  - IT: 54 + 2 = 56 => 64 IPs will be assigned

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  - Unused: 256 - 64 - 64 - 8 - 8 = 112

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Subnetting Practice #2

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

How many assignable IP addresses exist in this network?
172.16.1.0/27

- 30
- 32
- 14
- 64

Subnetting Practice #2

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

How many assignable IP addresses exist in this network?
172.16.1.0/27

- 30
- 32
- 14
- 64

$2^h - 2$ = # of usable hosts

Subnetting Practice #2

How many assignable IP addresses exist in this network?
172.16.1.0/27

CIDR	# Subnets	# IPs
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- 30
- 32
- 14
- 64

$2^h - 2$ = # of usable hosts

$2^{(32-27)} - 2$

Subnetting Practice #2

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

How many assignable IP addresses exist in this network?
172.16.1.0/27

- 30
- 32
- 14
- 64

$2^h - 2$ = # of usable hosts

$2^{(32-27)} - 2$
$= 2^{(5)} - 2$

Subnetting Practice #2

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
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/25	2	128

How many assignable IP addresses exist in this network?
172.16.1.0/27

- 30
- 32
- 14
- 64

$2^h - 2 = \#$ of usable hosts

$$2^{(32-27)} - 2$$
$$= 2^{(5)} - 2$$
$$= 32 - 2$$

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How many assignable IP addresses exist in this network?
172.16.1.0/27

- 30
- 32
- 14
- 64

$2^h - 2 = \#$ of usable hosts

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$= 2^{(5)} – 2$
$= 32 -2$
$= 30$

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How many assignable IP addresses exist in this network?
172.16.1.0/27

- 30
- 32
- 14
- 64

$2^h - 2 = \#$ of usable hosts

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$= 2^{(5)} – 2$
$= 32 - 2$
$= 30$

Subnetting Practice #3

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

How many assignable IP addresses exist in this network?
192.168.1.0/28

- 30
- 16
- 14
- 64

Subnetting Practice #3

CIDR	# Subnets	# IPs
/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

How many assignable IP addresses exist in this network?
192.168.1.0/28

- 30
- 16
- 14
- 64

Subnetting Practice #3

How many assignable IP addresses exist in this network?
192.168.1.0/28

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/29	32	8
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- 16
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- 64

16 usable IPs – Network IP – Broadcast IP

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/30	64	4
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/28	16	16
/27	8	32
/26	4	64
/25	2	128

How many assignable IP addresses exist in this network?
192.168.1.0/28

- 30
- 16
- 14
- 64

16 usable IPs – Network IP – Broadcast IP
= 16 – 1 – 1

Subnetting Practice #3

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/30	64	4
/29	32	8
/28	16	16
/27	8	32
/26	4	64
/25	2	128

How many assignable IP addresses exist in this network?
192.168.1.0/28

- 30
- 16
- 14
- 64

16 usable IPs – Network IP – Broadcast IP
= 16 – 1 – 1
= 16 – 2

Subnetting Practice #3

How many assignable IP addresses exist in this network?
192.168.1.0/28

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- 16
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16 usable IPs – Network IP – Broadcast IP
= 16 – 1 – 1
= 16 – 2
= 14

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How many assignable IP addresses exist in this network?
192.168.1.0/28

