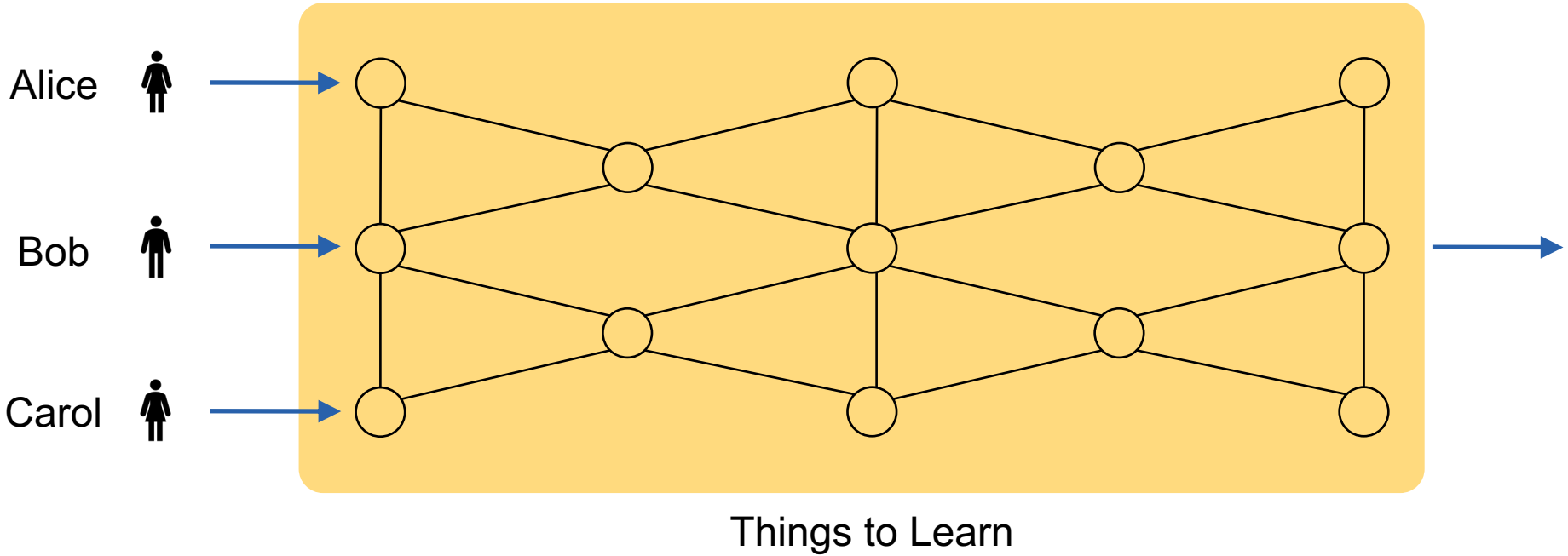
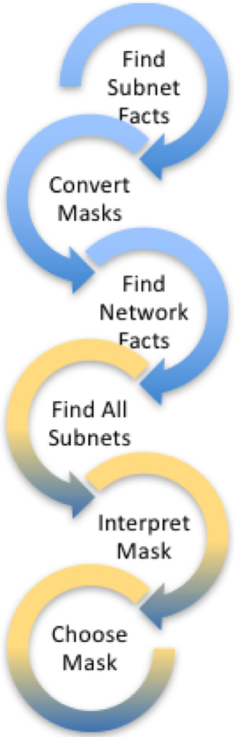
IP Subnetting:
From Beginning to Mastery

Starting Points and Finishing Points



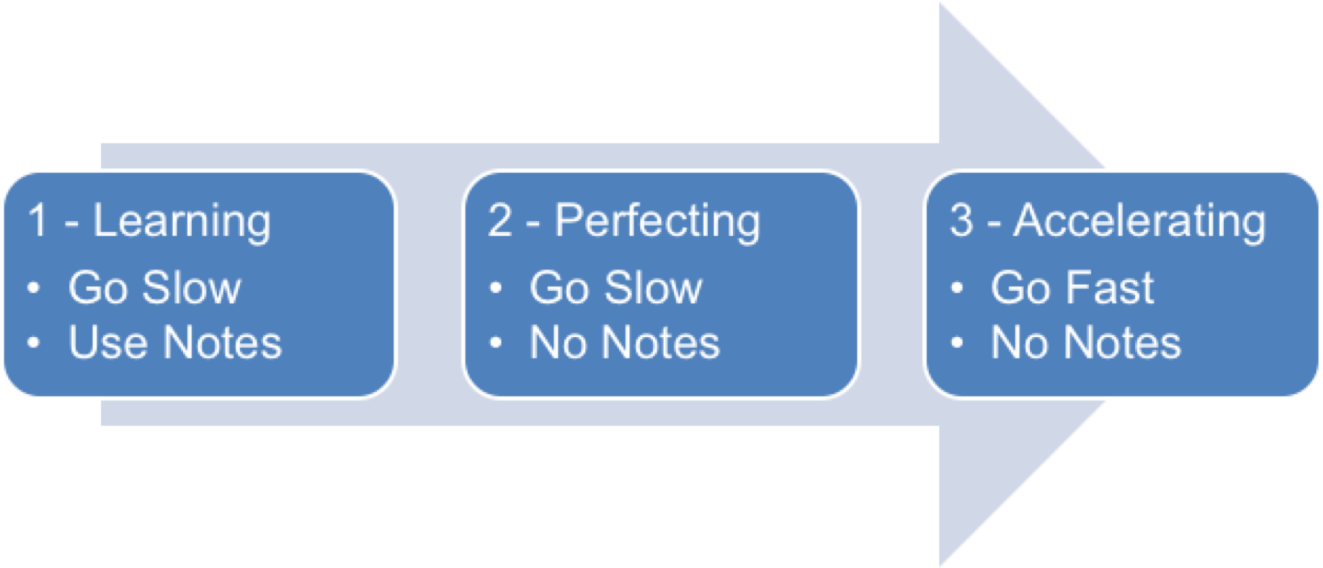
Six Subnetting Branches for This Course

Day 1



Day 2

Learning Stages



Course Outline

Day 1

Section 1: Analyzing Existing Subnets
Section 2: Converting Subnet Masks
Section 3: Analyzing IP Networks

Day 2

Office Hours (QA for the First 20 Minutes)
Section 4: Finding All Subnets in a Network
Section 5: Analyzing Designs Using Masks
Section 6: Subnetting and the Exam

IPv4 Subnetting – Sections

Section 1: Analyzing Individual Subnets

Section 2: Converting Subnet Masks

Section 3: Analyzing IP Networks

Section 4: Identifying the Subnets of a Network

Section 5: Analyzing Designs Using Masks

Section 6: Subnetting and the Exam

IPv4 Subnetting – Section 1

Addressing, Routing, and Routing Protocols

IPv4 Subnetting Basics

Learning Stages

* Finding Subnet Facts: Simple Masks

* Finding Subnet Facts: Difficult Masks

In This Lesson...

Addressing, Routing, and Routing Protocols

- **IP Addressing**
- IP Routing
- IP Routing Protocols
- Summary and Terms

What is an IP Address?

1. A number defined by Internet Protocol (IP) in RFC 791
2. A 32-bit Binary Number
3. A Dotted Decimal Number (DDN)
4. An Identifier for an Interface Connected to a TCP/IP Network
5. A Destination and Source for IP Packets
6. A Key Used by Routers for Routing Table Lookups
7. A Value that when Combined with a Mask Identifies a Subnet

A Sample IP Address

Binary				DDN
00001010	00000001	00000001	00000001	10.1.1.1

First Few Addresses of Network 10.0.0.0

10.0.0.0
10.0.0.1
10.0.0.2
10.0.0.3
10.0.0.4
10.0.0.5
10.0.0.6
10.0.0.7

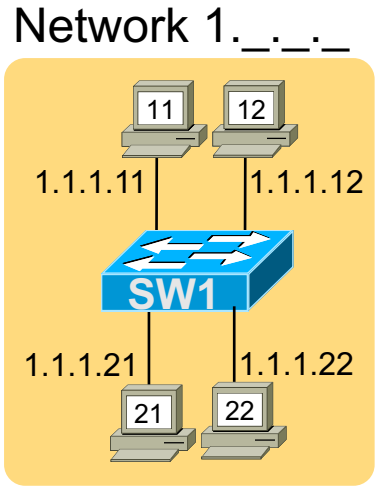
First Few Addresses of Network 10.0.0.0

00001010	00000000	00000000	00000000	10.0.0.0
00001010	00000000	00000000	00000001	10.0.0.1
00001010	00000000	00000000	00000010	10.0.0.2
00001010	00000000	00000000	00000011	10.0.0.3
00001010	00000000	00000000	00000100	10.0.0.4
00001010	00000000	00000000	00000101	10.0.0.5
00001010	00000000	00000000	00000110	10.0.0.6
00001010	00000000	00000000	00000111	10.0.0.7

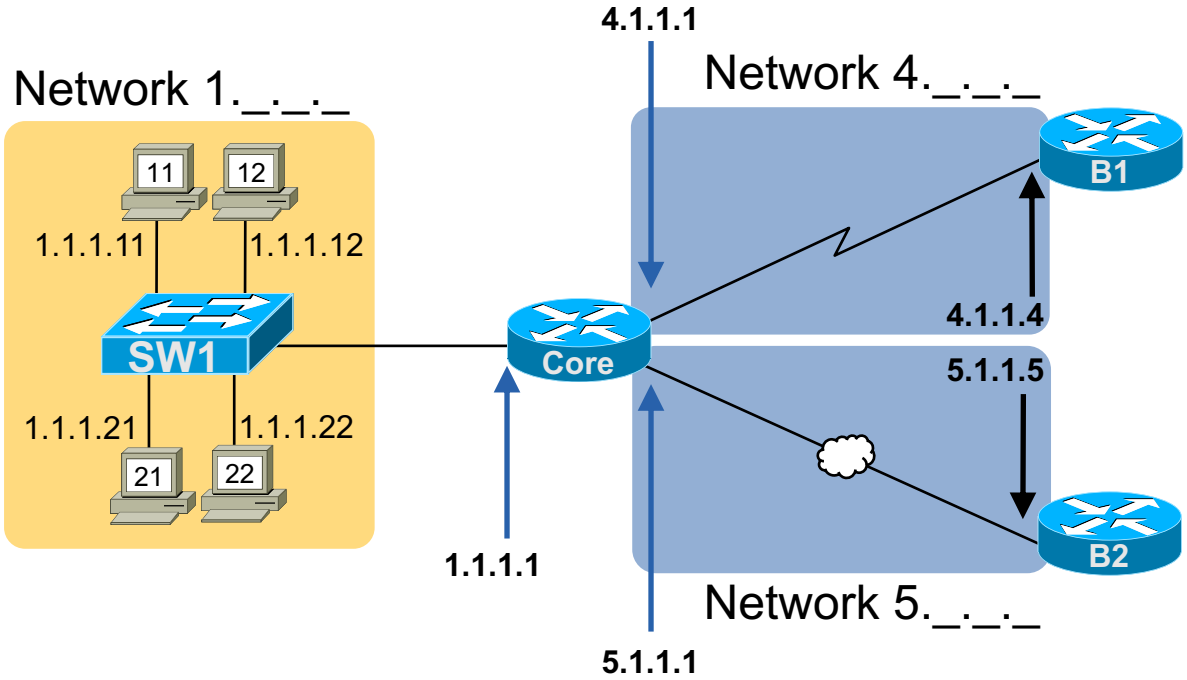
Network

Host

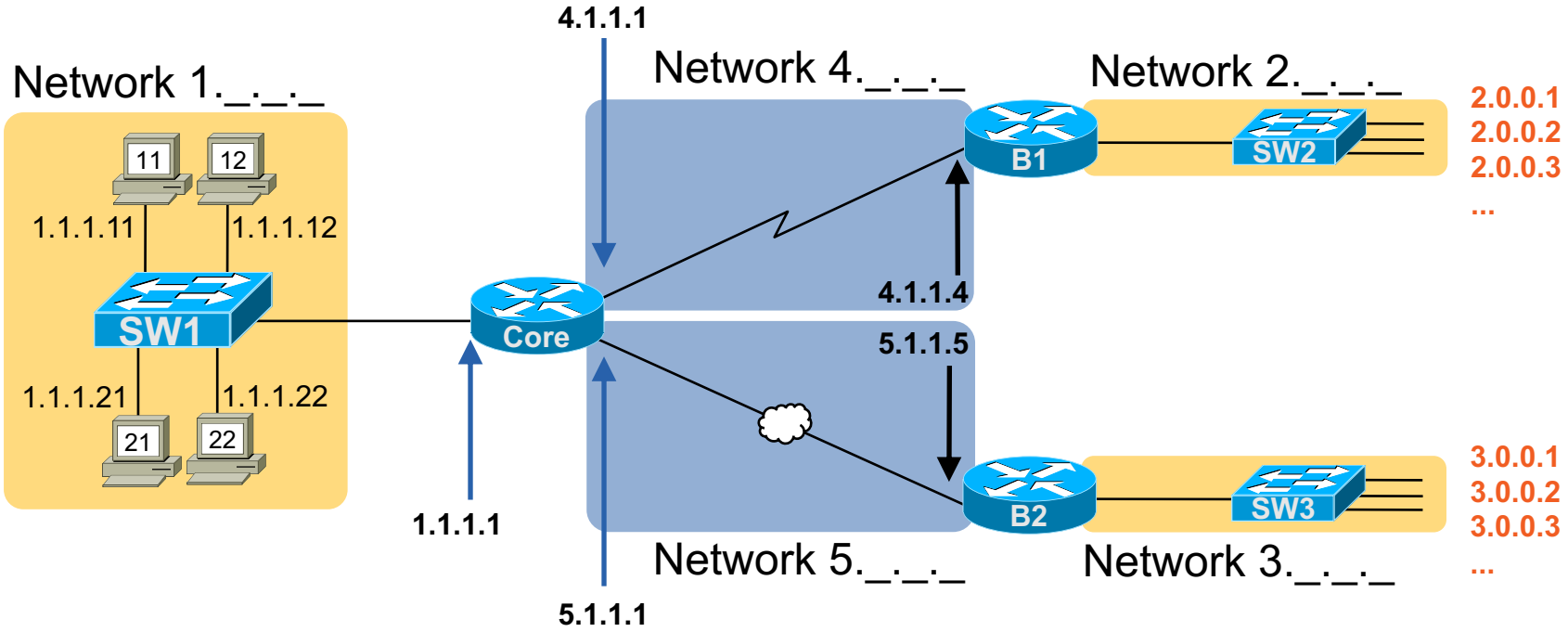
IP Address for Each LAN Interface



One IP Address Per Router Interface



Pick Unused Addresses from Each Network



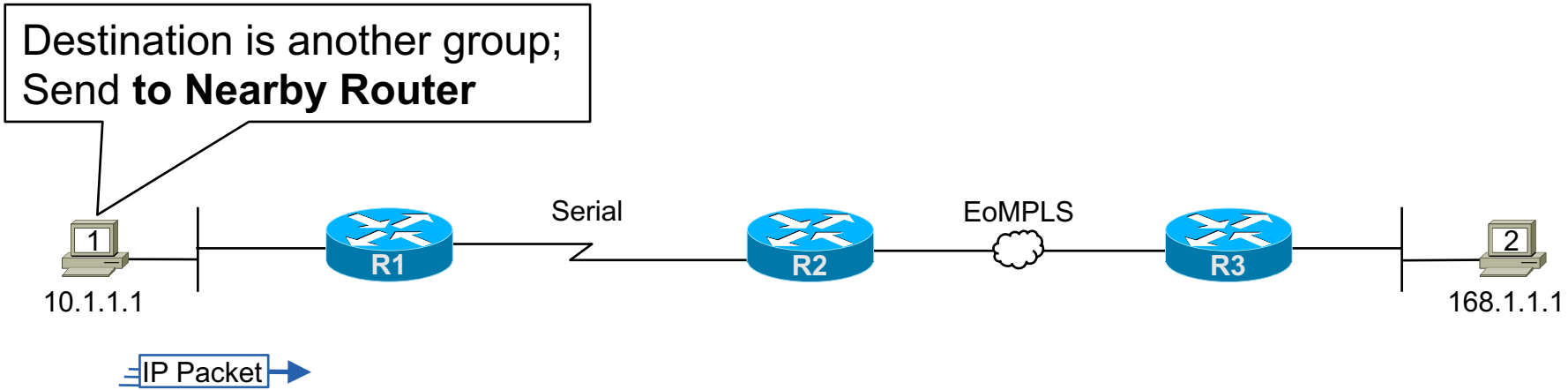
In This Lesson...

Addressing, Routing, and Routing Protocols

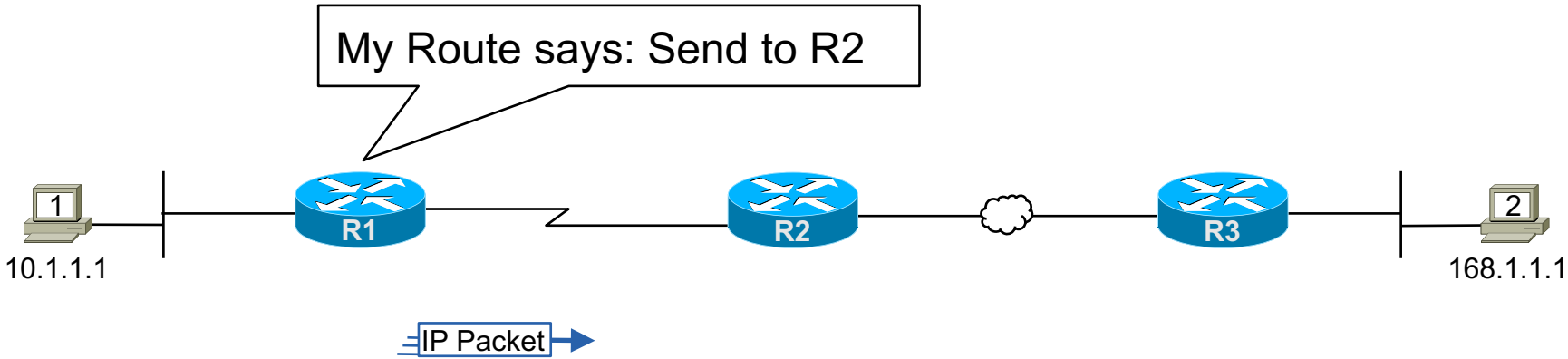
- IP Addressing
- **IP Routing**
- IP Routing Protocols
- Summary and Terms