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- 30
- 16
- 14
- 64

16 usable IPs – Network IP – Broadcast IP
= 16 – 1 – 1
= 16 – 2
= 14

IPv6 Addresses

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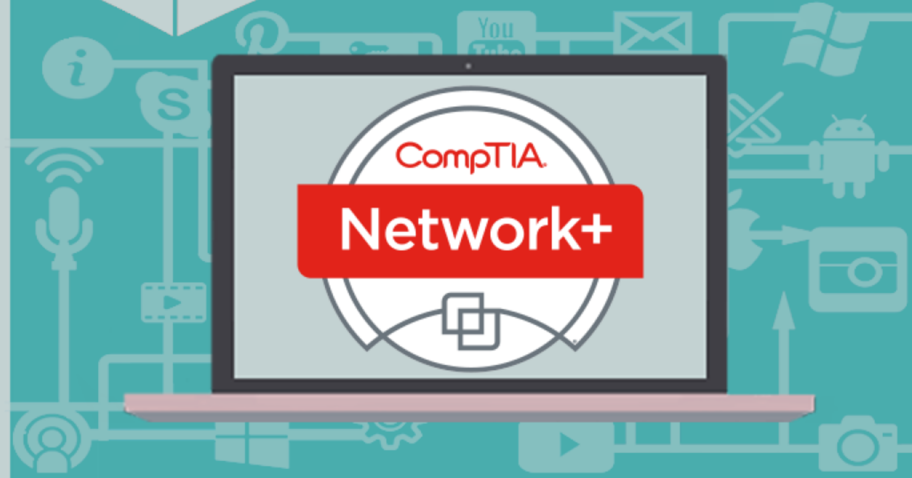
Internet Protocol Version 6 (IPv6)

- We've essentially ran out of IPv4 addresses due to proliferation of networked devices
- IPv6 addressing provides enough IP addresses for generations to come
- Enough IPv6 addresses for every person on the planet (5×10^{28})

IPv4 = 2^{32} = 4.2 billion addresses

IPv6 = 2^{128} = 340 undecillion addresses

If you are curious, IPv5 was an experimental protocol that was abandoned, although some of its concepts have been incorporated into other protocols



IPv6 Benefits

- No broadcasts
- No fragmentation
  - Performs MTU (maximum transmission units) discovery for each session
- Can coexist with IPv4 during transition
  - Dual stack (run IPv4 and IPv6 simultaneously)
  - IPv6 over IPv4 (tunneling over IPv4)
- Simplified header
  - 5 fields instead of 12 fields

Headers (IPv4 and IPv6)

Ver. 4	HL	TOS	Datagram Length
Datagram-ID		Flags	Flag Offset
TTL	Protocol		Header Checksum
Source IP Address			
Destination IP Address			
IP Options (with padding if necessary)			

Ver. 6	Traffic Class	Flow Label	
Payload Length		Next Header	Hop Limit
Source IP Address			
Destination IP Address			

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IPv6 Address Structure

- Each hexadecimal digit is 4-bits
- 128-bits in an IPv6 address
- No more than 32 hexadecimal digits

2018:0:0:0000:0:000:4815:54ae

Consecutive groups of 0's can be summarized as ::

2018::4815:54ae

IPv6 Address Types

- Globally routable unicast addresses
  - Begins with 2000 to 3999
- Link-local address
  - Begins with FE80
- Multicast addresses
  - Begins with FF

Do you need DHCP for IPv6?

- IPv6 uses auto configuration to discover the current network and selects its own host ID based on its MAC using the EUI64 process

- If you want to still use DHCP, there is a DHCPv6 protocol

- IPv6 uses Neighbor Discovery Protocol (NDP) to learn the Layer 2 addresses on the network

Neighbor Discovery Protocol (NDP)

- Used to learn Layer 2 addresses on network

- Router Solicitation
  - Hosts send message to locate routers on link
- Router Advertisement
  - Router advertise their presence periodically and in response to solicitation
- Neighbor Solicitation
  - Used by nodes to determine link layer addresses
- Neighbor Advertisement
  - Used by nodes to respond to solicitation messages
- Redirect
  - Routers informing host of better first-hop routers

IPv6 Data Flows

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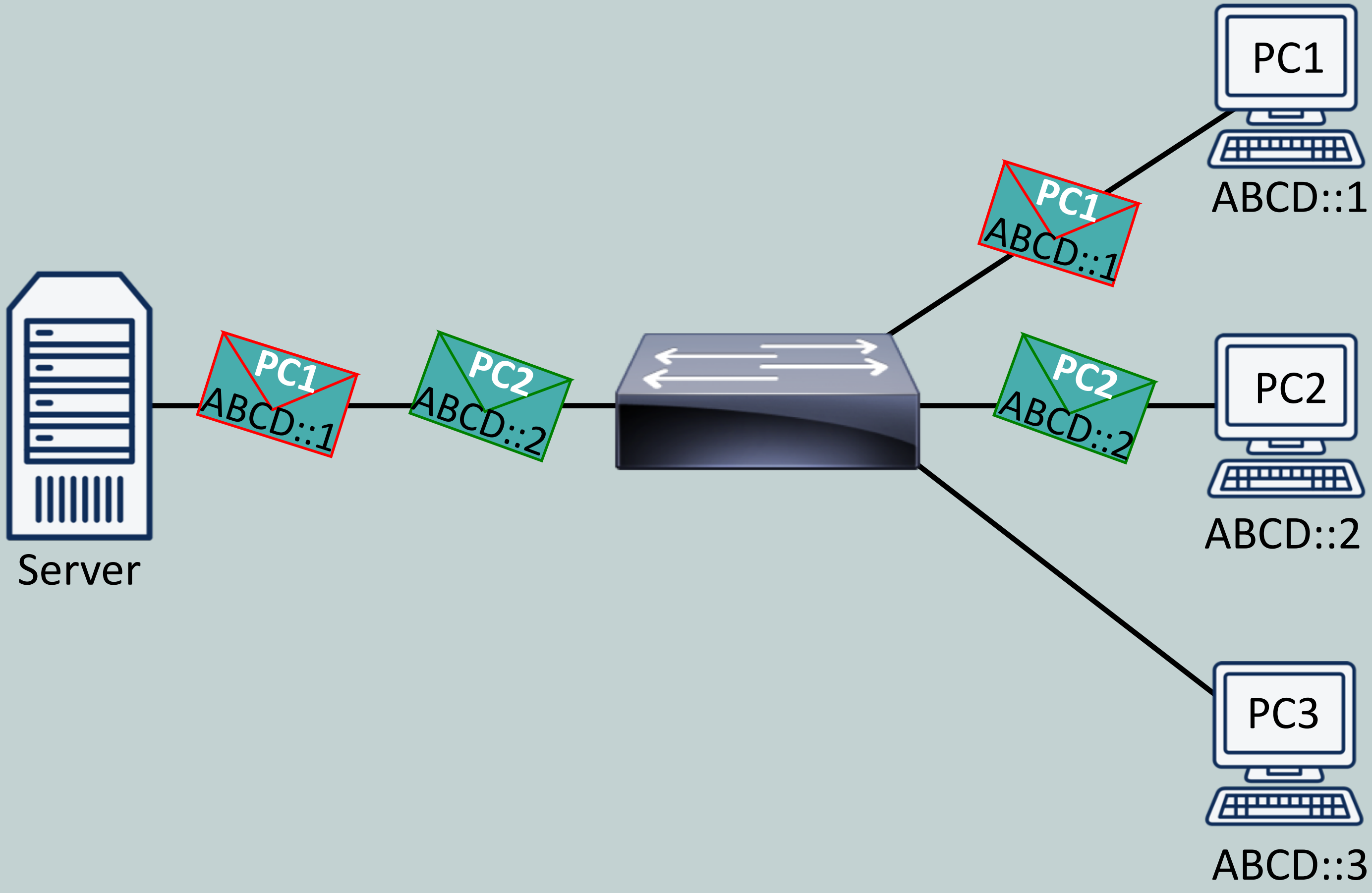
IPv6 Data Flows