A Sample IPv4 Topology Figure

IPv4 Routing Review



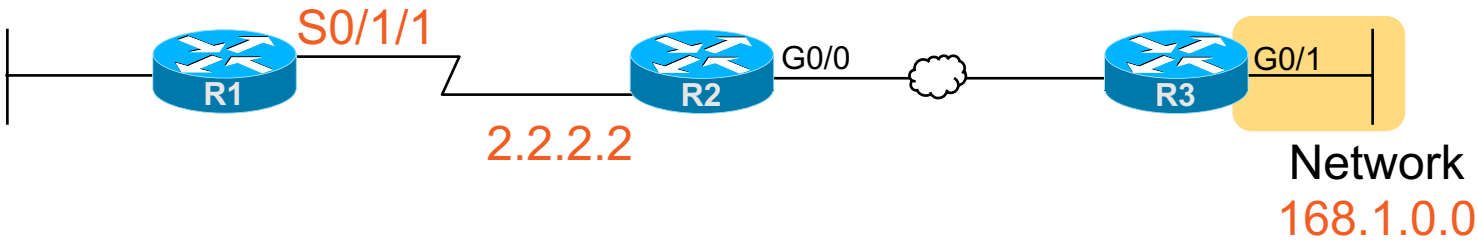
IPv4 Routing Review



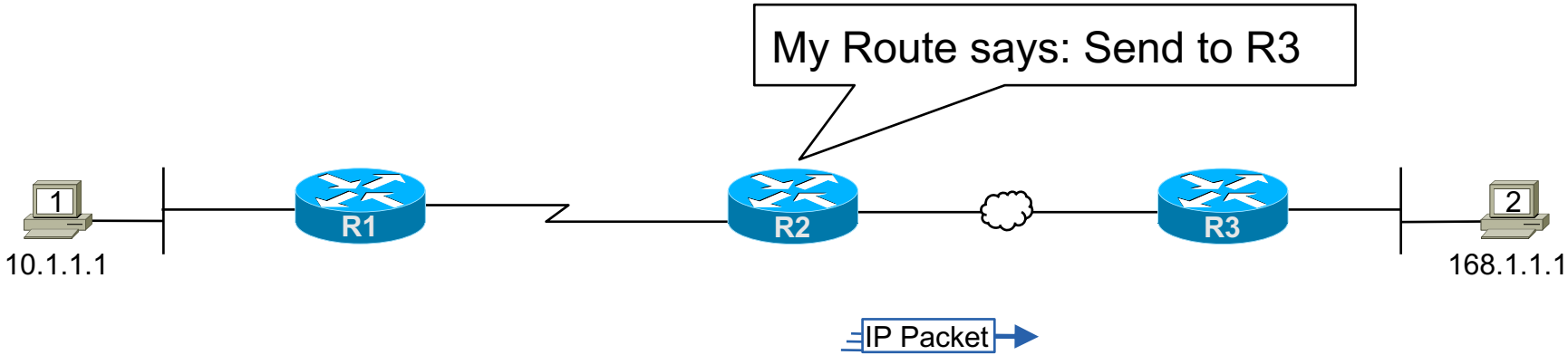
Sample IP Routing Table Entry

R1 Routing Table

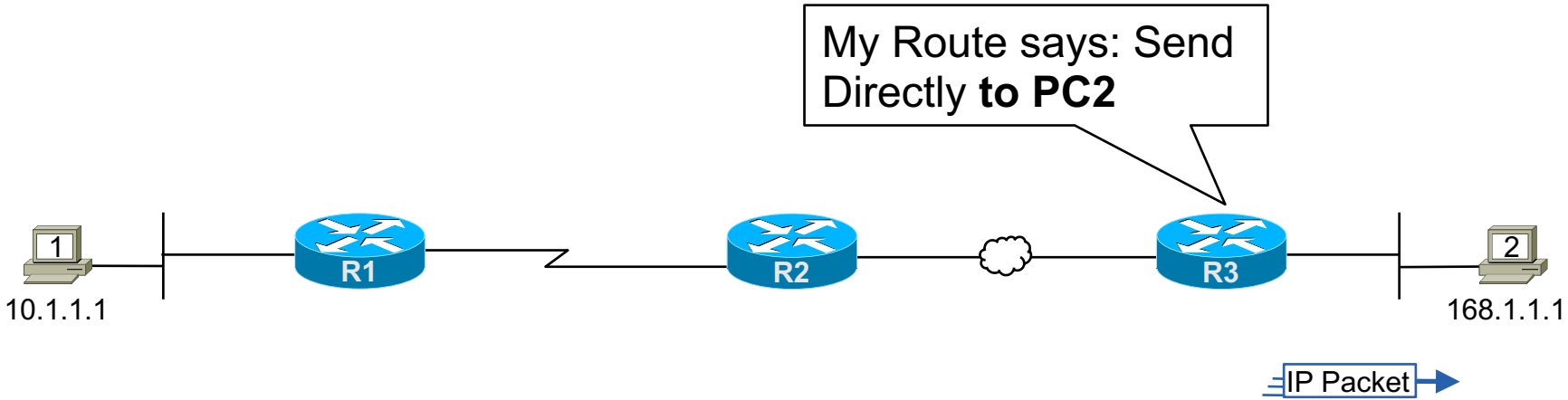
Subnet	Interface	Next Hop
168.1.0.0	Serial0/1/1	2.2.2.2



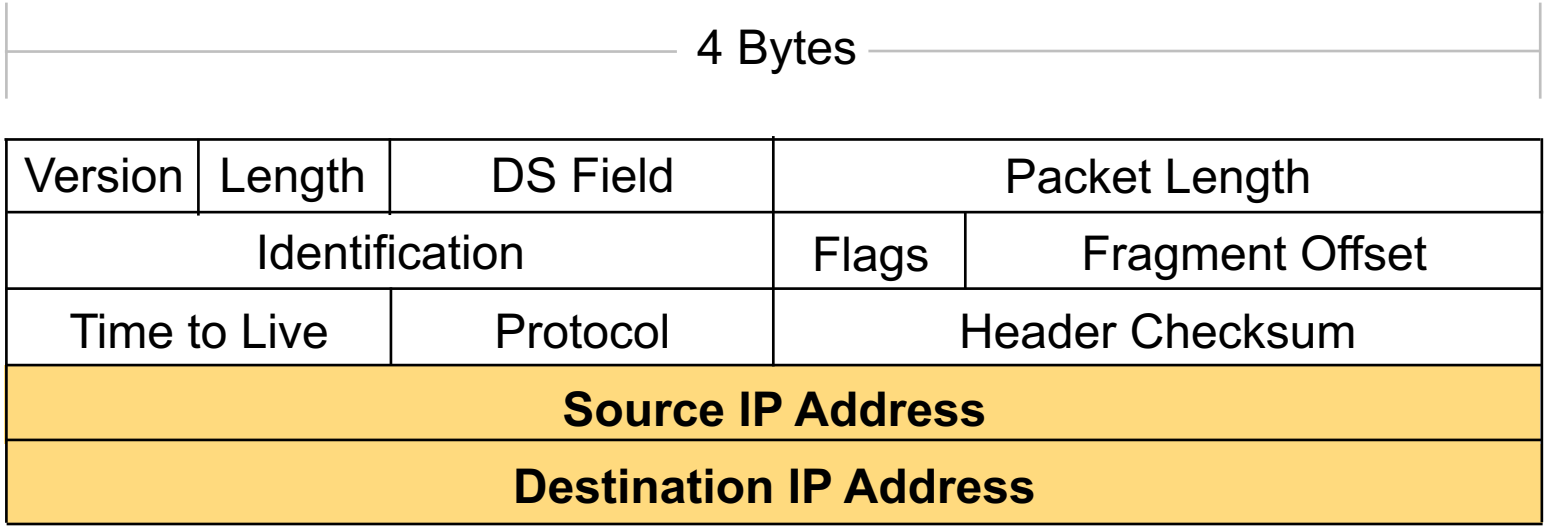
IPv4 Routing Review



IPv4 Routing Review



IPv4 Header Reference

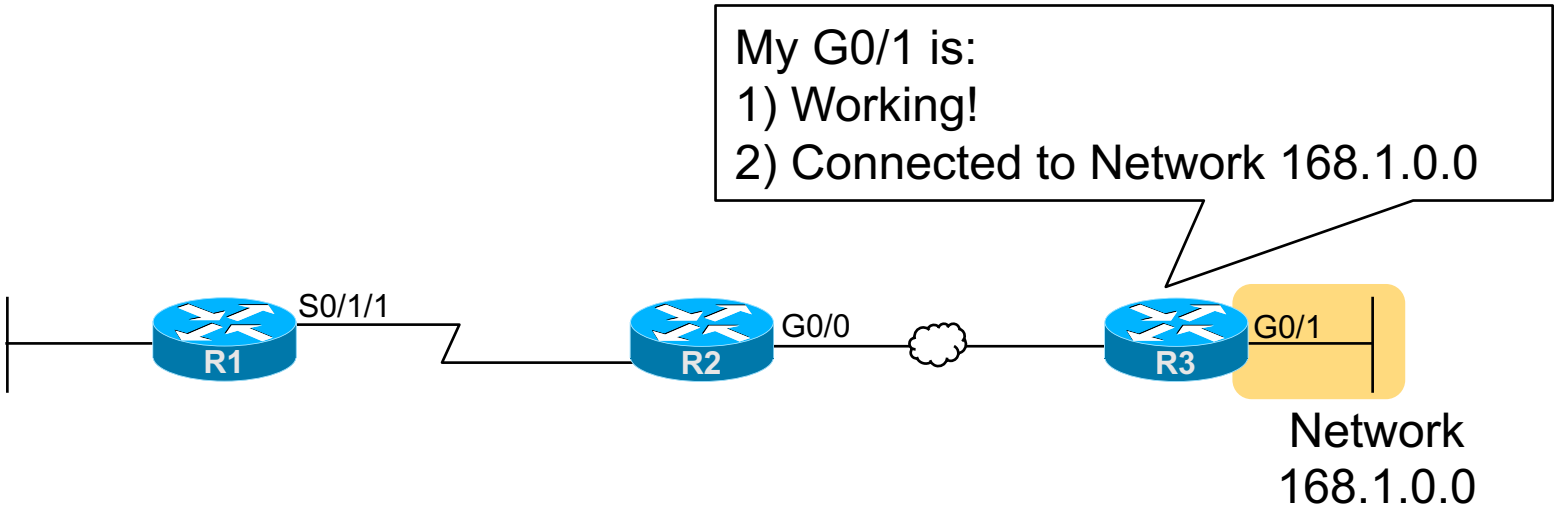


In This Lesson...

Addressing, Routing, and Routing Protocols

- IP Addressing
- IP Routing
- **IP Routing Protocols**
- Summary and Terms

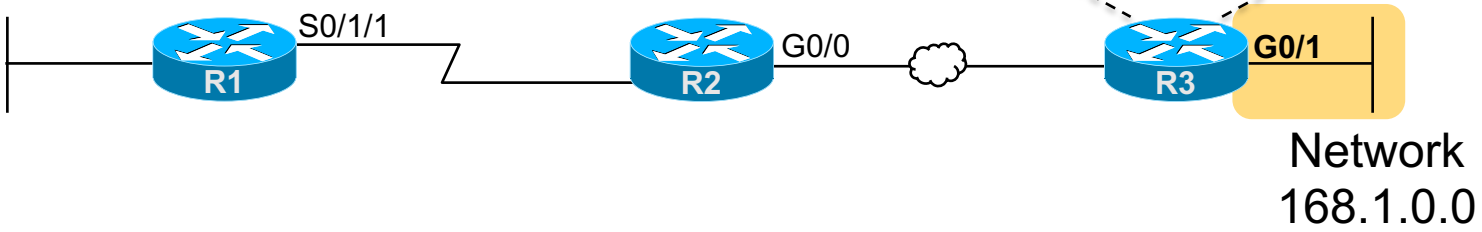
Connected Routes



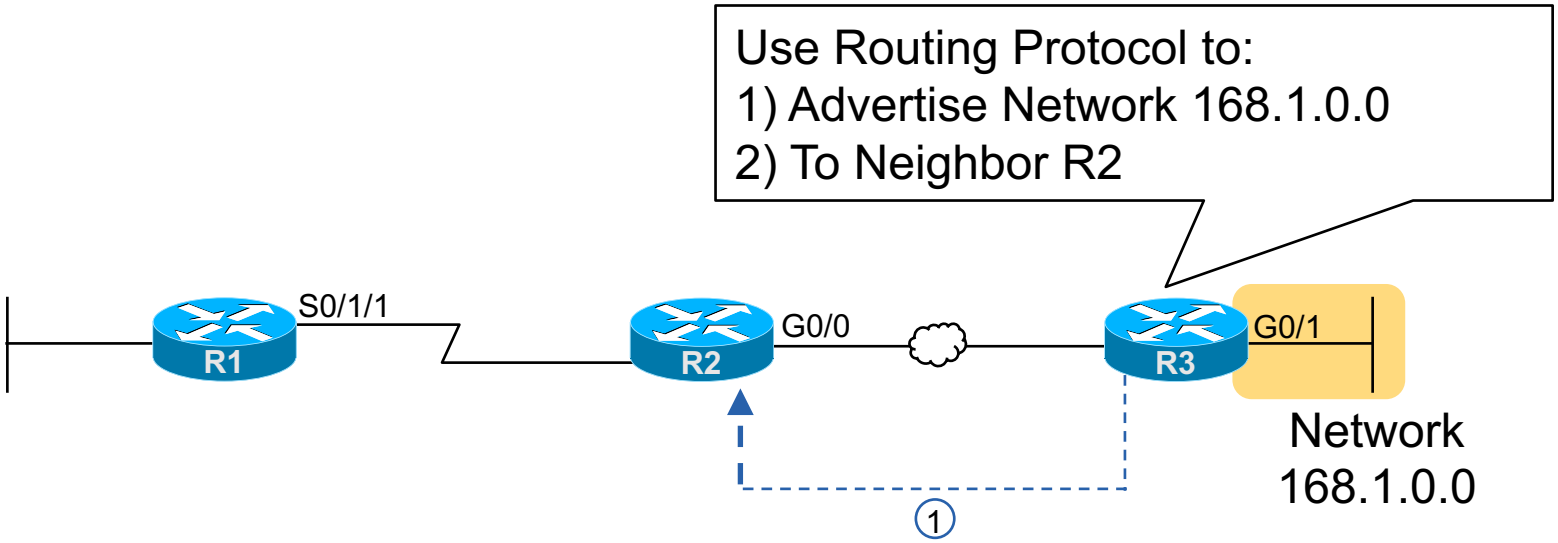
Connected Routes

R3 Routing Table

Subnet	Interface	Next Hop
168.1.0.0	G0/1	N/A



Routing Protocol Operation: R3 to R2



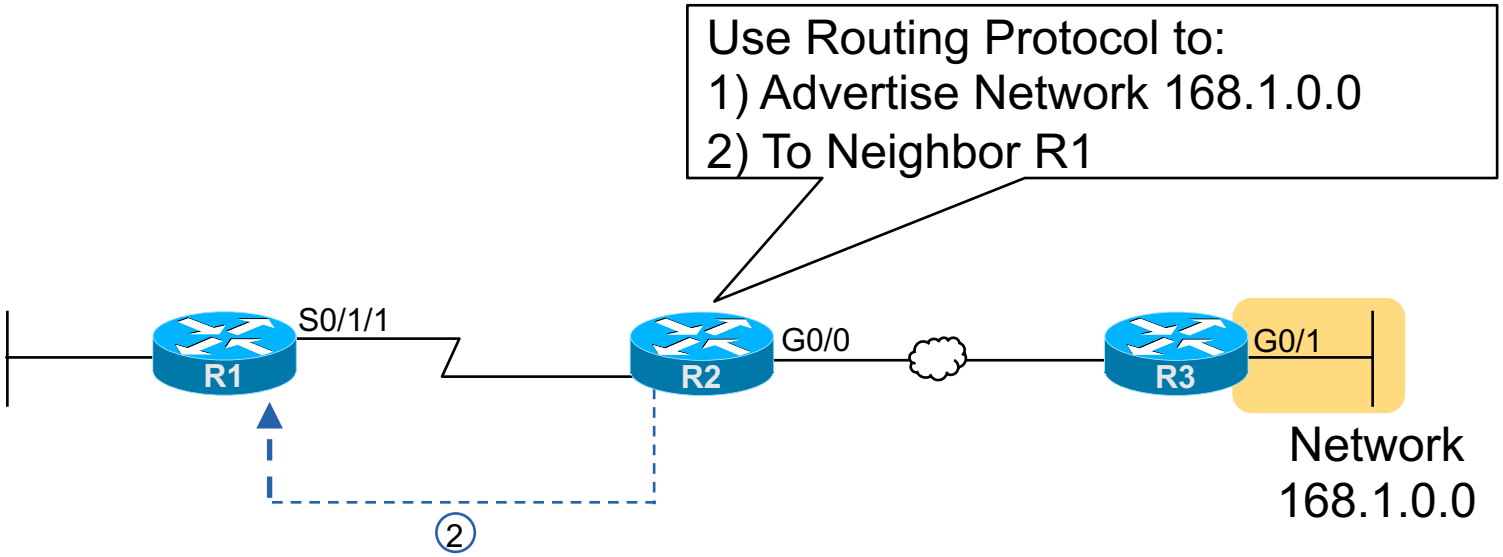
New Route on R2

R2 Routing Table

Subnet	Interface	Next Hop
168.1.0.0	G0/0	R3

Network
168.1.0.0

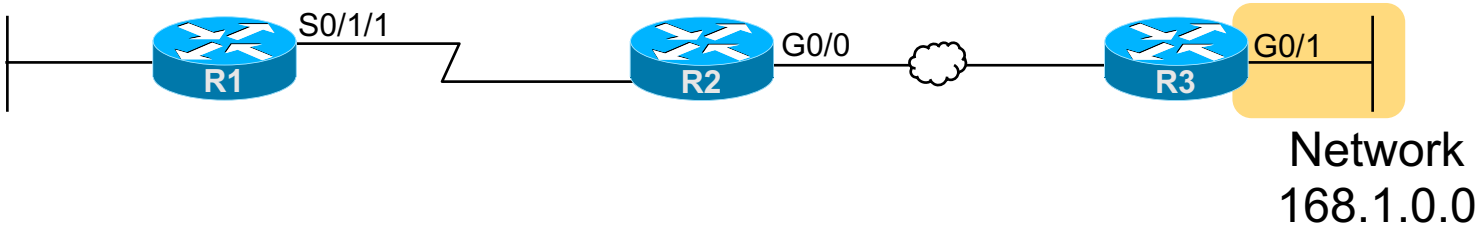
Routing Protocol Operation: R2 to R1



New Route on R1

R1 Routing Table

Subnet	Interface	Next Hop
168.1.0.0	Serial0/1/1	R2



In This Lesson...

Addressing, Routing, and Routing Protocols

- IP Addressing
- IP Routing
- IP Routing Protocols
- **Summary and Terms**

Terms from this Topic

Protocol:
Request for Comment (RFC)
IP
IPv4 (Synonym)

Routing:
Routing
Forwarding
Connected network
Default Gateway
Routing table
Outgoing interface
Next-hop router
Routing protocol
Routing advertisement

Addresses:
IP Address
IPv4 Address (Synonym)

Source IP Address
Destination IP Address

Unicast
Multicast

Interface address

Terms from this Topic

Address Groupings:

Network
IPv4 Network (Synonym)
Classful Network (Synonym)

Class A, B, or C Network
Subnet

Network ID
Network Address (Synonym)
Network Number (Synonym)

Miscellaneous

Subnet
Binary
Dotted Decimal Number (DDN)
Octet
Router interface

Masks:

Default Mask
Mask
Subnet Mask

IPv4 Subnetting – Sections

Section 1: Analyzing Individual Subnets

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IPv4 Subnetting – Section 1

Addressing, Routing, and Routing Protocols

IPv4 Subnetting Basics

Learning Stages

* Finding Subnet Facts: Simple Masks

* Finding Subnet Facts: Difficult Masks

Definition and Attributes of Subnets

Topological:

1. Addresses in the Same VLAN
2. Addresses on the Same WAN Link

Conceptual:

1. A Predictable Set of Consecutive Numbers
2. Subnet Size and Starting Value Based on 2^H
3. Defines a Location

Mathematical:

1. Defined by Two Numbers: ID and Mask
2. Two Reserved Numbers Per Subnet
3. Address Values: Identical Vs. Different Parts

In This Lesson...

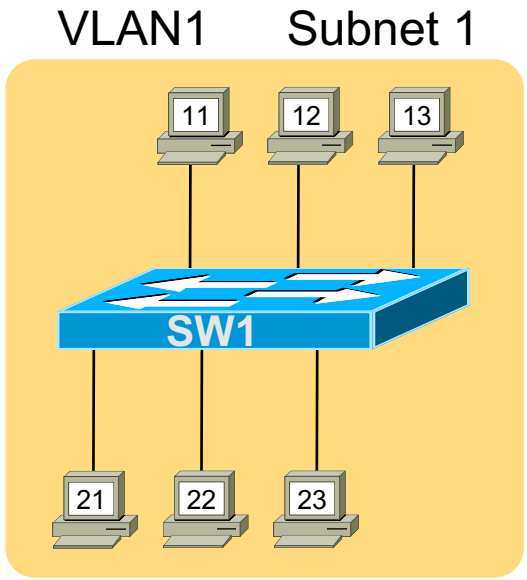
Subnetting: Topology, Concepts, and Math

- **Topology and Subnetting**
- Concepts and Subnetting
- Math and Subnetting
- Summary and Terms

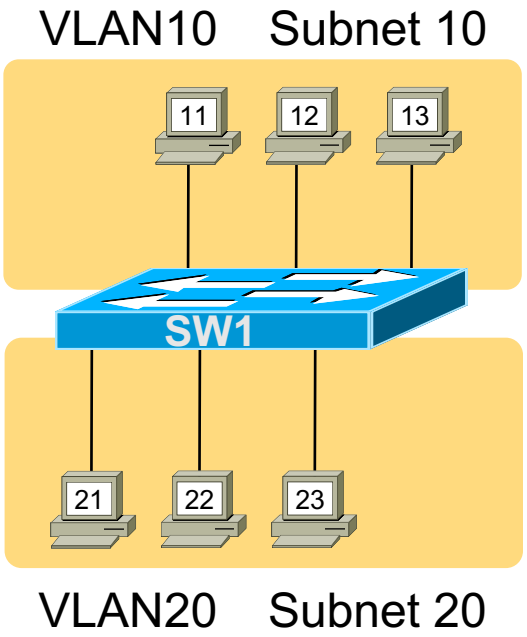
Subnet Needs

- VLAN
- Serial Link
- Ethernet WAN

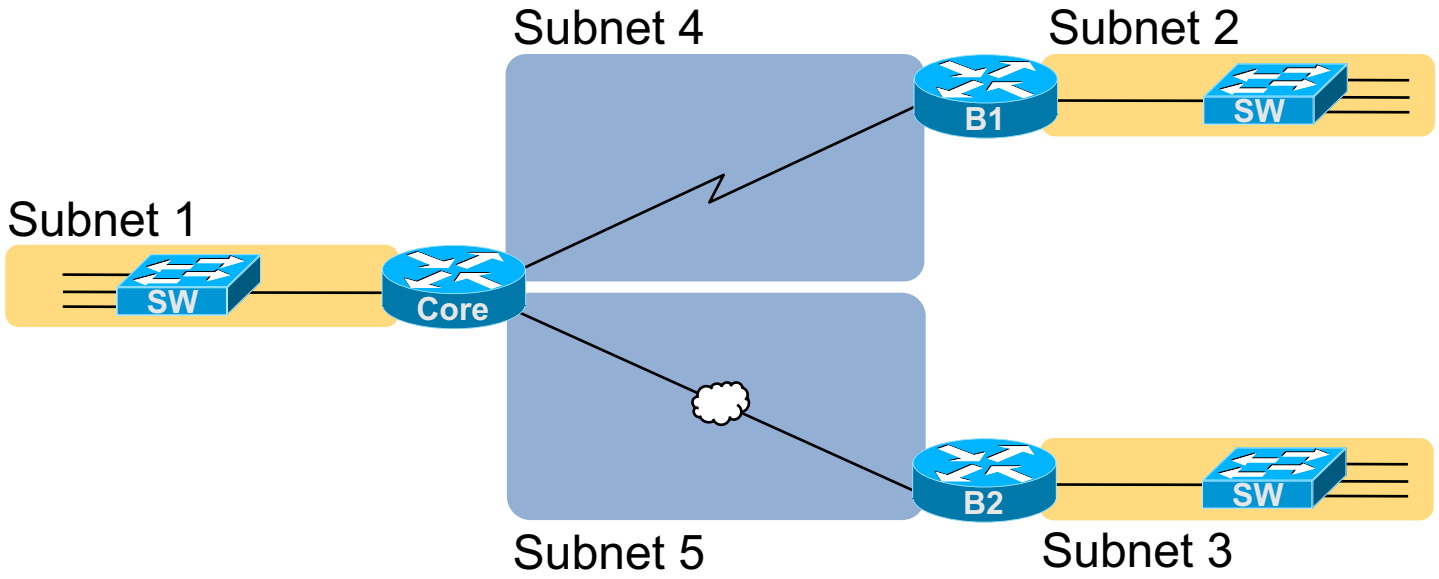
Topology: One VLAN, One Subnet



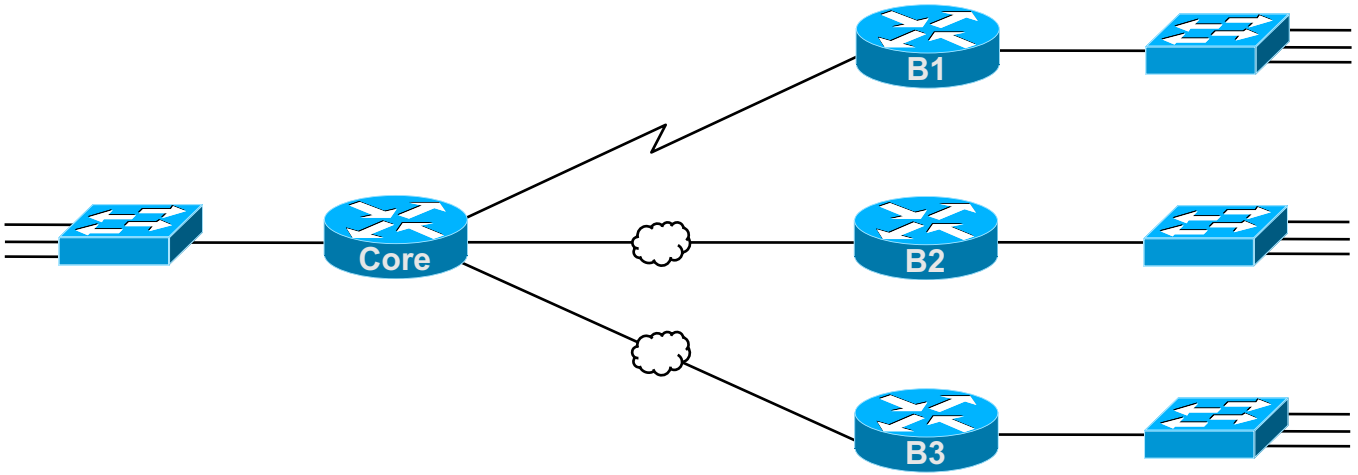
Topology: Two VLANs, Two Subnets



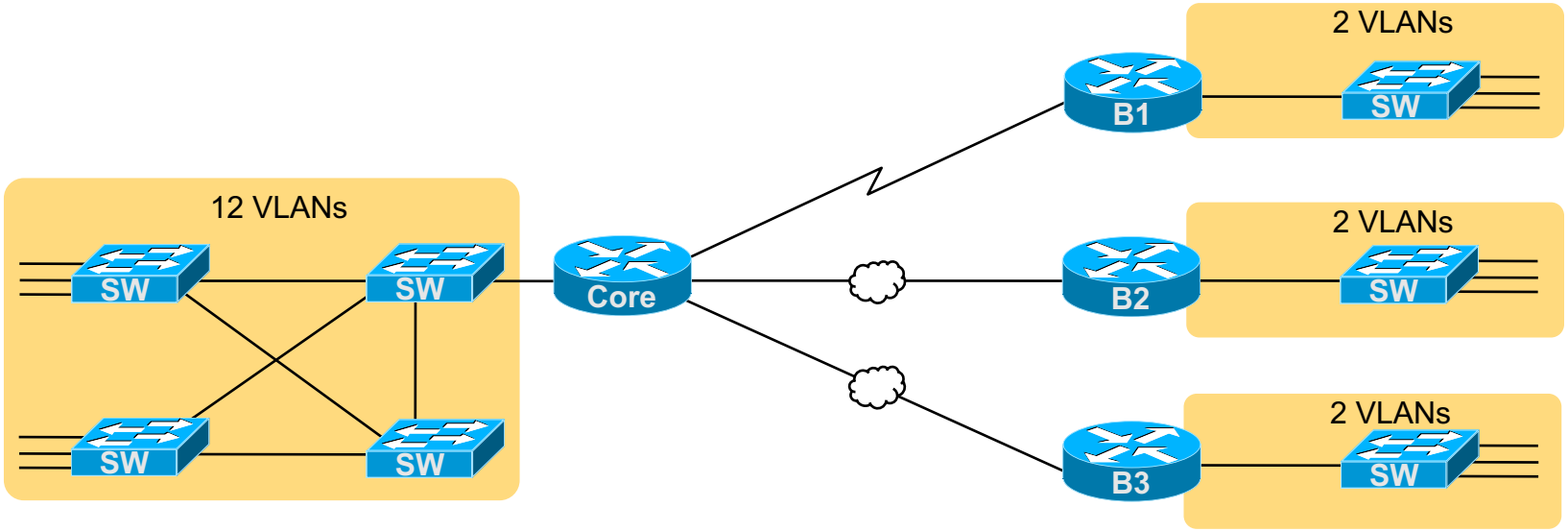
Three VLANs and Two WAN Links



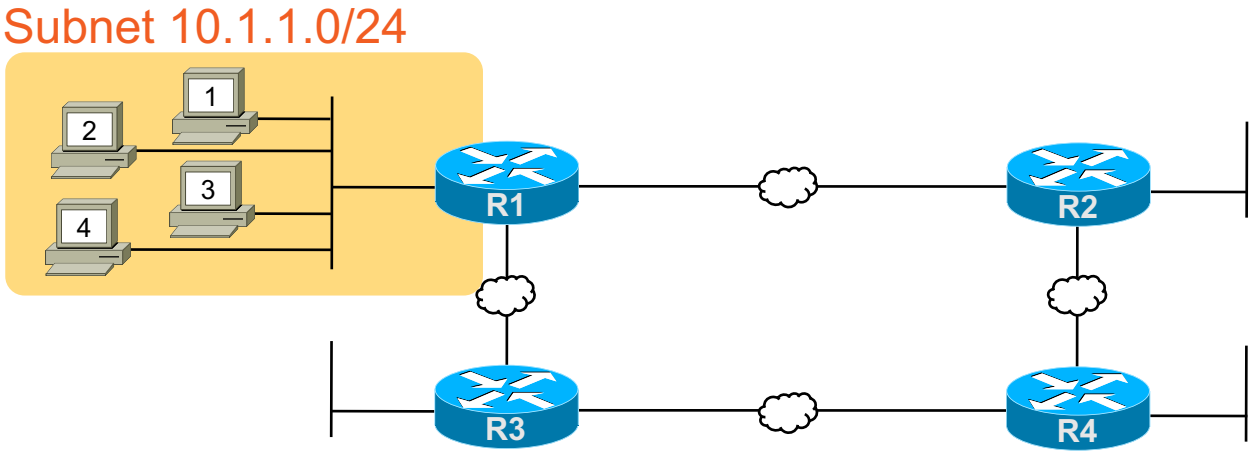
Subnet Needs



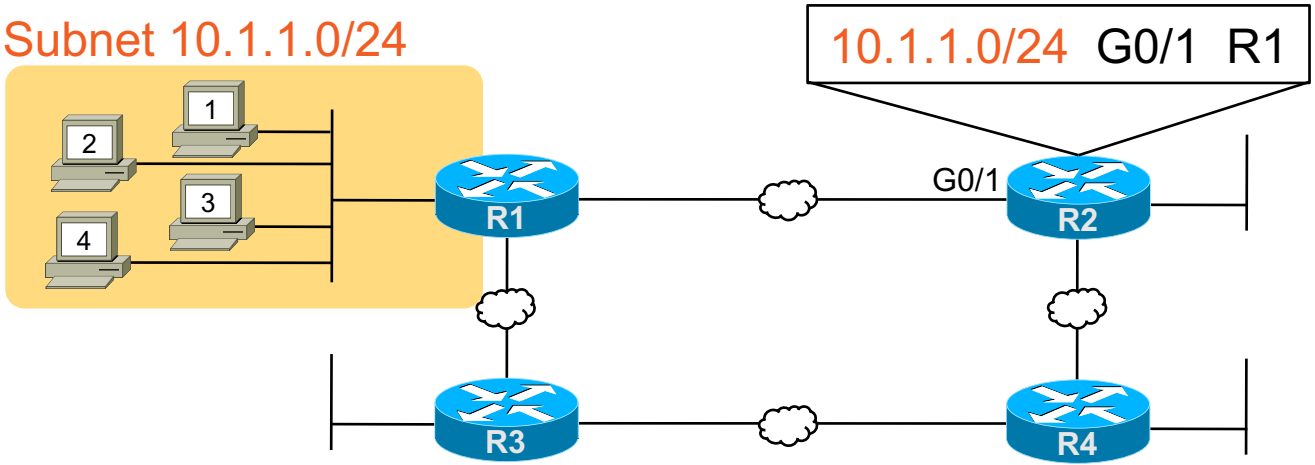
Subnet Needs



Correct Use of Addresses in Same Subnet

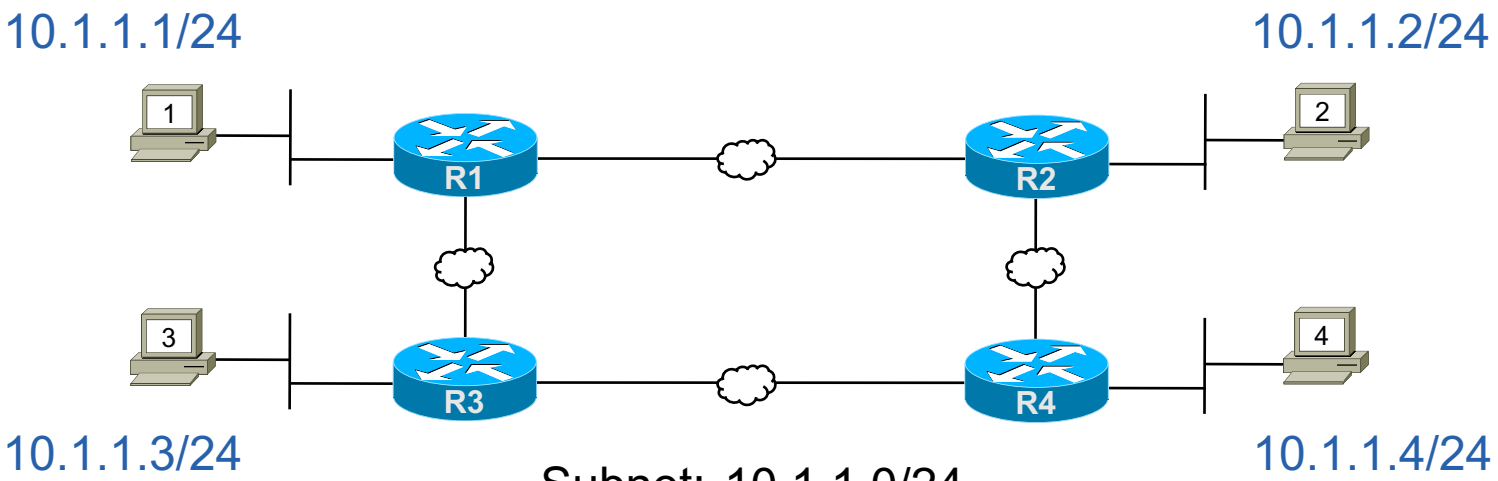


Correct Use of Addresses in Same Subnet



Subnet:	10.1.1.0/24
ID:	10.1.1.0
First:	10.1.1.1
Last:	10.1.1.254
B'Cast:	10.1.1.255

Incorrect Use of Addresses in Same Subnet



Subnet: 10.1.1.0/24

ID:	10.1.1.0
1st:	10.1.1.1
Last:	10.1.1.254
B'Cast:	10.1.1.255

In This Lesson...

Subnetting: Topology, Concepts, and Math

- Topology and Subnetting
- **Concepts and Subnetting**
- Math and Subnetting
- Summary and Terms

A Game: A Predictable Set Size

Game:

1. Choose 10 non-negative integers
2. Consecutive values
3. Write as an inclusive range (e.g., 15-24)

1,111,111 – 1,111,121

1 - 10

85-94

22,456 – 23,465

351,160 – 351,169

110 - 119

4,320 – 4,329

A Game: A Predictable Set Size

Game:

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1,111,111 – 1,111,121

1 - 10

85-94

22,456 – 23,465

351,160 – 351,169

110 - 119

4,320 – 4,329

A Game: New Rule: Start with Multiple of 10

Game:

1. Choose 10 non-negative integers
2. Consecutive values
3. Write as an inclusive range (e.g., 15-24)
4. **Must Start with a multiple of 10**

1 - 10

85-94

351,160 – 351,169

110 - 119

4,320 – 4,329

Defining “Subnet”: Noun

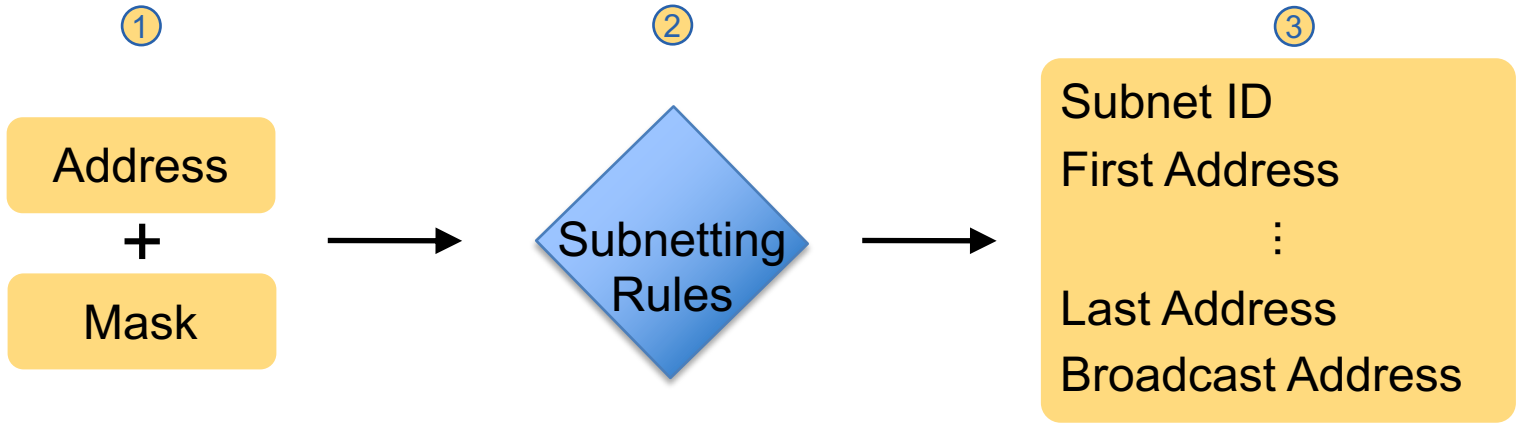
1. A Predictable Set of Consecutive Numbers Like IP Addresses
   A. **Subnet ID**: The Lowest Number in the Subnet
   B. **Address Range**: The Numbers in Between
   C. **Subnet Broadcast Address**: The Highest Number in the Subnet
2. A Set with a Predictable Size
   A. Theoretical Size: 2^H (H is Based on the Subnet Mask)
   B. Two Reserved Numbers: (Subnet ID, Subnet Broadcast Address)
   C. Usable Size: $2^H - 2$

Defining “Subnet”: Verb

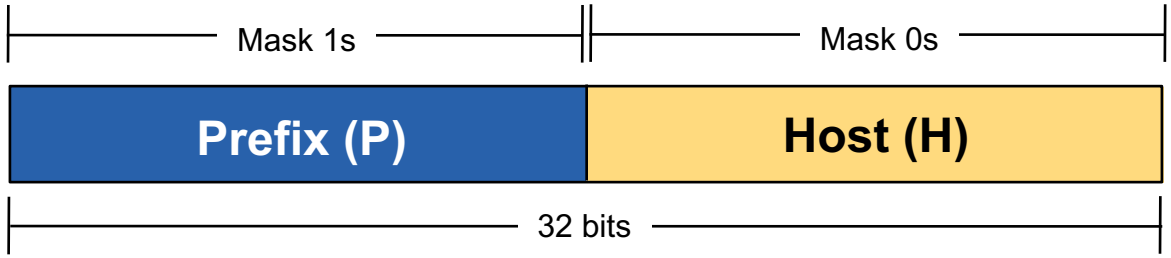
To Follow the Rules of IP Addressing and Subnetting to Subdivide a Network, Including:

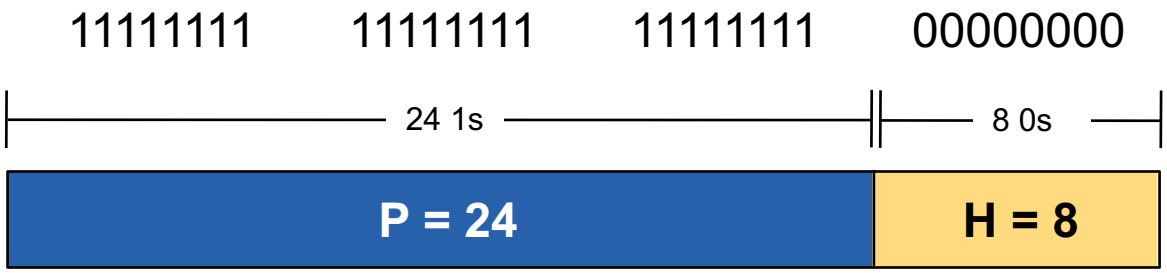
1. To Subdivide a Larger Set of IPv4 Addresses into Multiple Smaller Sets
2. To Subdivide a Set of Size 2^N into Smaller Sets of Size 2^H, in Which H<N
3. To Begin Each Subnet’s Range of Numbers not at an Arbitrary Number, but a Predictable Number: An Integer Multiple of 2^H

Concept: Address + Mask = Subnet Details



Concept: Mask Defines Size Prefix and Host





Calculations: Size of Subnets

Power	Decimal	$2^H - 2$ (# of Hosts)
2^0	1	N/A
2^1	2	N/A
2^2	4	2
2^3	8	6
2^4	16	14
2^5	32	30
2^6	64	62
2^7	128	126

Concept: Subnet Size as 2^H

255 . 255 . 255 . 224

11111111 11111111 11111111 11100000

H = 5

$2^5 = 32$

In This Lesson...