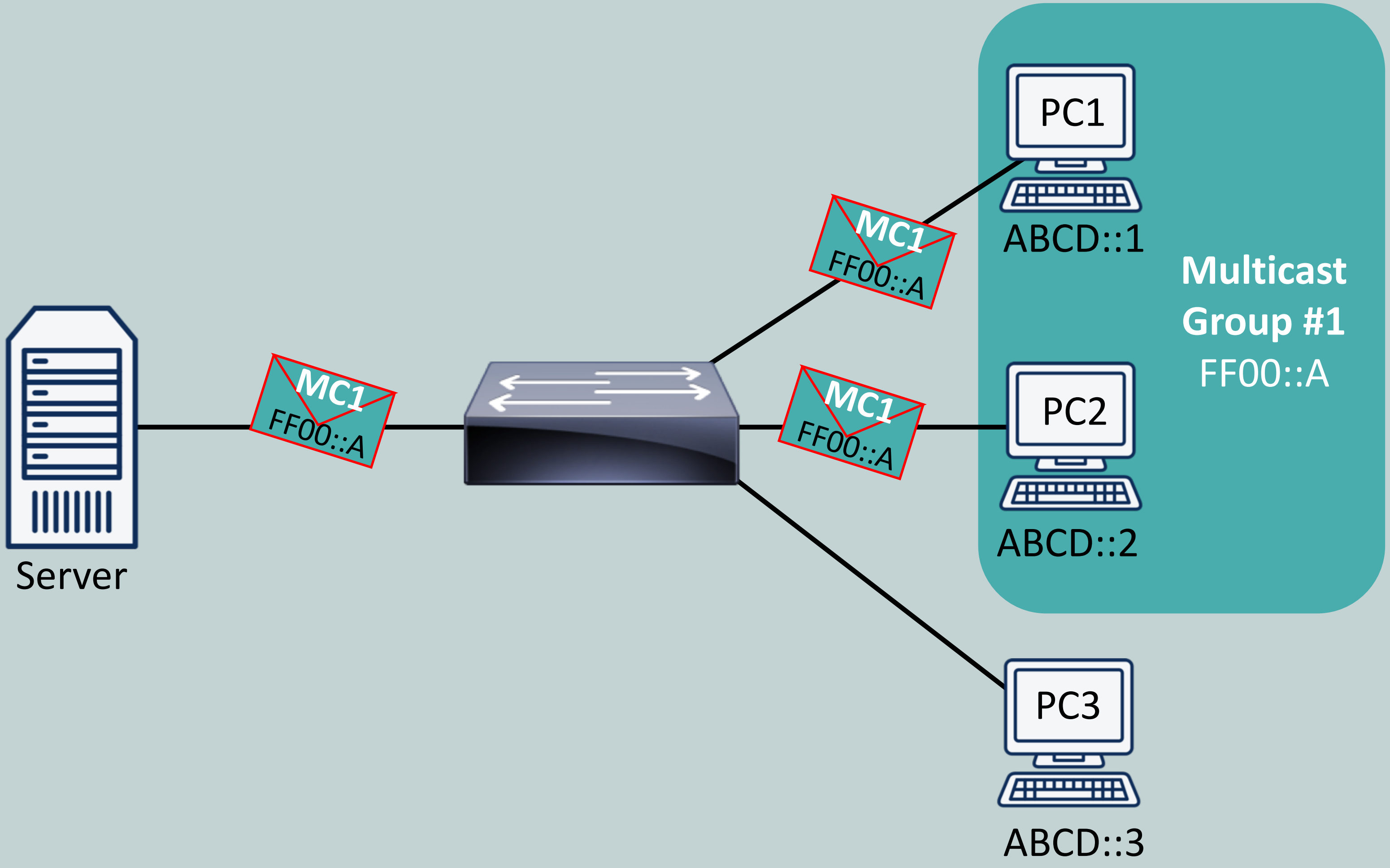
- Three data flow methods, like IPv4
  - Unicast
  - Multicast
  - Anycast (new to IPv6)