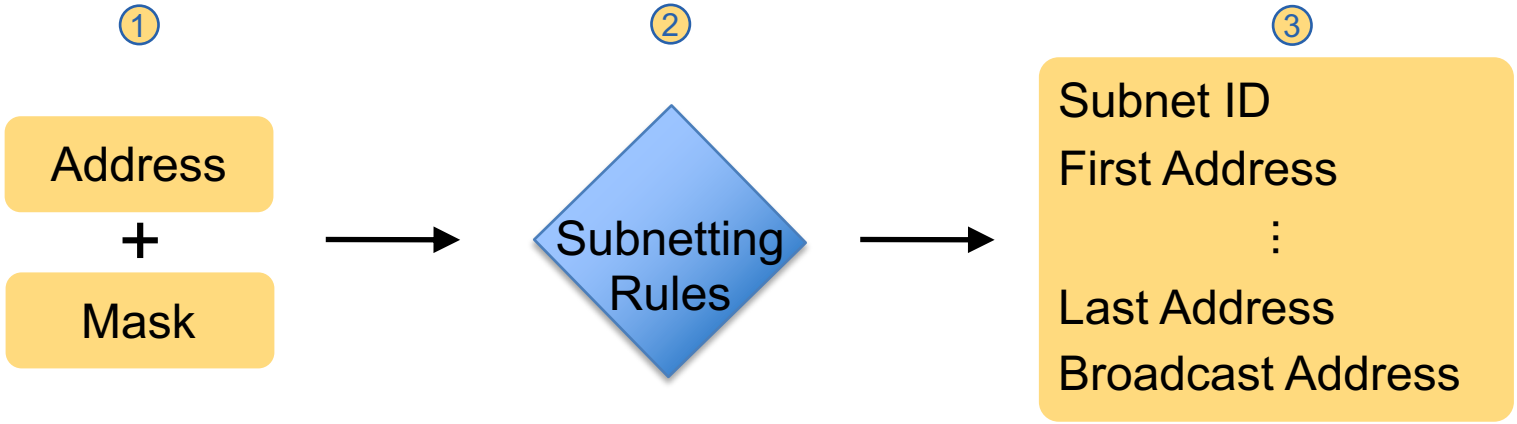
Subnetting: Topology, Concepts, and Math

- Topology and Subnetting
- Concepts and Subnetting
- **Math and Subnetting**
- Summary and Terms

Mathematical

1. Defined by Two Numbers: Subnet ID and Subnet Mask
2. Two Reserved Numbers Per Subnet
3. Address Values: Identical (Prefix) Vs. Different (Host) Parts

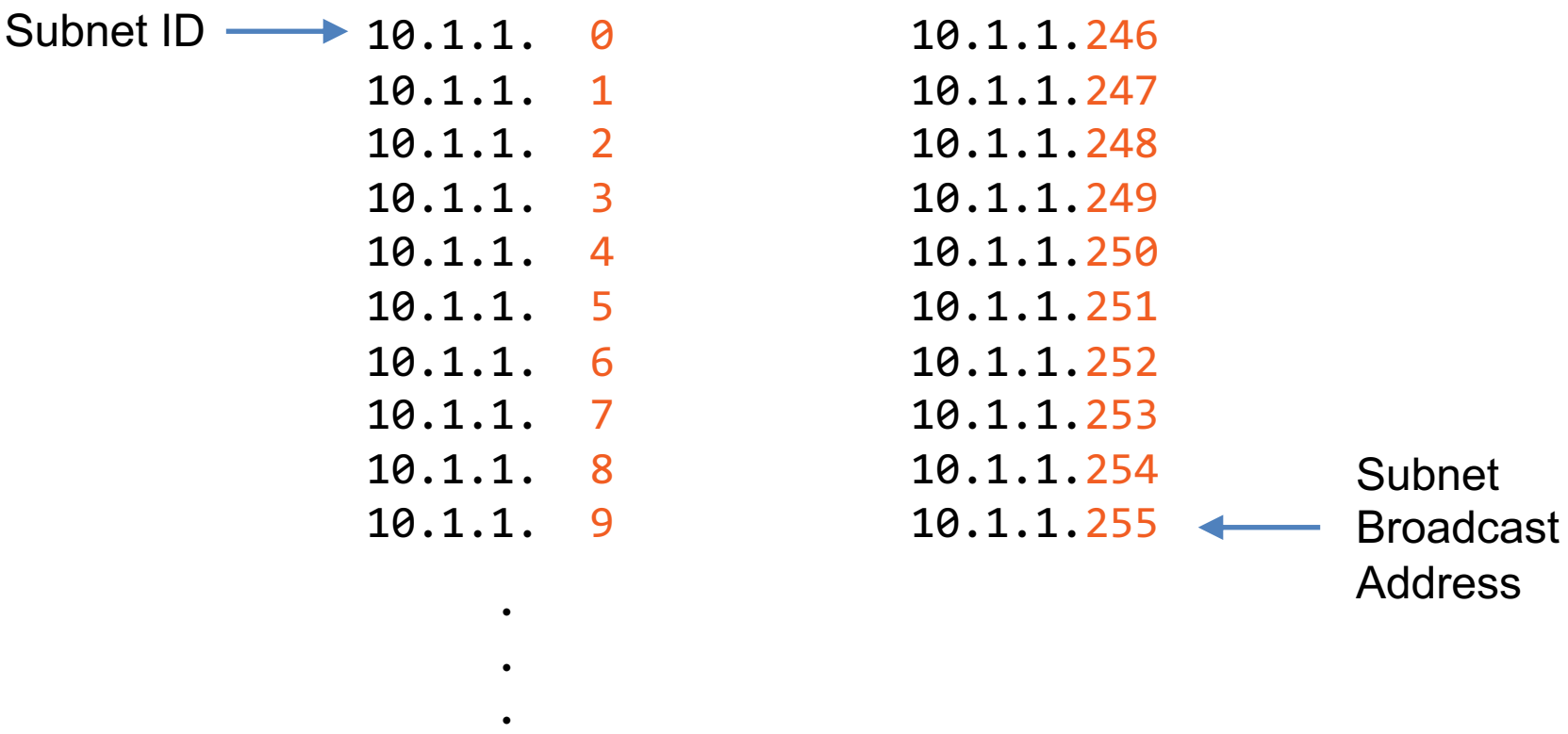
Concept: Address + Mask = Subnet Details



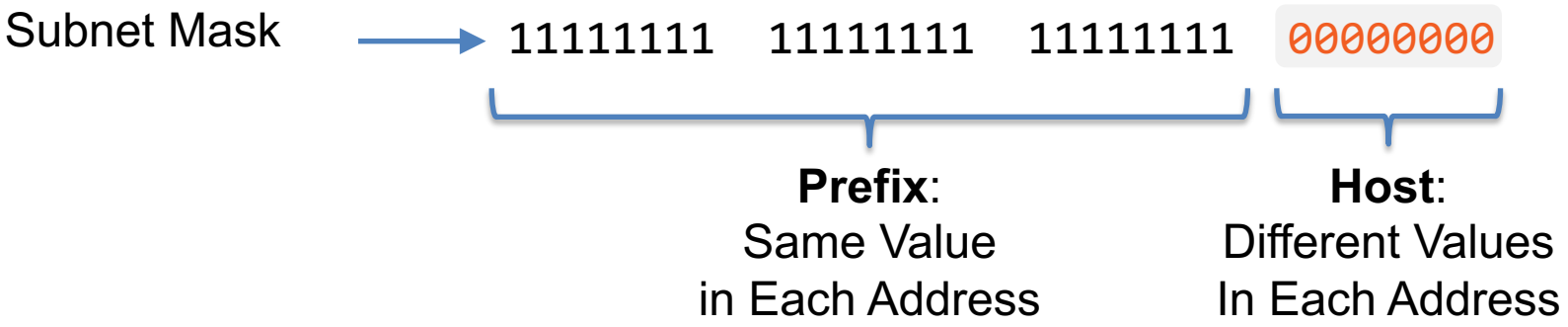
How?

1. Boolean (Binary)
2. Decimal Patterns

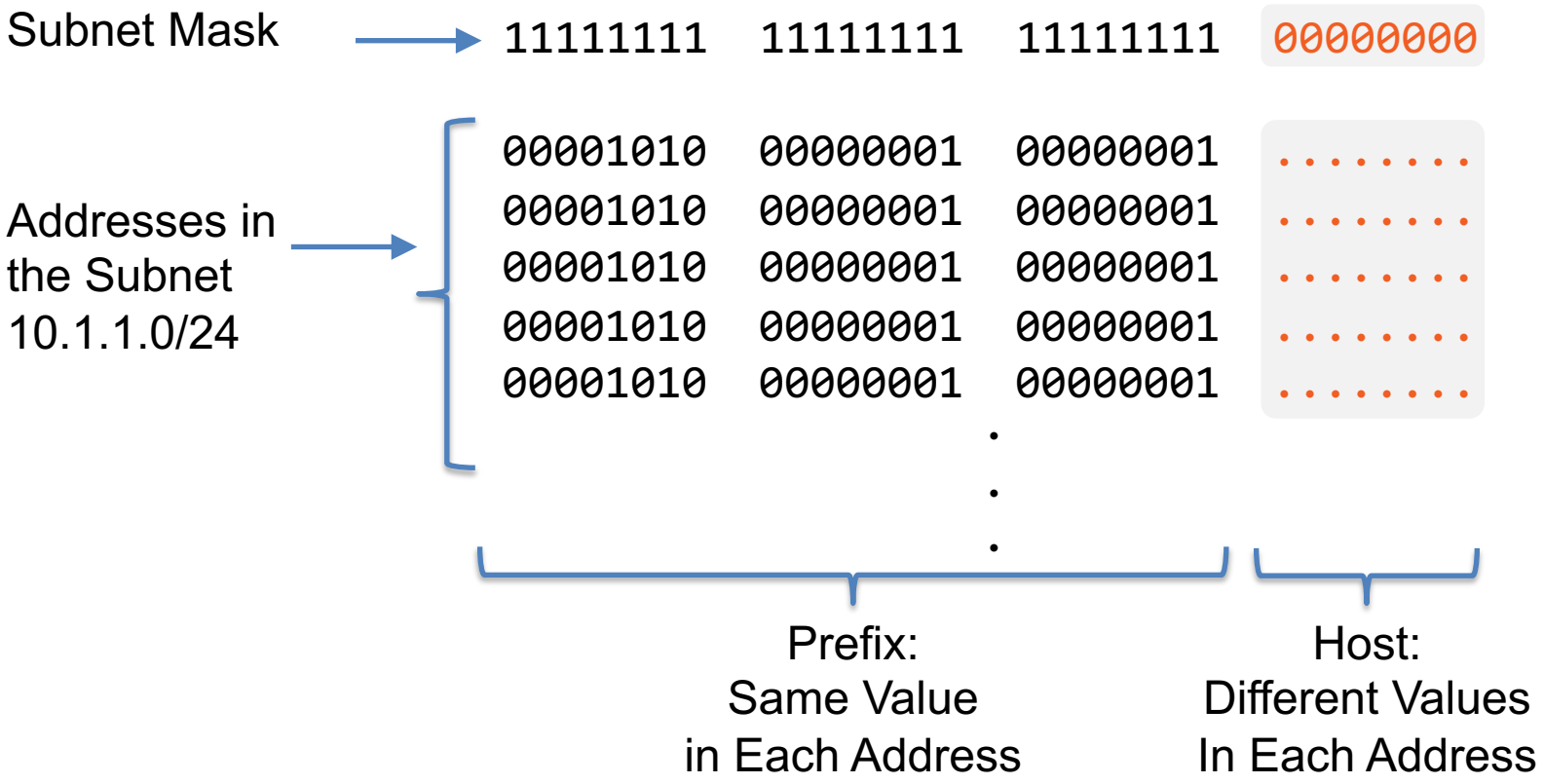
Sample Subnet: 10.1.1.0 /24



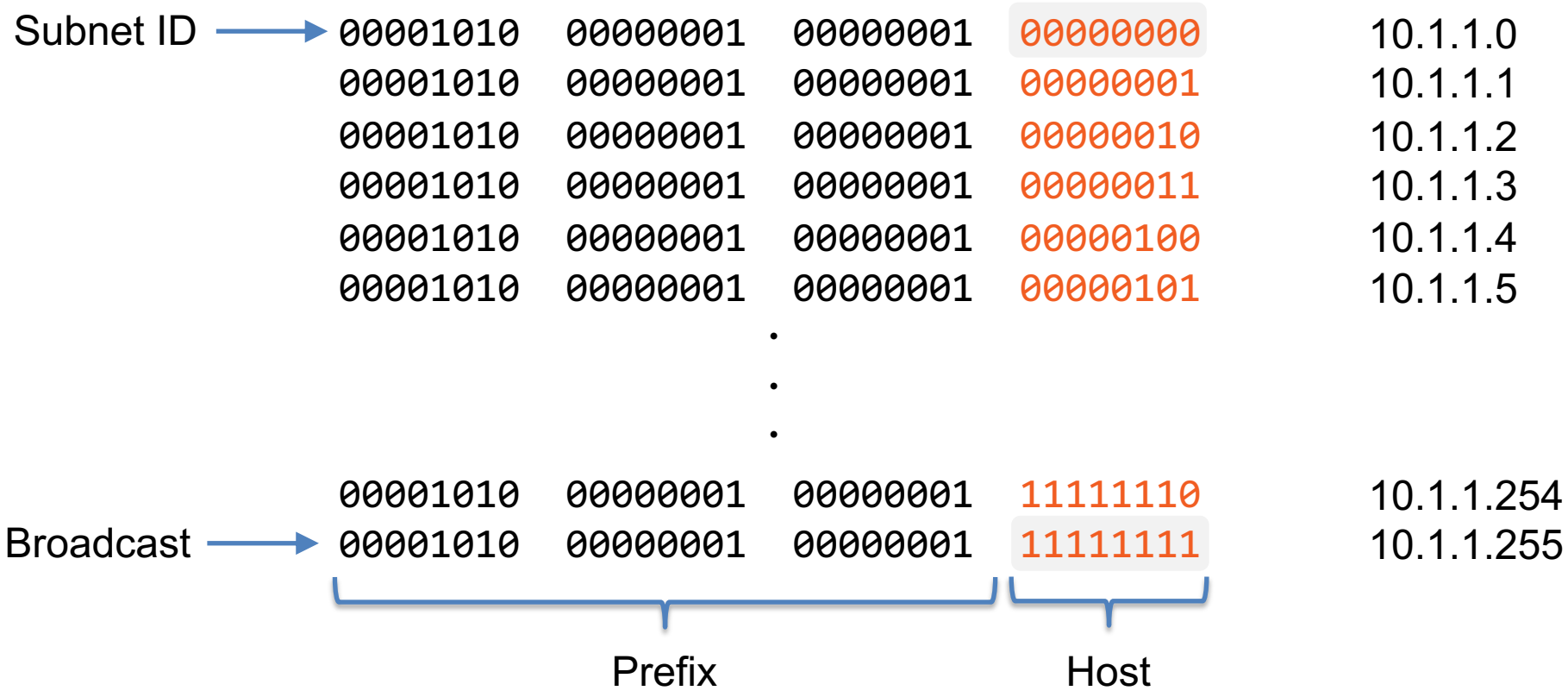
Subnet Mask: Defines Prefix (1s) and Host (0s)



Subnet Mask: Defines Prefix (1s) and Host (0s)



Binary: Subnet ID, Subnet Broadcast Address



Subnet ID and Subnet Broadcast Address

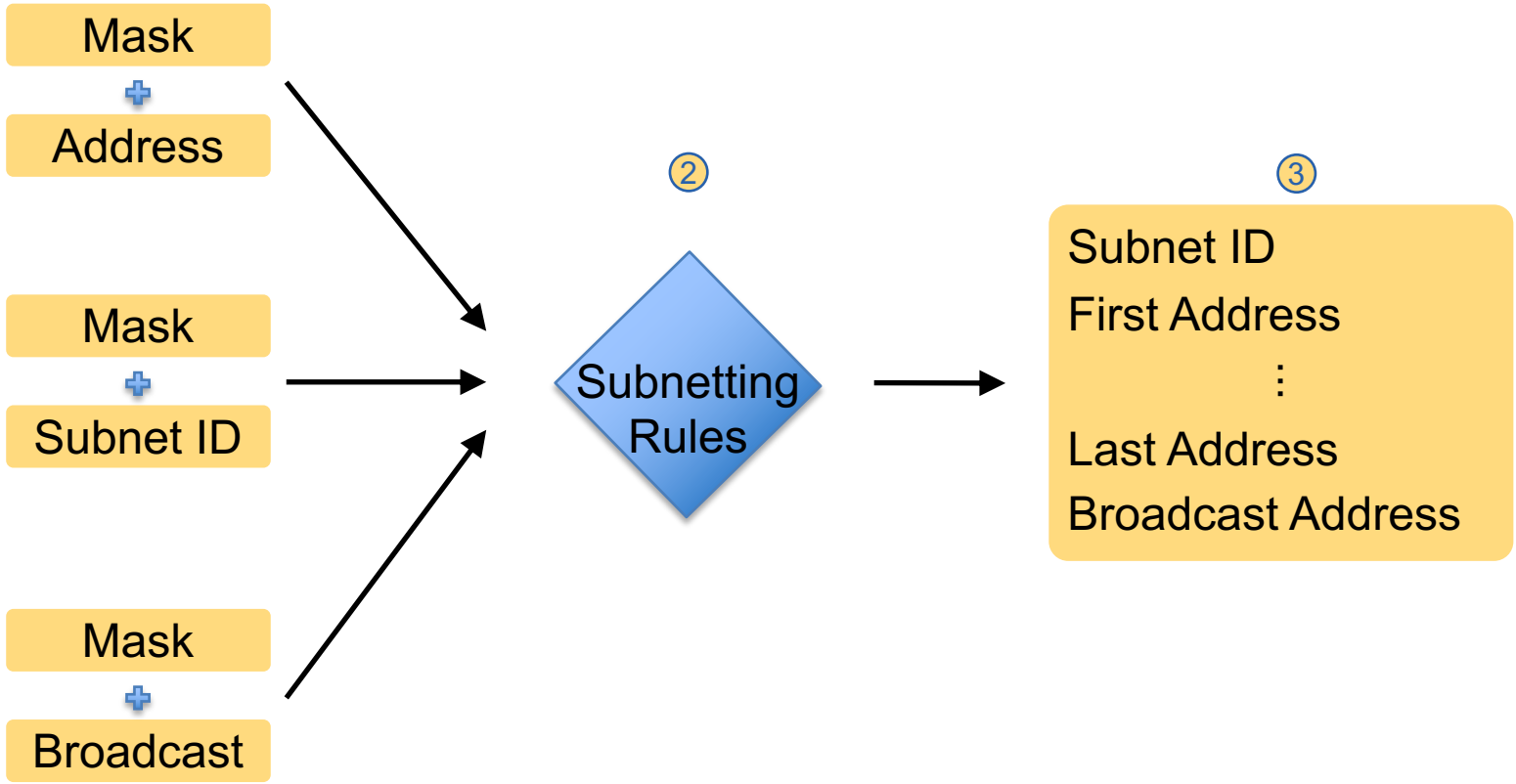
Subnet ID

- Numerically Lowest Value
- Binary: All Host Bits = 0

Subnet Broadcast Address

- Numerically Highest Value
- Binary: All Host Bits = 1

Start with Any Number in the Subnet



In This Lesson...

Subnetting: Topology, Concepts, and Math

- Topology and Subnetting
- Concepts and Subnetting
- Math and Subnetting
- **Summary and Terms**

Terms from this Topic

Subnetting:
Subnet ID
Subnet Number (Synonym)
Subnet Address (Synonym)

Subnet Broadcast Address

Masks:
Mask
Subnet Mask
Prefix Length
Prefix Bits
Host Bits

Links:
VLAN
Serial Link
Ethernet WAN

Subnet Facts:
Subnet ID
Address Range
Subnet Broadcast Address

Miscellaneous:
Routing Table
Boolean
Classless addressing
Classful addressing

Summary: Key Concepts

Topology:

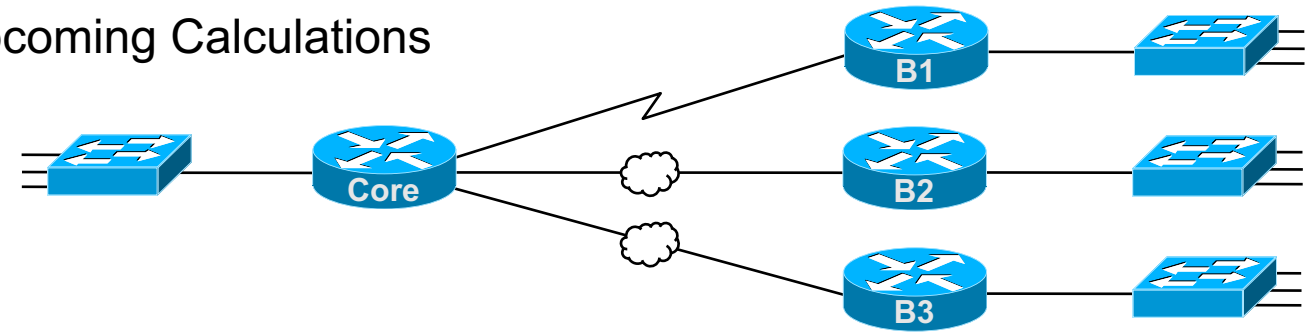
- One Subnet per VLAN
- One Subnet per WAN Link

Concept:

- A Set of Consecutive Numbers...
- 2^H in Size
- Ties to Routing/Location

Math:

- Two Reserved Values in Each Subnet
- Focus on Upcoming Calculations



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Addressing, Routing, and Routing Protocols

IPv4 Subnetting Basics

Learning Stages

* Finding Subnet Facts: Simple Masks

* Finding Subnet Facts: Difficult Masks

In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Easy Masks: /16 and /24
- Three Examples of Using the Process
- **Learning Stages and Practice**

Stages

Stage	Primary Study Goal	Have You Understood and Memorized Ideas and Processes?	Do You Get 100% Correct?	Do You Go Fast?
1	Learning	No		

Stage 1 (Learning) Activities

Study Approach:

1. Use All Notes and Examples
2. Take Your Time
3. Investigate Mistakes **after Each Question**

Exam Day Prep:

1. None

Graduate to Stage 2 When:

1. Memorized the Process(es)
2. Understand when to Use the Process(es)
3. Understand the Information Found with the Processes

Stages

Stage	Primary Study Goal	Have You Understood and Memorized Ideas and Processes?	Do You Get 100% Correct?	Do You Go Fast?
1	Learning	No		
2	Perfecting	Yes	No	

Stage 2 (Perfecting) Activities

Study Approach:

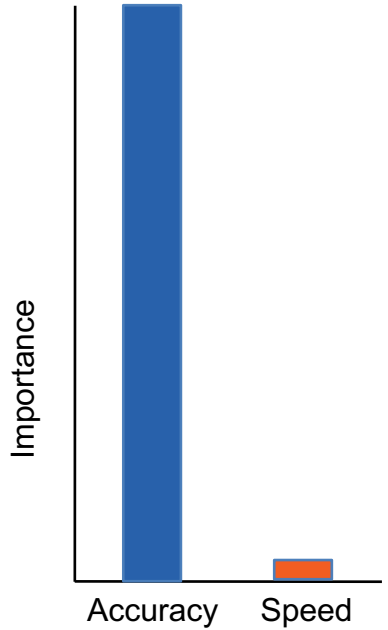
1. ~~Use All Notes and Examples~~ **Clear Your Desk!**
2. Take Your Time
3. Investigate Mistakes ~~after each Question~~ **after Each Set**

Exam Day Prep:

1. Practice Writing Your **Pre-Exam Notes**

Graduate to Stage 3 When:

1. 100% Accurate When Practicing
2. Easily Write Pre-Exam Notes from Memory



Stages

Stage	Primary Study Goal	Have You Understood and Memorized Ideas and Processes?	Do You Get 100% Correct?	Do You Go Fast?
1	Learning	No		
2	Perfecting	Yes	No	
3	Accelerating	Yes	Yes	No

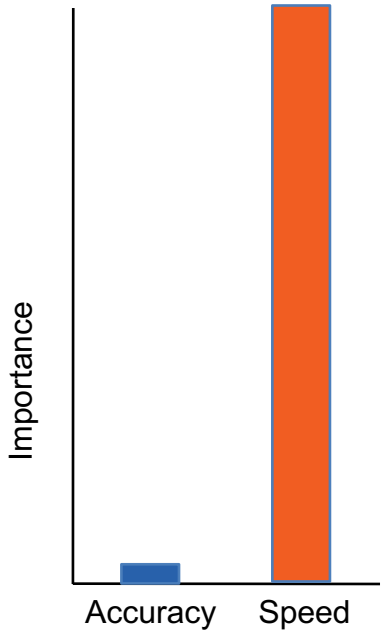
Stage 3 (Accelerating) Challenges

Study Approach:

1. ~~Use All Notes an~~ **Clear Your Desk!**
2. ~~Take Your Time~~ **Go Fast!**
3. Investigate Mistakes **after Each Set**

Exam Day Prep:

1. Practice Writing Your Pre-Exam Notes
2. Each Question Set:
   - A. Write Pre-Exam Notes
   - B. Set a Time Goal
   - C. Start Clock
   - D. Time Trial
   - E. Compare Your Speed to Time Goal



Question with Subnetting Math

A packet destined to 10.1.15.150 arrives at router R1. Out which interface does the router forward the packet?

A. G0/1.1
B. G0/1.99
C. G0/1.100
D. None; Packet is Discarded

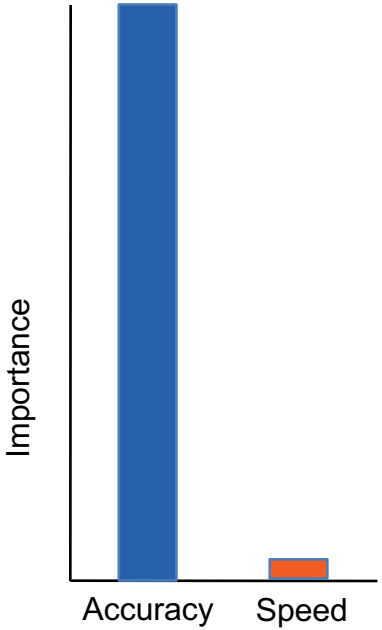
```
R1# show ip route
! Legend omitted for brevity

     10.0.0.0/8 is variably subnetted, 240 subnets, 8 masks
D       10.1.1.0/26 [90/2172416] via 10.2.1.1, 00:00:34, G0/1.1
D       10.1.1.128/28 [90/2172416] via 10.2.1.5, 00:00:34, G0/1.2
D       10.2.1.160/28 [90/2172416] via 10.2.1.9, 00:00:34, G0/1.3
D       10.1.14.0/23 [90/2172416] via 10.2.2.141, 00:00:34, G0/1.99
D       10.1.15.128/29 [90/2172416] via 10.2.2.145, 00:00:34, G0/1.100
! Lines omitted for brevity
```

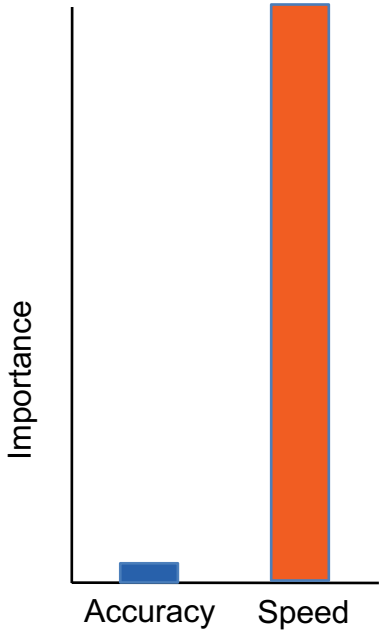
Subnetting Math to Answer the Question

Output Interface	Destination Subnet	Time to Convert Mask	Time to Find Address Range	Totals Per Row
G0/1.1	10.1.1.0/26	10	30	40
G0/1.99	10.1.14.0/23	10	30	40
G0/1.100	10.1.15.128/29	10	30	40

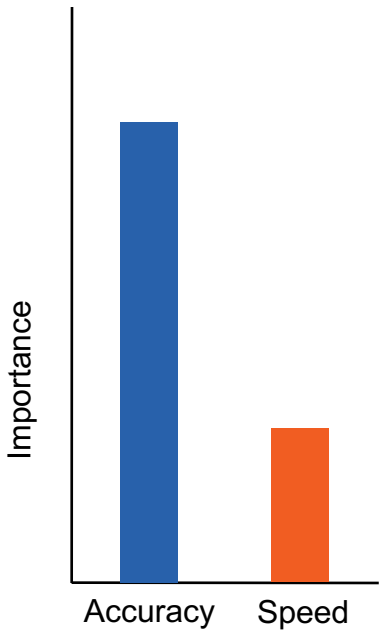
Priorities: Stage 2, 3, and the Real Exam



Stage 2: Perfecting



Stage 3: Accelerating



The Real Exam

Stages

Stage	Primary Study Goal	Have You Understood and Memorized Ideas and Processes?	Do You Get 100% Correct?	Do You Go Fast?
1	Learning	**No**		
2	Perfecting	Yes	**No**	
3	Accelerating	Yes	Yes	**No**
4	Completed	**Yes**	**Yes**	**Yes**

Graduate to Stage 4 (Complete) When:

(Stage 2) 100% Accurate When Practicing
(Stage 2) Comfortable Writing Pre-Exam Notes from Memory
(Stage 3) Achieve Your Speed Goals During Time Trial

Speed Goals and Learning Stages

Subnetting Processes	Book Speed Goals	Your Speed Goal	Your Current Speed	Your Current Stage
Find Classful Network Facts *	10			
Convert Mask Formats *	10			
Find Subnet Facts	30			
Interpret Design w/ Mask	15			
Choose One Mask	15			
Find All Subnet IDs *	45			

* These Time Estimates Do Not Include the Time to Write/Type the Answers

IPv4 Subnetting – Sections

Section 1: Analyzing Individual Subnets

Section 2: Converting Subnet Masks

Section 3: Analyzing IP Networks

Section 4: Identifying the Subnets of a Network

Section 5: Analyzing Designs Using Masks

Section 6: Subnetting and the Exam

IPv4 Subnetting – Section 1

Addressing, Routing, and Routing Protocols

IPv4 Subnetting Basics

Learning Stages

*** Finding Subnet Facts: Simple Masks**

* Finding Subnet Facts: Difficult Masks

In This Lesson...

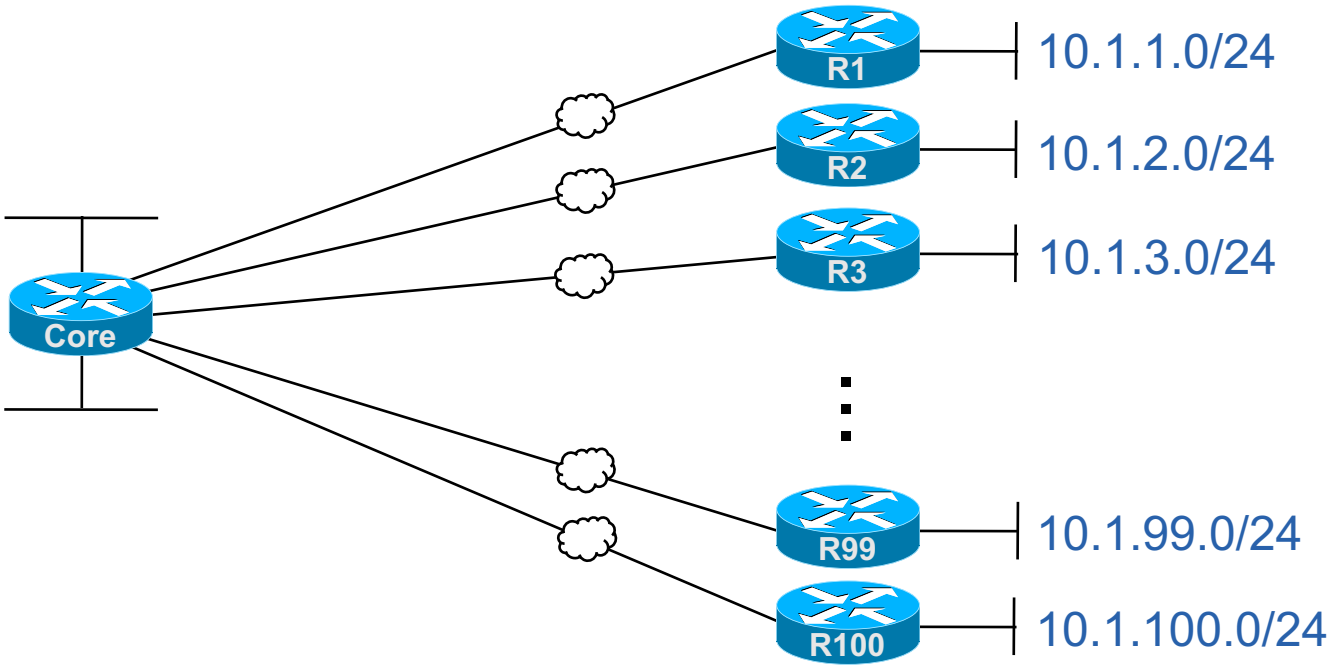
Find Subnet Facts: Decimal, Easy Cases

- **The Process with Easy Masks**
- Three Examples of Using the Process
- Learning Stages and Practice

Three Easy Masks

Binary				Prefix	DDN
11111111	00000000	00000000	00000000	/8	255.0.0.0
11111111	11111111	00000000	00000000	/16	255.255.0.0
11111111	11111111	11111111	00000000	/24	255.255.255.0

Network 10.0.0.0 with /24 Mask

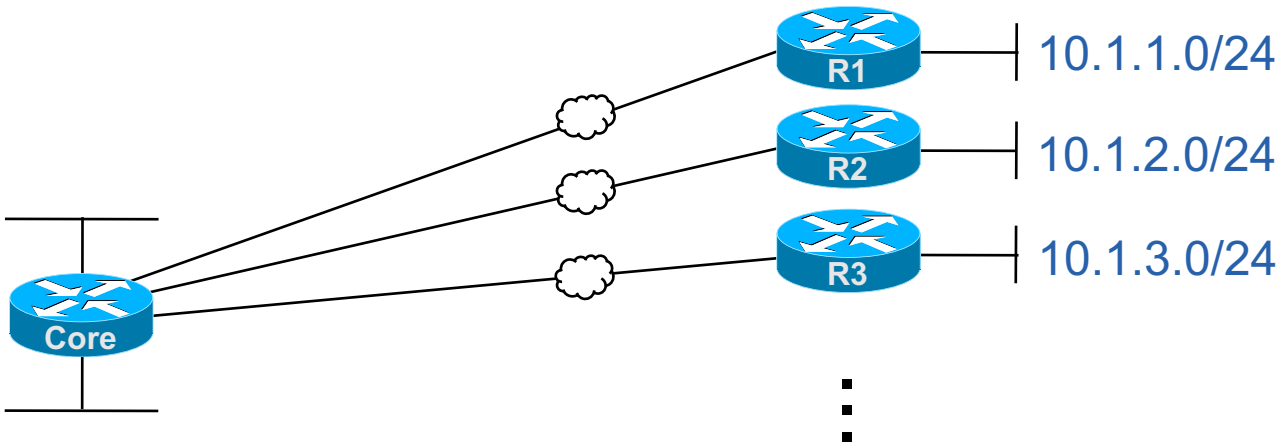


Example Subnets of Network 10.0.0.0 with /24

10. 0. 0. 0	10. 1. 0. 0	10. 2. 0. 0	10.254. 0. 0	10.255. 0. 0
10. 0. 1. 0	10. 1. 1. 0	10. 2. 1. 0	10.254. 1. 0	10.255. 1. 0
10. 0. 2. 0	10. 1. 2. 0	10. 2. 2. 0	10.254. 2. 0	10.255. 2. 0
10. 0. 3. 0	10. 1. 3. 0	10. 2. 3. 0	10.254. 3. 0	10.255. 3. 0
10. 0. 4. 0	10. 1. 4. 0	10. 2. 4. 0	10.254. 4. 0	10.255. 4. 0
10. 0. 5. 0	10. 1. 5. 0	10. 2. 5. 0	10.254. 5. 0	10.255. 5. 0
10. 0. 6. 0	10. 1. 6. 0	10. 2. 6. 0	10.254. 6. 0	10.255. 6. 0
10. 0. 7. 0	10. 1. 7. 0	10. 2. 7. 0	10.254. 7. 0	10.255. 7. 0
10. 0. 8. 0	10. 1. 8. 0	10. 2. 8. 0	10.254. 8. 0	10.255. 8. 0
10. 0. 9. 0	10. 1. 9. 0	10. 2. 9. 0	10.254. 9. 0	10.255. 9. 0
10. 0. 10. 0	10. 1. 10. 0	10. 2. 10. 0	10.254. 10. 0	10.255. 10. 0
…	…	…	…	…
10. 0.249. 0	10. 1.249. 0	10. 2.249. 0	10.254.249. 0	10.255.249. 0
10. 0.250. 0	10. 1.250. 0	10. 2.250. 0	10.254.250. 0	10.255.250. 0
10. 0.251. 0	10. 1.251. 0	10. 2.251. 0	10.254.251. 0	10.255.251. 0
10. 0.252. 0	10. 1.252. 0	10. 2.252. 0	10.254.252. 0	10.255.252. 0
10. 0.253. 0	10. 1.253. 0	10. 2.253. 0	10.254.253. 0	10.255.253. 0
10. 0.254. 0	10. 1.254. 0	10. 2.254. 0	10.254.254. 0	10.255.254. 0
10. 0.255. 0	10. 1.255. 0	10. 2.255. 0	10.254.255. 0	10.255.255. 0