Unicast



Data travels from a single source device to a single destination device

Multicast

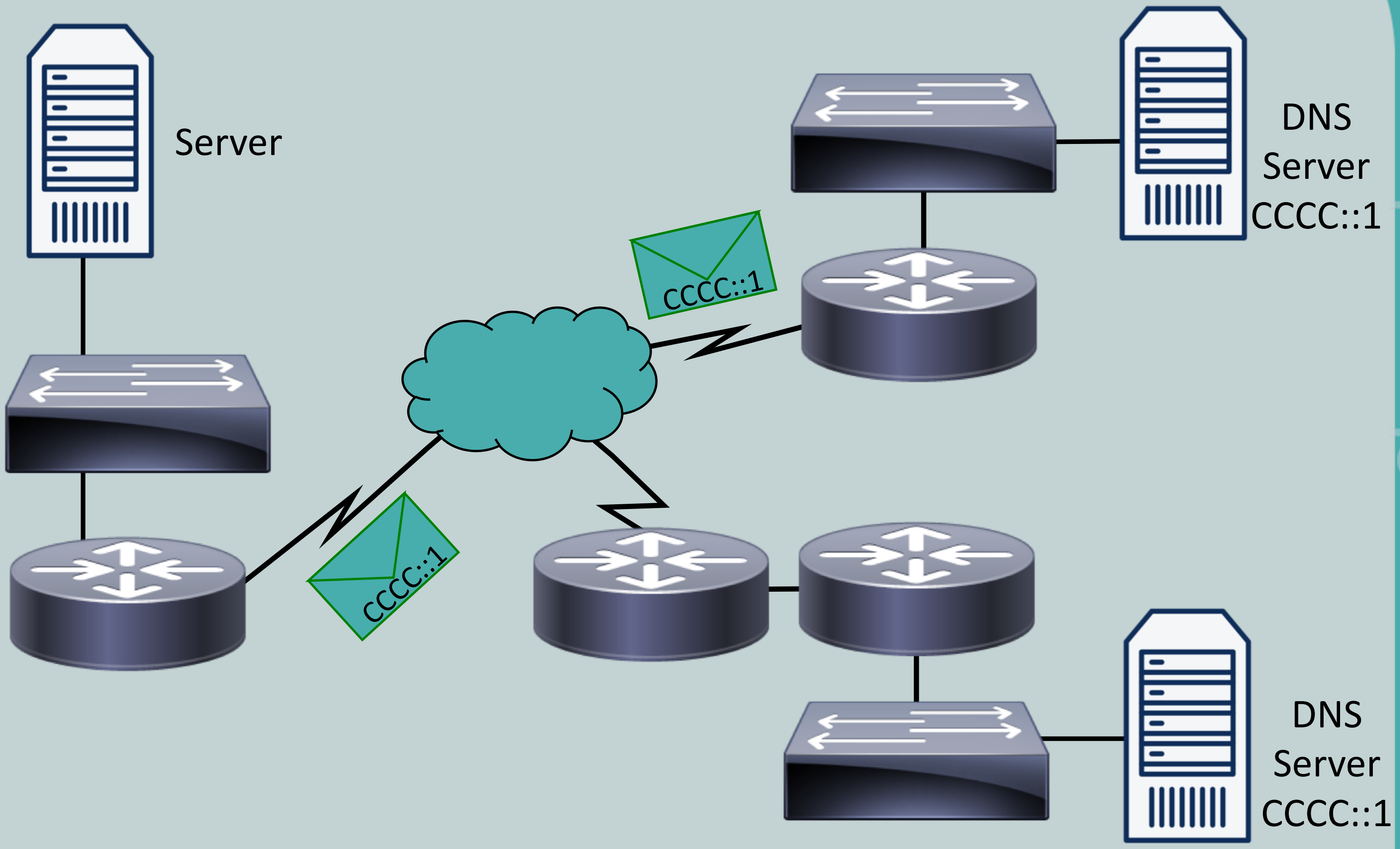


Data travels from a single source device to multiple (but specific) destination devices

Anycast

- Designed to let one host initiate the efficient updating of router tables for a group of hosts
- IPv6 can determine which gateway host is closest and sends the packets to that host as though it were a unicast communication
- That host can anycast to another host in the group until all routing tables are updated

Anycast



Data travels from a single source device to the device nearest to multiple (but specific) destination devices