Correct Use of Addresses in Same Subnet

Subnet: 10.1.1.0/24
ID: 10.1.1.0
First: 10.1.1.1
Last: 10.1.1.254
B'Cast: 10.1.1.255



Process: Calculating Subnet Facts

1. **Set up the Problem on Paper**
   A. Write: Mask Above, Address Below, Column Aligned
   B. Leave Space for: Subnet ID, Subnet Broadcast Address, Two More Values

2. **For Each Column, If Mask = 255:**
   A. **Copy Address Octets(s)** to Subnet ID
   B. **Copy Address Octets(s)** to Subnet Broadcast Address

3. **For Each Column, If Mask = 0:**
   A. **Write 0s** in the Subnet ID
   B. **Write 255s** in Subnet Broadcast Address

4. **To Find the Range of Addresses:**
   A. In 4th Octet, **Subnet ID: +1**
   B. In 4th Octet, **Broadcast: –1**

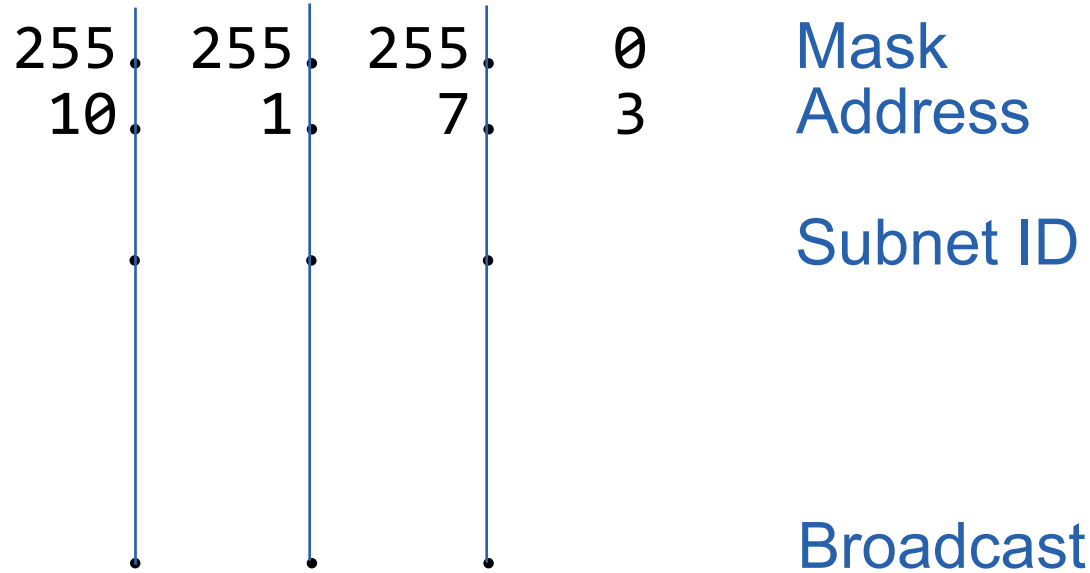
In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Easy Masks: /16 and /24
- **Three Examples of Using the Process**
- Learning Stages and Practice

Example 1: Step 1

1. Set up the Problem on Paper
   A. Mask Above, Address Below, Column Aligned
   B. Space for: Subnet ID, Broadcast, +2



Example 1: Step 2

2. If Mask = 255:
   A. Copy Address Octet(s) to Subnet ID
   B. Copy Address Octet(s) to Broadcast Address

255.	255.	255.	0	Mask
10.	1.	7.	3	Address
10. (A)	1. (A)	7. (A)		Subnet ID
10. (B)	1. (B)	7. (B)		Broadcast

Example 1: Step 3

3. If Mask = 0:
   A. Write 0s in the Subnet ID
   B. Write 255s in Subnet Broadcast Address

255. 255. 255. 0	Mask
10. 1. 7. 3	Address
10. 1. 7. 0 (A)	Subnet ID
10. 1. 7. 255 (B)	Broadcast

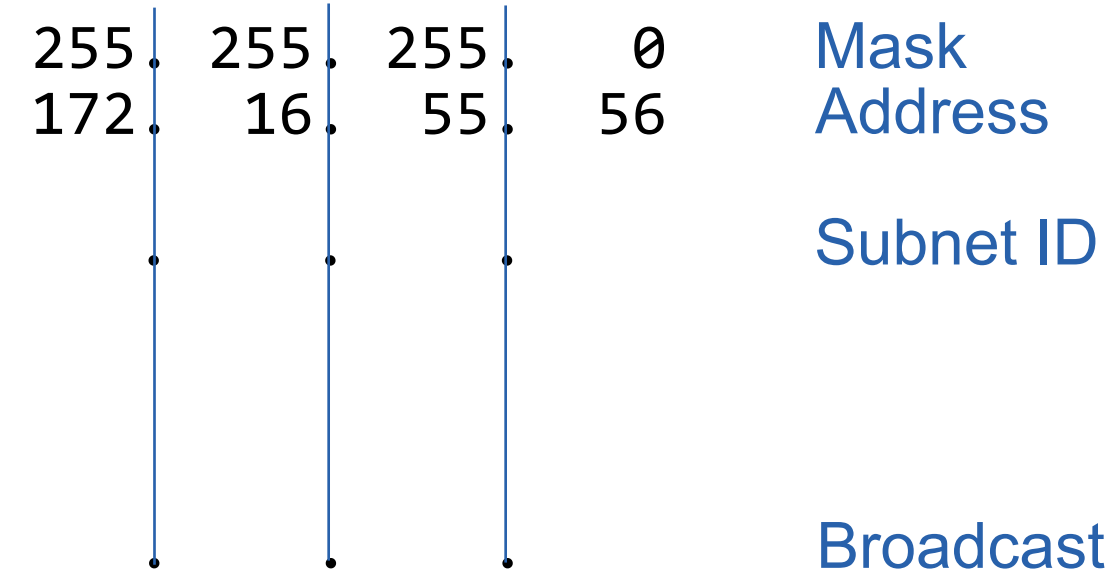
Example 1: Step 4

4. To Find the Range of Addresses in the Network:
   - A. In 4th Octet, Subnet ID: +1
   - B. In 4th Octet, Broadcast: –1

255. 255. 255. 0	Mask
10. 1. 7. 3	Address
10. 1. 7. 0	Subnet ID
Ⓐ	
10. 1. 7. 1	First Address
10. 1. 7. 254	Last Address
Ⓑ	
10. 1. 7. 255	Broadcast

Example 2: Step 1

1. Set up the Problem on Paper
   A. Mask Above, Address Below, Column Aligned
   B. Space for: Subnet ID, Broadcast, +2



Example 2: Step 2

2. If Mask = 255:
   A. Copy Address Octet(s) to Subnet ID
   B. Copy Address Octet(s) to Broadcast Address

255. 255. 255. 0	Mask
172. 16. 55. 56	Address
172.(A) 16.(A) 55.(A)	Subnet ID
172.(B) 16.(B) 55.(B)	Broadcast

Example 2: Step 3

3. If Mask = 0:
   A. Write 0s in the Subnet ID
   B. Write 255s in Subnet Broadcast Address

255. 255. 255. 0	Mask
172. 16. 55. 56	Address
172. 16. 55. 0 (A)	Subnet ID
172. 16. 56. 255 (B)	Broadcast

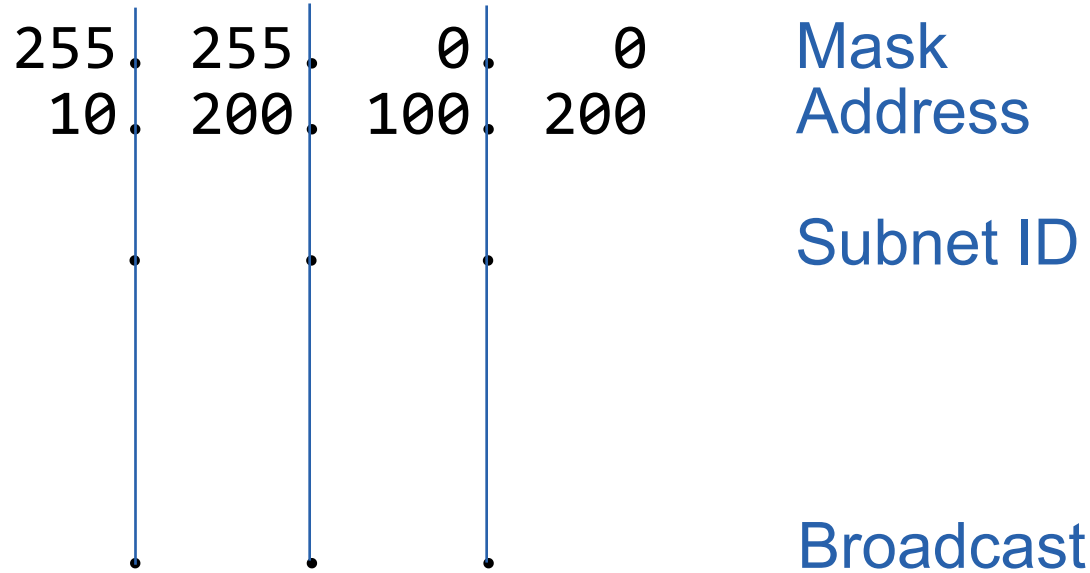
Example 2: Step 4

4. To Find the Range of Addresses in the Network:
   - A. In 4th Octet, Subnet ID: +1
   - B. In 4th Octet, Broadcast: –1

255. 255. 255. 0	Mask
172. 16. 55. 56	Address
172. 16. 55. 56	Subnet ID
Ⓐ	
172. 16. 55. 1	First Address
172. 16. 55. 254	Last Address
Ⓑ	
172. 16. 55. 255	Broadcast

Example 3: Step 1

1. Set up the Problem on Paper
   A. Mask Above, Address Below, Column Aligned
   B. Space for: Subnet ID, Broadcast, +2



Example 3: Step 2

2. If Mask = 255:
   A. Copy Address Octet(s) to Subnet ID
   B. Copy Address Octet(s) to Broadcast Address

255. 255. 0. 0	Mask
10. 200. 100. 200	Address
10. 200.	Subnet ID
10. 200.	Broadcast

Example 3: Step 3

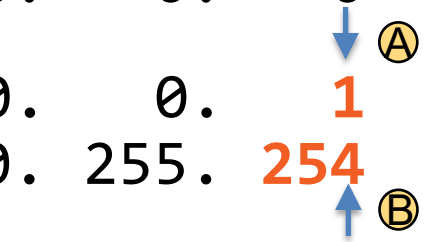
3. If Mask = 0:
   A. Write 0s in the Subnet ID
   B. Write 255s in Subnet Broadcast Address

255.	255.	0.	0	Mask
10.	200.	100.	200	Address
10.	200.	0 (A).	0 (A)	Subnet ID
10.	200.	255 (B).	255 (B)	Broadcast

Example 3: Step 4

4. To Find the Range of Addresses in the Network:
   - A. In 4th Octet, Subnet ID: +1
   - B. In 4th Octet, Broadcast: –1

255. 255. 0. 0	Mask
10. 200. 100. 200	Address
10. 200. 0. 0	Subnet ID
10. 200. 0. 1	First Address
10. 200. 255. 254	Last Address
10. 200. 255. 255	Broadcast



In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Easy Masks: /16 and /24
- Three Examples of Using the Process
- **Learning Stages and Practice**

Stages

Stage	Primary Study Goal	Have You Understood and Memorized Ideas and Processes?	Do You Get 100% Correct?	Do You Go Fast?
1	Learning	No		
2	Perfecting	Yes	No	
3	Accelerating	Yes	Yes	No
4	Completed	Yes	Yes	Yes

Stage 1 (Learn) Advice for This Exercise

Approach to the Exercises:

1. Use Notes/Examples
2. Check Answer if Unsure
3. Investigate Mistakes
4. **Ask Instructor to Work the Problem!**

Graduate to Stage 2 Now if:

1. Could Hide All Notes and Still Answer!

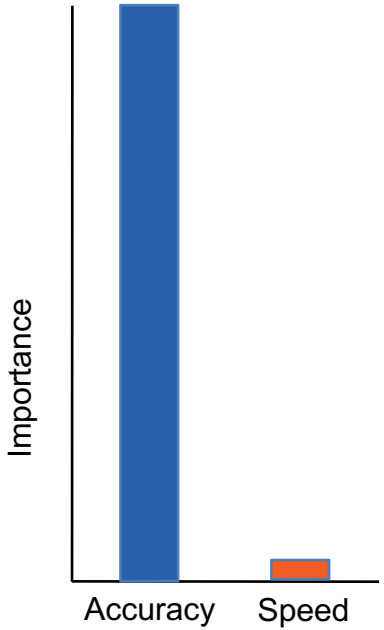
Stage 2 (Perfect) Advice for This Exercise

Approach to the Exercises:

1. Do Not Use Your Notes
2. Take Your Time
3. Complete a Question Set before Checking Answers

Graduate to Stage 3 Now if:

1. 100% Correct on Two Sets



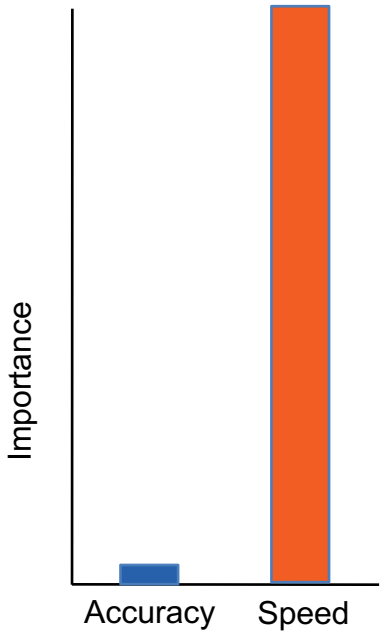
Stage 3 (Accelerate) Advice for this Exercise

Study Approach:

1. Each Time Trial:
    A. Write Pre-exam Notes
    B. Set a Per-item Time Goal
    C. Start Clock
    D. Complete the Entire Question Set
    E. Compare your Speed to Time Goal

Graduate to Stage 4 Now if:

1. Don't! For now, keep practicing for speed.



Speed Goals for CCNA Exam

Subnetting Processes	Book Speed Goals	Your Speed Goal	Your Current Speed	Your Current Stage
Find Classful Network Facts *	10			
Convert Mask Formats *	10			
Find Subnet Facts	30			
Interpret Design w/ Mask	15			
Choose One Mask	15			
Find All Subnet IDs *	45			

* These Time Estimates Do Not Include the Time to Write/Type the Answers

Practice!

Exercises for:

“Find Subnet Facts –
Easy Masks”

Come Back to Class!

Exercises for:

“Find Subnet Facts –
Easy Masks”

Time Finished!

IPv4 Subnetting – Sections

Section 1: Analyzing Individual Subnets

Section 2: Converting Subnet Masks

Section 3: Analyzing IP Networks

Section 4: Identifying the Subnets of a Network

Section 5: Analyzing Designs Using Masks

Section 6: Subnetting and the Exam

IPv4 Subnetting – Section 1

Addressing, Routing, and Routing Protocols

IPv4 Subnetting Basics

Learning Stages

* Finding Subnet Facts: Simple Masks

*** Finding Subnet Facts: Difficult Masks**

In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- **The Process with Difficult Masks**
- Example 1: 10.1.7.3 /23
- Example 2: 172.16.55.56 /20
- Example 3: 10.200.100.100 /26
- Example 4: 10.200.100.200 /14
- Learning Stages and Practice

The Difficult Masks

255.128.0.0	255.255.128.0	255.255.255.128
255.192.0.0	255.255.192.0	255.255.255.192
255.224.0.0	255.255.224.0	255.255.255.224
255.240.0.0	255.255.240.0	255.255.255.240
255.248.0.0	255.255.248.0	255.255.255.248
255.252.0.0	255.255.252.0	255.255.255.252
255.254.0.0	255.255.254.0	

The Nine Possible Octet Values of a Mask

Binary	Decimal	Easy or Difficult
00000000	0	Easy
10000000	128	Difficult
11000000	192	Difficult
11100000	224	Difficult
11110000	240	Difficult
11111000	248	Difficult
11111100	252	Difficult
11111110	254	Difficult
11111111	255	Easy

Revised: Calculating Subnet Facts

1. **Set up the Problem on Paper (Same as Before)**

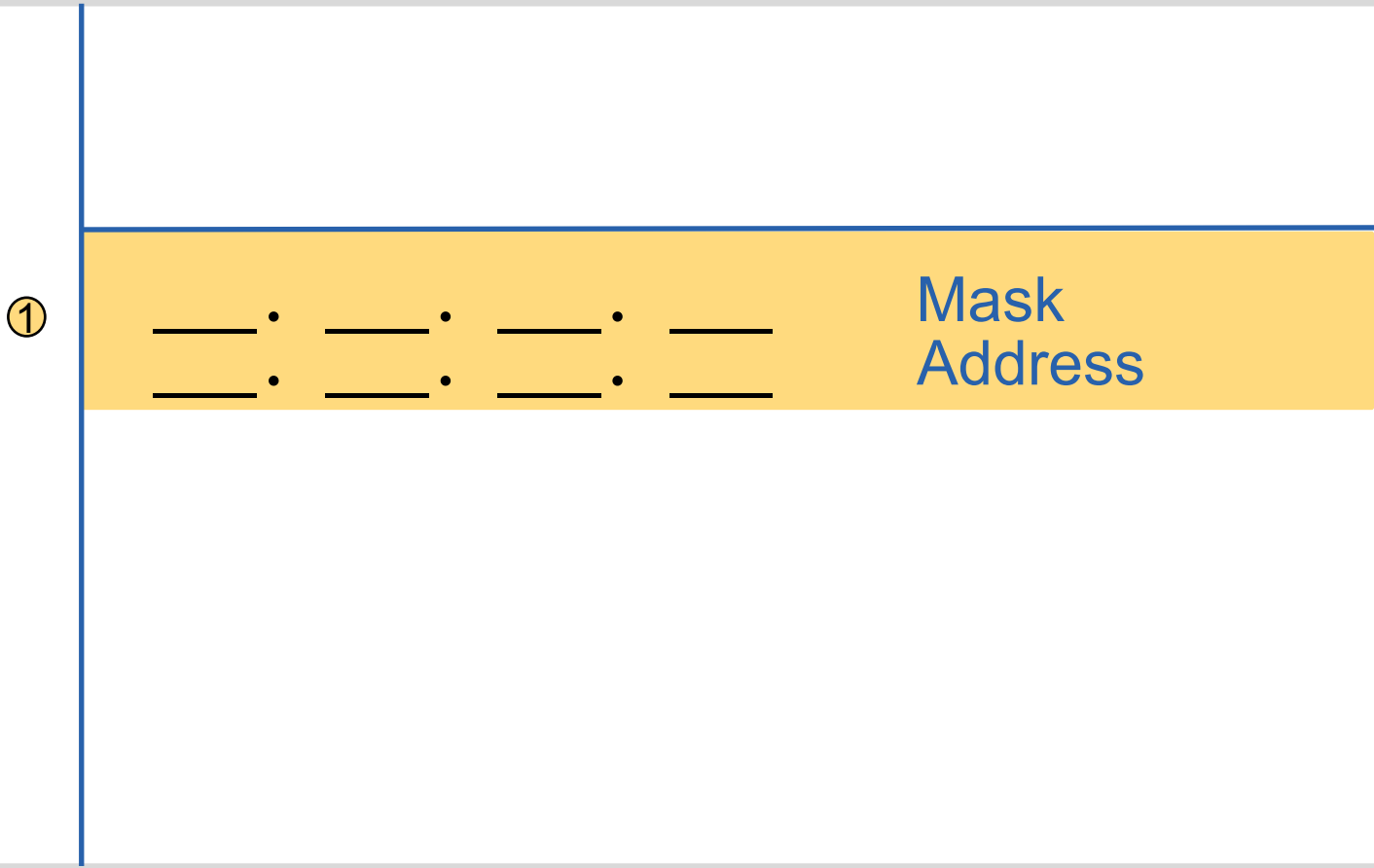
2. **For Each Column, If Mask = 255: (Same as Before)**
   A. Copy Address Octets(s) to **Subnet** ID
   B. Copy Address Octets(s) to **Subnet** Broadcast Address

3. **For Each Column, If Mask = 0 (Same as Before)**
   A. Write 0s in the **Subnet** ID
   B. Write 255s in **Subnet** Broadcast Address

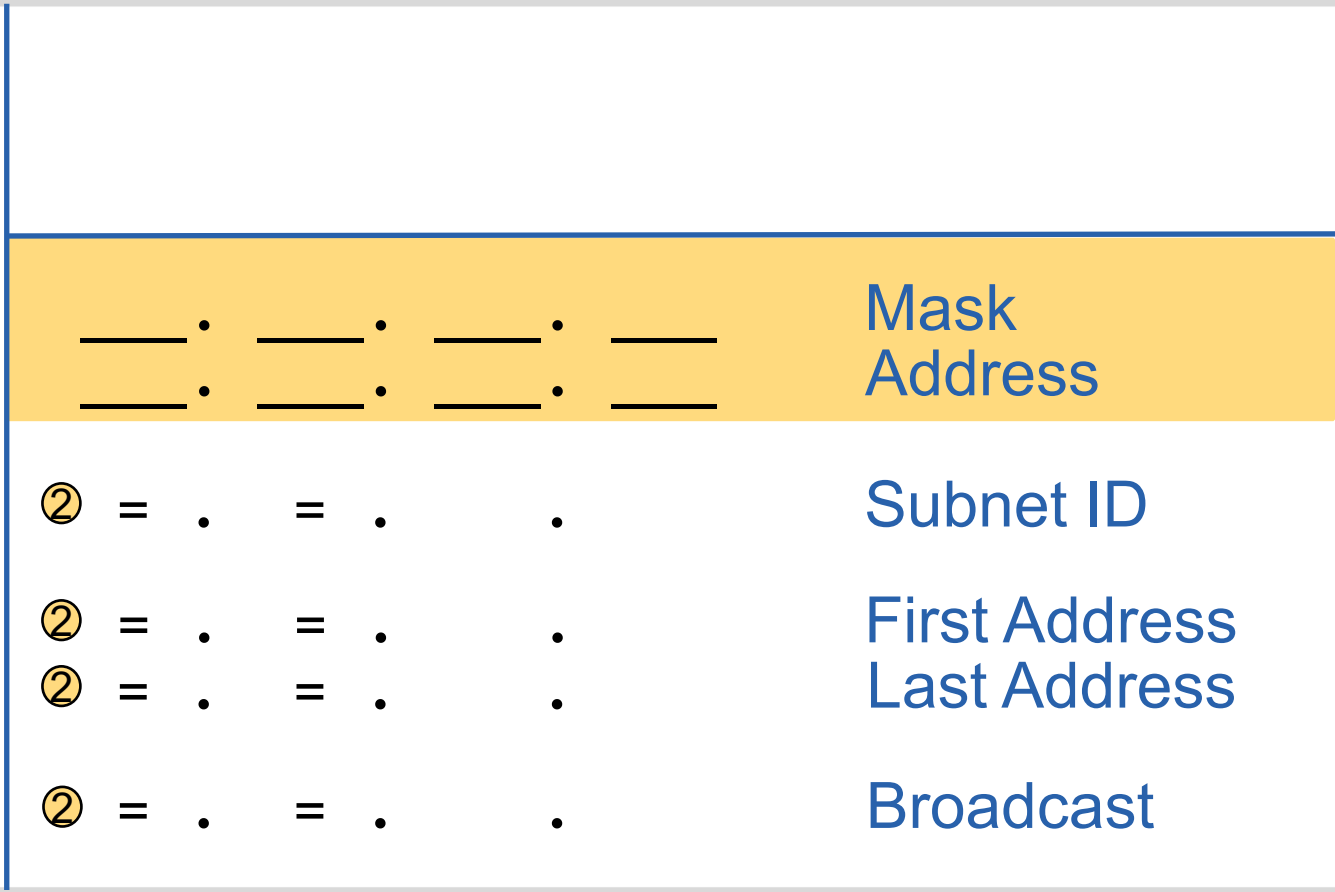
4. **If Mask is Neither 0 Nor 255:**
   A. Calculate Magic = 256 – Mask_Value
   B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
   C. Broadcast: Use Next Magic Multiple, Minus 1

5. **To Find the Range of Addresses (Same as Before)**

Visual Reference Step 1



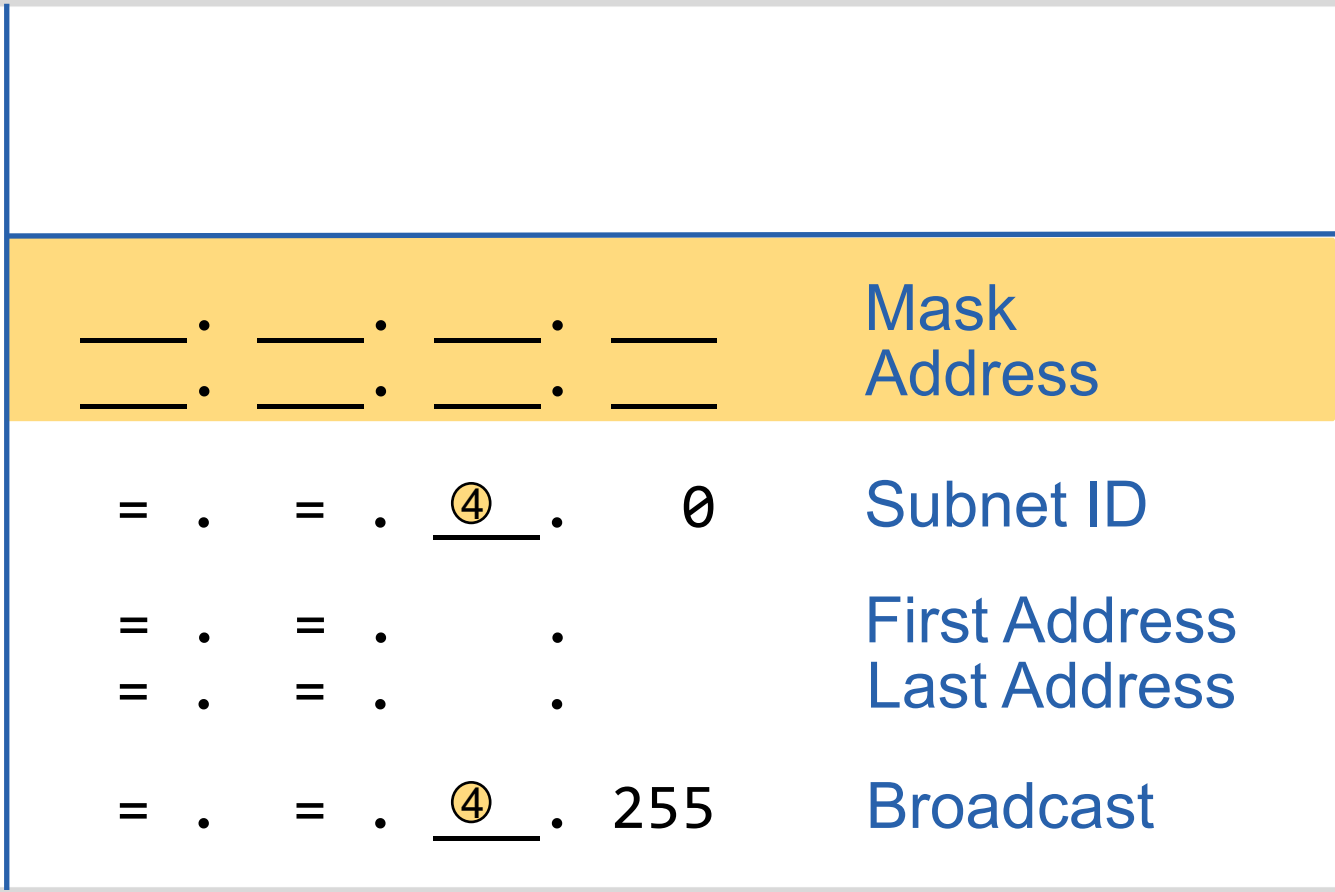
Visual Reference Step 2



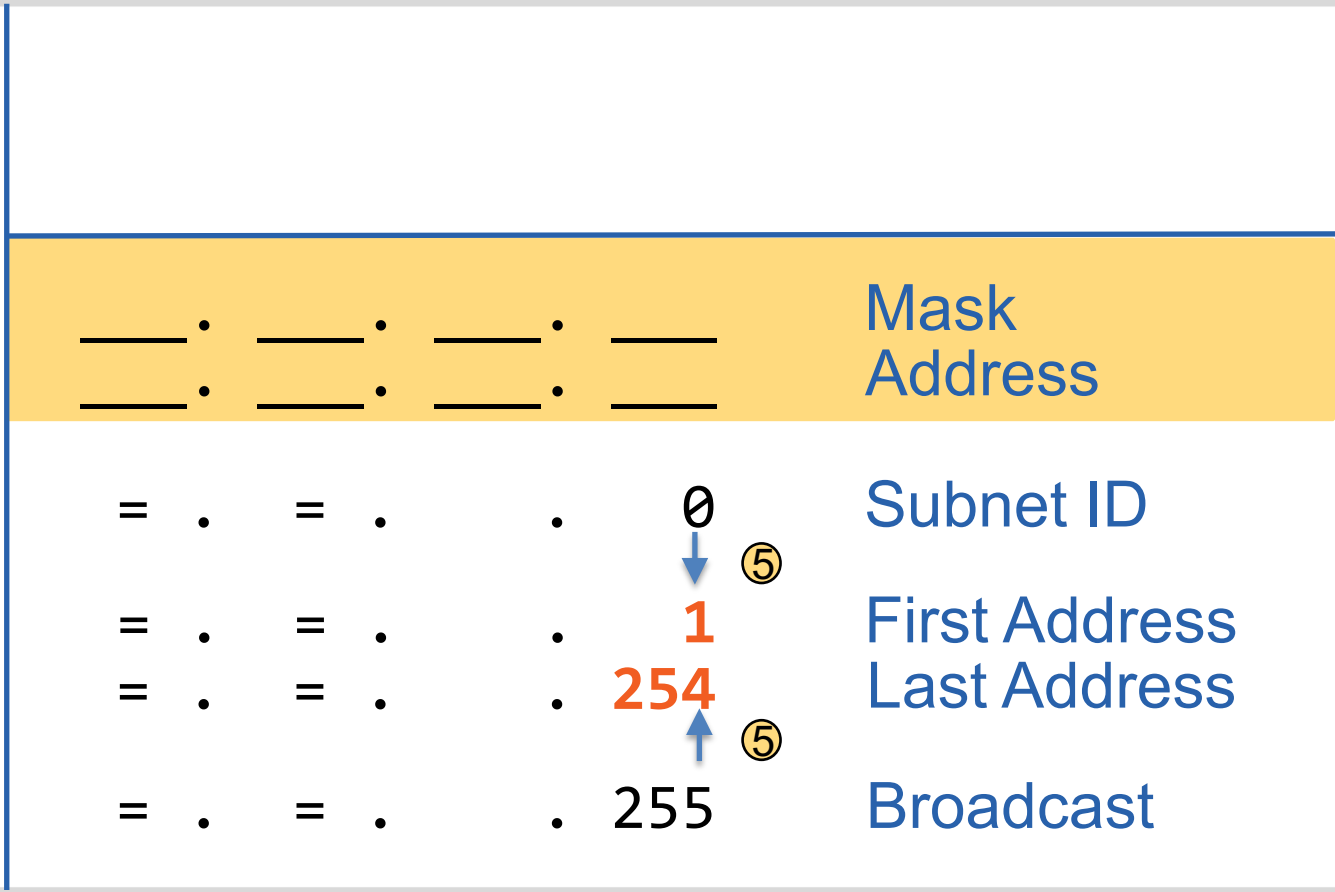
Visual Reference Step 3

___. ___. ___. ___ ___. ___. ___. ___	Mask Address
= . = . . 0 ③	Subnet ID
= . = . .	First Address
= . = . .	Last Address
= . = . . 255 ③	Broadcast

Visual Reference Step 4



Visual Reference for Process Steps



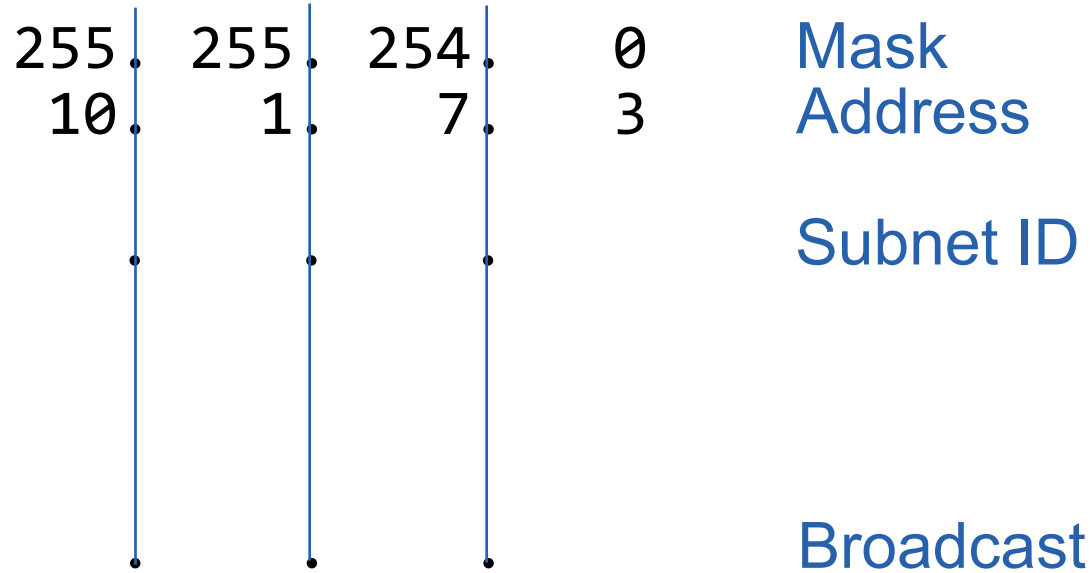
In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Difficult Masks
- **Example 1: 10.1.7.3 /23**
- Example 2: 172.16.55.56 /20
- Example 3: 10.200.100.100 /26
- Example 4: 10.200.100.200 /14
- Learning Stages and Practice

Example 10.1.7.3 /23 - Step 1

1. Set up the Problem on Paper
   A. Mask Above, Address Below, Column Aligned
   B. Space for: Subnet ID, Broadcast, +2



Example 10.1.7.3 /23 - Step 2

2. If Mask = 255:
   A. Copy Address Octet(s) to Subnet ID
   B. Copy Address Octet(s) to Broadcast Address

255.	255.	254.	0	Mask
10.	1.	7.	3	Address
10 (A).	1 (A).	.		Subnet ID
10 (B).	1 (B).	.		Broadcast

Example 10.1.7.3 /23 - Step 3

3. If Mask = 0:
   A. Write 0s in the Subnet ID
   B. Write 255s in Subnet Broadcast Address

255.	255.	254.	0	Mask
10.	1.	7.	3	Address
10.	1.	.	0 (A)	Subnet ID
10.	1.	.	255 (B)	Broadcast

Example 10.1.7.3 /23 – The Interesting Octet

4. **If Mask is Neither 0 Nor 255:**
   A. Calculate Magic = 256 – Mask_Value
   B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
   C. Broadcast: Use Next Magic Multiple, Minus 1

255.	255.	254.	0	Mask
10.	1.	7.	3	Address
10.	1.	.	0	Subnet ID
10.	1.	.	255	Broadcast

Example 10.1.7.3 /23 - Step 4A

```
  256
- 254
    2   (A)
```

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value

B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)

C. Broadcast: Use Next Magic Multiple, Minus 1

255.	255.	254.	0	Mask
10.	1.	7.	3	Address
10.	1.	.	0	Subnet ID
10.	1.	.	255	Broadcast

Example 10.1.7.3 /23 - Step 4B

256
− 254
2 Ⓐ

0
2
4
6 Ⓑ
8
10
12
14
16
18
.
.

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value
B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
C. Broadcast: Use Next Magic Multiple, Minus 1

255.	255.	254.	0	Mask
10.	1.	7.	3	Address
10.	1.	6. Ⓑ	0	Subnet ID
10.	1.	.	255	Broadcast

Example 10.1.7.3 /23 - Step 4C

```
  256
- 254
    2  (A)
```

```
  0
  2
  4
  6  (B)
  8  (C)
 10
 12
 14
 16
 18
  .
  .
```

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value

B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)

C. Broadcast: Use Next Magic Multiple, Minus 1

255. 255. 254. 0	Mask
10. 1. 7. 3	Address
10. 1. 6. 0	Subnet ID
10. 1. 7. 255	Broadcast

8 − 1 (C)

Example 10.1.7.3 /23 - Step 5

4. To Find the Range of Addresses in the Network:
   - A. In 4th Octet, Subnet ID: +1
   - B. In 4th Octet, Broadcast: –1

255.	255.	254.	0	Mask
10.	1.	7.	3	Address
10.	1.	6.	0	Subnet ID
			Ⓐ	
10.	1.	6.	1	First Address
10.	1.	7.	254	Last Address
			Ⓑ	
10.	1.	7.	255	Broadcast

In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Difficult Masks
- Example 1: 10.1.7.3 /23
- **Example 2: 172.16.55.56 /20**
- Example 3: 10.200.100.100 /26
- Example 4: 10.200.100.200 /14
- Learning Stages and Practice

Repeat: Calculating Subnet Facts

1. **Set up the Problem on Paper (Same as Before)**

2. **For Each Column, If Mask = 255: (Same as Before)**
   A. Copy Address Octets(s) to **Subnet** ID
   B. Copy Address Octets(s) to **Subnet** Broadcast Address

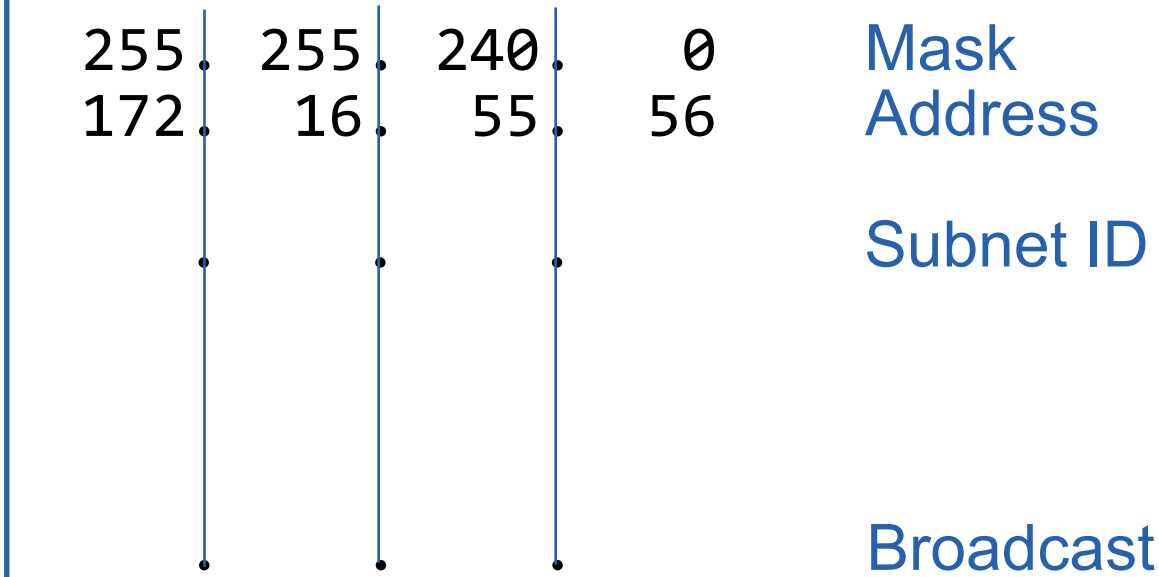
3. **For Each Column, If Mask = 0 (Same as Before)**
   A. Write 0s in the **Subnet** ID
   B. Write 255s in **Subnet** Broadcast Address

4. **If Mask is Neither 0 Nor 255:**
   A. Calculate Magic = 256 – Mask_Value
   B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
   C. Broadcast: Use Next Magic Multiple, Minus 1

5. **To Find the Range of Addresses (Same as Before)**

Example 172.16.55.56 /20 - Step 1

1. Set up the Problem on Paper
   A. Mask Above, Address Below, Column Aligned
   B. Space for: Subnet ID, Broadcast, +2



Example 172.16.55.56 /20 - Step 2

2. If Mask = 255:
   A. Copy Address Octet(s) to Subnet ID
   B. Copy Address Octet(s) to Broadcast Address

255. 255. 240. 0	Mask
172. 16. 55. 56	Address
172.(A) 16.(A) .	Subnet ID
172.(B) 16.(B) .	Broadcast

Example 172.16.55.56 /20 - Step 3

3. If Mask = 0:
   A. Write 0s in the Subnet ID
   B. Write 255s in Subnet Broadcast Address

255.	255.	240.	0	Mask
172.	16.	55.	56	Address
172.	16.	.	0 (A)	Subnet ID
172.	16.	.	255 (B)	Broadcast

Example 172.16.55.56 /20 – Interesting Octet

4. **If Mask is Neither 0 Nor 255:**
   A. Calculate Magic = 256 – Mask_Value
   B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
   C. Broadcast: Use Next Magic Multiple, Minus 1

255. 255. 240. 0	Mask
172. 16. 55. 56	Address
172. 16. . 0	Subnet ID
172. 16. . 255	Broadcast

Example 172.16.55.56 /20 - Step 4A

```
  256
- 240
   16  (A)
```

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value
B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
C. Broadcast: Use Next Magic Multiple, Minus 1

255. 255. 240. 0	Mask
172. 16. 55. 56	Address
172. 16. . 0	Subnet ID
172. 16. . 255	Broadcast

Example 172.16.55.56 /20 - Step 4B

```
  256
- 240
   16  (A)
```

```
   0
  16
  32
  48  (B)
  64
  80
  96
 112
 128
 144
  .
  .
```

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value

B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)

C. Broadcast: Use Next Magic Multiple, Minus 1

255.	255.	240.	0	Mask
172.	16.	55.	56	Address
172.	16.	48. (B)	0	Subnet ID
172.	16.	.	255	Broadcast

Example 172.16.55.56 /20 - Step 4C

```
  256
- 240
   16 (A)
```

```
  0
 16
 32
 48 (B)
 64 (C)
 80
 96
112
128
144
 .
 .
```

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value

B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)

C. Broadcast: Use Next Magic Multiple, Minus 1

```
255. 255. 240.   0      Mask
172.  16.  55.  56      Address

172.  16.  48    0      Subnet ID

                64
              - 1 (C)
172.  16.  63. 255      Broadcast
```

Example 172.16.55.56 /20 - Step 5

4. To Find the Range of Addresses in the Network:
   - A. In 4th Octet, Subnet ID: +1
   - B. In 4th Octet, Broadcast: –1

255.	255.	240.	0	Mask
172.	16.	55.	56	Address
172.	16.	48.	0	Subnet ID
			Ⓐ	
172.	16.	48.	1	First Address
172.	16.	63.	254	Last Address
			Ⓑ	
172.	16.	63.	255	Broadcast

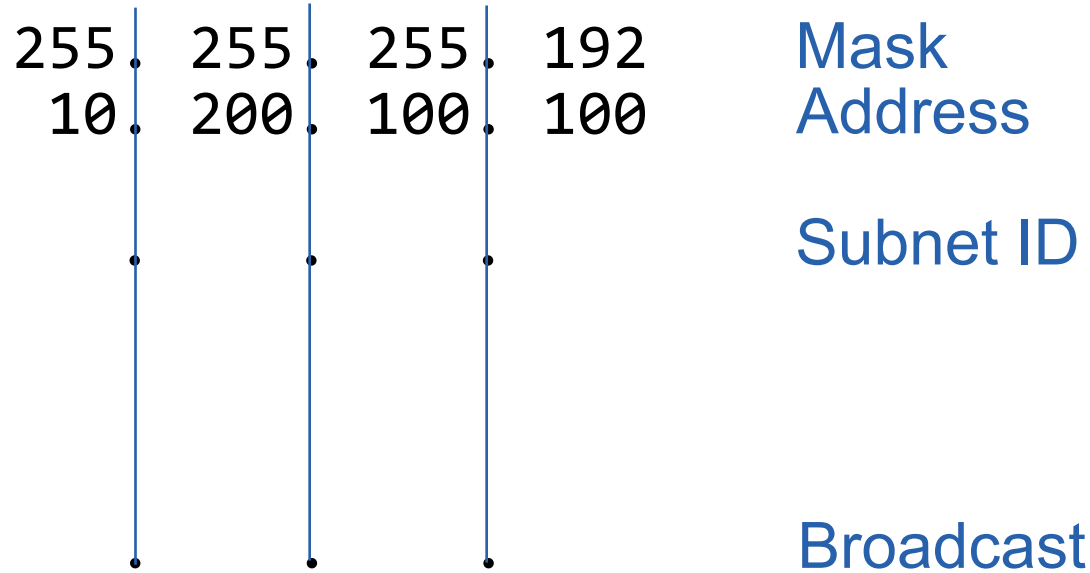
In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Difficult Masks
- Example 1: 10.1.7.3 /23
- Example 2: 172.16.55.56 /20
- **Example 3: 10.200.100.100 /26**
- Example 4: 10.200.100.200 /14
- Learning Stages and Practice

Example 10.200.100.100 /26 - Step 1

1. Set up the Problem on Paper
   A. Mask Above, Address Below, Column Aligned
   B. Space for: Subnet ID, Broadcast, +2



Example 10.200.100.100 /26 - Step 2

2. If Mask = 255:
   A. Copy Address Octet(s) to Subnet ID
   B. Copy Address Octet(s) to Broadcast Address

255. 255. 255. 192	Mask
10. 200. 100. 100	Address
10.(A) 200.(A) 100.(A)	Subnet ID
10.(B) 200.(B) 100.(B)	Broadcast

Example 10.200.100.100 /26 - Step 3

3. If Mask = 0:
   A. Write 0s in the Subnet ID
   B. Write 255s in Subnet Broadcast Address

255. 255. 255. 192	Mask
10. 200. 100. 100	Address
10. 200. 100.	Subnet ID
10. 200. 100.	Broadcast

Example 10.200.100.100 /26 – Interesting Octet

4. **If Mask is Neither 0 Nor 255:**
   A. Calculate Magic = 256 – Mask_Value
   B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
   C. Broadcast: Use Next Magic Multiple, Minus 1

255. 255. 255. 192	Mask
10. 200. 100. 100	Address
10. 200. 100.	Subnet ID
10. 200. 100.	Broadcast

Example 10.200.100.100 /26 - Step 4A

256
– 192
64 Ⓐ

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value
B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
C. Broadcast: Use Next Magic Multiple, Minus 1

255. 255. 255. 192	Mask
10. 200. 100. 100	Address
10. 200. 100.	Subnet ID
10. 200. 100.	Broadcast

Example 10.200.100.100 /26 - Step 4B

256
− 192
64 Ⓐ

0
64
128 Ⓑ
192
256

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value
B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
C. Broadcast: Use Next Magic Multiple, Minus 1

255. 255. 255. 192	Mask
10. 200. 100. 100	Address
10. 200. 100. 64 Ⓑ	Subnet ID
10. 200. 100.	Broadcast

Example 10.200.100.100 /26 - Step 4C

256
− 192
64 Ⓐ

0
64 Ⓑ
128 Ⓒ
192
256

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value
B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
C. Broadcast: Use Next Magic Multiple, Minus 1

255. 255. 255. 192	Mask
10. 200. 100. 100	Address
10. 200. 100. 64	Subnet ID
128 Ⓒ − 1 10. 200. 100. 127	Broadcast

Example 10.200.100.100 /26 - Step 5

4. To Find the Range of Addresses in the Network:
   - A. In 4th Octet, Subnet ID: +1
   - B. In 4th Octet, Broadcast: –1

255. 255. 255. 192	Mask
10. 200. 100. 100	Address
10. 200. 100. 64	Subnet ID
Ⓐ	
10. 200. 100. **65**	First Address
10. 200. 100. **126**	Last Address
Ⓑ	
10. 200. 100. 127	Broadcast

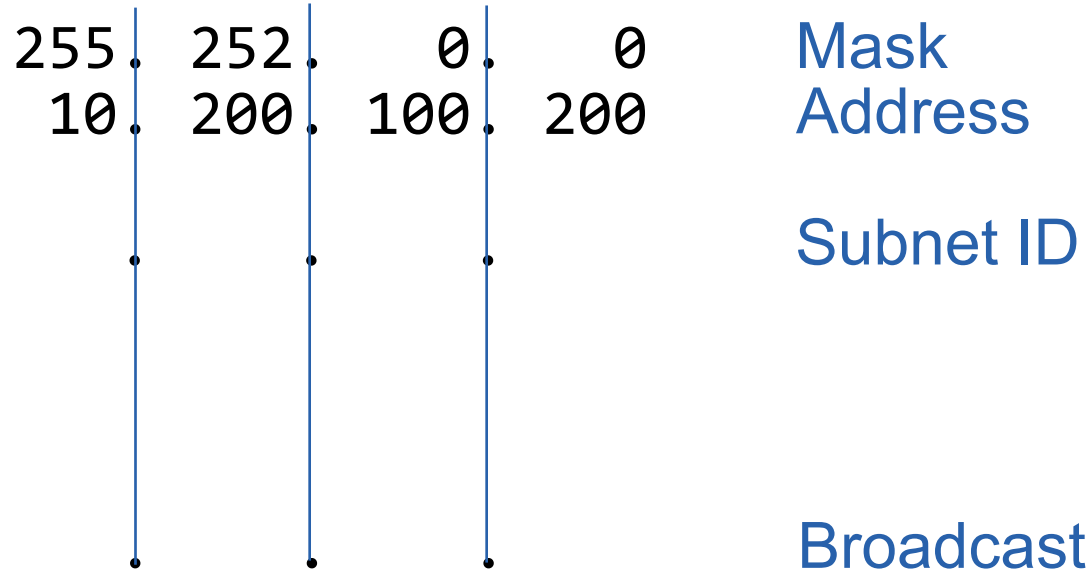
In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Difficult Masks
- Example 1: 10.1.7.3 /23
- Example 2: 172.16.55.56 /20
- Example 3: 10.200.100.100 /26
- **Example 4: 10.200.100.200 /14**
- Learning Stages and Practice

Example 10.200.100.200 /14 - Step 1

1. Set up the Problem on Paper
   A. Mask Above, Address Below, Column Aligned
   B. Space for: Subnet ID, Broadcast, +2



Example 10.200.100.200 /14 - Step 2

2. If Mask = 255:
   A. Copy Address Octet(s) to Subnet ID
   B. Copy Address Octet(s) to Broadcast Address

255. 252. 0. 0	Mask
10. 200. 100. 200	Address
10. (A)	Subnet ID
10. (B)	Broadcast

Example 10.200.100.200 /14 - Step 3

3. If Mask = 0:
   A. Write 0s in the Subnet ID
   B. Write 255s in Subnet Broadcast Address

255. 252. 0. 0 10. 200. 100. 200	Mask Address
10. . 0. 0 (A, A)	Subnet ID
10. . 255. 255 (B, B)	Broadcast

Example 10.200.100.200 /14 – Interesting Octet

4. **If Mask is Neither 0 Nor 255:**
   A. Calculate Magic = 256 – Mask_Value
   B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
   C. Broadcast: Use Next Magic Multiple, Minus 1

255. 252. 0. 0	Mask
10. 200. 100. 200	Address
10. . 0. 0	Subnet ID
10. . 255. 255	Broadcast

Example 10.200.100.200 /14 - Step 4A

256
− 252
4 (A)

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value
B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
C. Broadcast: Use Next Magic Multiple, Minus 1

255. 252. 0. 0	Mask
10. 200. 100. 200	Address
10. . 0. 0	Subnet ID
10. . 255. 255	Broadcast

Example 10.200.100.200 /14 - Step 4B

256
− 252
4 Ⓐ

0
4
.
.
.
196
200 Ⓑ
204
218
212
.
.

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value
B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)
C. Broadcast: Use Next Magic Multiple, Minus 1

255. 252. 0. 0	Mask
10. 200. 100. 200	Address
10. 200.Ⓑ 0. 0	Subnet ID
10. . 255. 255	Broadcast

Example 10.200.100.200 /14 - Step 4C

```
  256
- 252
    4   (A)
```

```
  0
  4
  .
  .
  .
196
200   (B)
204   (C)
218
212
  .
  .
```

4. If Mask is Neither 0 Nor 255:

A. Calculate Magic = 256 – Mask_Value

B. Subnet ID: Use Nearest Magic Multiple (not Greater Than)

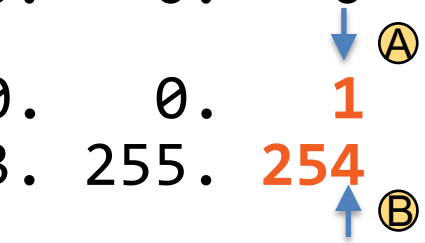
C. Broadcast: Use Next Magic Multiple, Minus 1

255. 252. 0. 0	Mask
10. 200. 100. 200	Address
10. 200. 0. 0	Subnet ID
204 − 1 (C)	
10. 203. 255. 255	Broadcast

Example 10.200.100.200 /14 - Step 5

4. To Find the Range of Addresses in the Network:
   - A. In 4th Octet, Subnet ID: +1
   - B. In 4th Octet, Broadcast: –1

255. 252. 0. 0	Mask
10. 200. 100. 200	Address
10. 200. 0. 0	Subnet ID
10. 200. 0. 1	First Address
10. 203. 255. 254	Last Address
10. 203. 255. 255	Broadcast



In This Lesson...

Find Subnet Facts: Decimal, Easy Cases

- The Process with Difficult Masks
- Example 1: 10.1.7.3 /23
- Example 2: 172.16.55.56 /20
- Example 3: 10.200.100.100 /26
- Example 4: 10.200.100.200 /14
- **Learning Stages and Practice**

Stages

Stage	Primary Study Goal	Have You Understood and Memorized Ideas and Processes?	Do You Get 100% Correct?	Do You Go Fast?
1	Learning	No		
2	Perfecting	Yes	No	
3	Accelerating	Yes	Yes	No
4	Completed	Yes	Yes	Yes

Stage 1 (Learn) Advice for This Exercise

Approach to the Exercises:

1. Use Notes/Examples
2. Check Answer if Unsure
3. Investigate Mistakes
4. **Ask Instructor to Work the Problem!**

Graduate to Stage 2 Now if:

1. Could Hide All Notes and Still Answer!

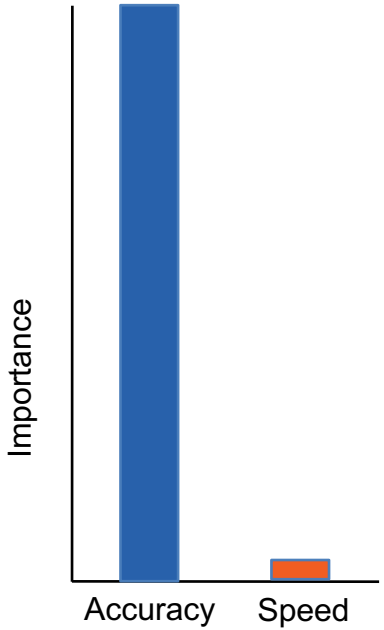
Stage 2 (Perfect) Advice for This Exercise

Approach to the Exercises:

1. Do Not Use Your Notes
2. Take Your Time
3. Complete a Question Set before Checking Answers

Graduate to Stage 3 Now if:

1. 100% Correct on Two Sets



Stage 3 (Accelerate) Advice for this Exercise

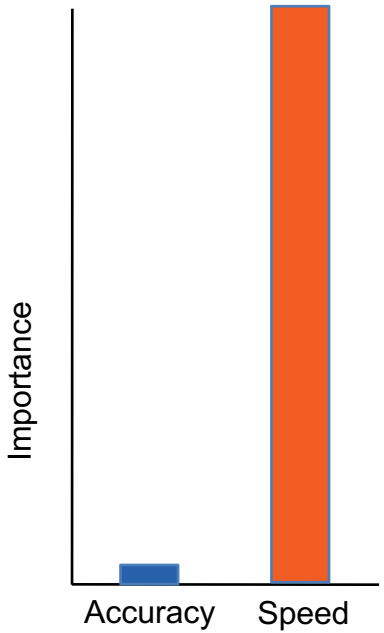
Study Approach:

1. Each Time Trial:
    A. Write Pre-exam Notes
    B. Set a Per-item Time Goal
    C. Start Clock
    D. Complete the Entire Question Set
    E. Compare your Speed to Time Goal

Do the Speed Practice in Lab

Graduate to Stage 4 Now if:

1. Don't! For now, keep practicing for speed.



Speed Goals for CCNA Exam

Subnetting Processes	Book Speed Goals	Your Speed Goal	Your Current Speed	Your Current Stage
Find Classful Network Facts *	10			
Convert Mask Formats *	10			
Find Subnet Facts	30			
Interpret Design w/ Mask	15			
Choose One Mask	15			
Find All Subnet IDs *	45			

* These Time Estimates Do Not Include the Time to Write/Type the Answers

Practice!

Exercises for:

“Find Subnet Facts – Difficult Masks”

Come Back to Class!

Exercises for:

“Find Subnet Facts – Difficult Masks”

Time Finished!