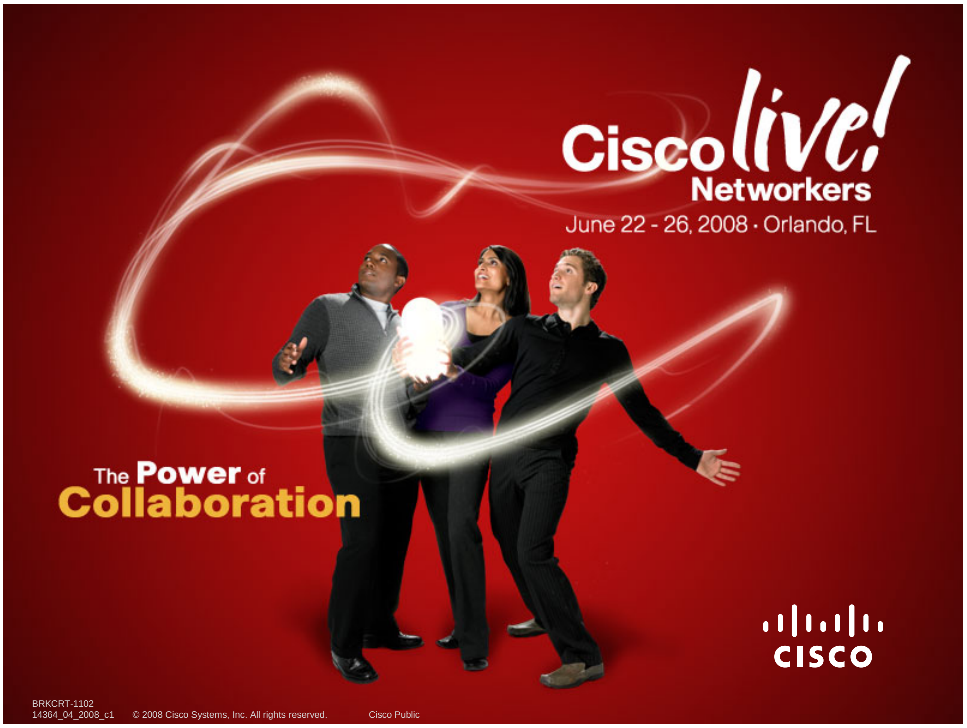
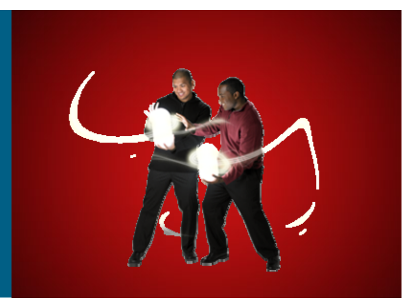


cisco

Cisco live! Networkers

Mastering IP Subnetting Forever



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Agenda live!

Class Participation is a MAJOR Key to Your Success !

- Setting the stage
    - **Why** the mastery of IP Subnetting skills is so important in the real world
    - What we know…or **think we know**, can be a factor in our mastery
- Key elements in successful execution of the subnetting procedure
    - No math required, start with the 'Answer'
    - Use the answer to execute the subnetting procedure
- Implementing the classful subnetting procedure using the Magic Box
- Reverse Engineering any IP Addressing scheme
    - The magic of application in the real world

SPEED! ACCURACY!

- Extending our IP Subnetting knowledge into Classless schemes—**VLSM and CIDR**
    - Variable Length Subnet Masking
    - Classless Inter-Domain Routing (Address Summarization, Supernetting, IP Address Aggregation)

What You Will Need to Be Successful

- Pen or pencil and multiple sheets of paper
- An open mind….
    - If you have failed to master IP subnetting before, it's ok….
    - If you are already a 'Master Subnetter Guy', this session may not be for you…or you just may learn a shortcut you haven't used before
- Seek to understand the 'Keys' and you will be rewarded with a skill that will serve you everyday
- Be willing to practice on your own…if you don't use it, you WILL lose it
- Fill out your session evaluation

Let's Begin...

The Question of the Day…

- WHY?

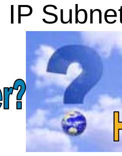
- Why are IP Subnetting skills so important in the real world?

  It is what makes it relevant to you and your situation that makes it important…

Responses—In the Form of Questions 

- How many of you attending today, use IP as the primary protocol in your production network? So it is Relevant?
- How many of you have ever had to troubleshoot an IP-related issue in a network? More Relevance?
- How many of you currently work in an environment where someone else designed the IP addressing scheme? Still Relevant
- How many of you have had a previous opportunity to learn IP Subnetting….and it just didn't quite stick? Big Aha Relevance!
- How many of you are already quite successful at mental IP Subnetting? You may want to leave now…  I wouldn't want to ruin it for you.
- The key to mastering IP Subnetting forever is to BEGIN with "**The Answer**"…

What is the answer?



Where is the answer?

How can I find the answer?

Finding the Answer…

- The answer has always been directly in front of your face…every time you look at an IP address it is there…
  - You simply may not have recognized it
- Everyone already has the answer if they deal with IP
  - The RFCs use mathematics to explain it—RFC 950 and 1123
  - IP networks rely on it to route packets—implemented correctly, of course
  - → You are here to be able to recognize it, understand it, use it, apply it, reverse it, tweak it and master it…f o r e v e r !
  - …And you cant get 'it' on eBay
- The answer is based on the IP Address itself
  - You have all seen an IP address…so where am I trying to take you with all of this?

To Master IP, You Must Discover the ANSWER for yourself

What We Know Already…or Maybe Not

190.16.221.0

10.1.0.255

Question:

How many of these addresses are valid IP numbers for a Host?

172.16.0.255

128.255.1.255

10.0.255.0

Correct Response? ______ How do you know?

What We Know Already…or Maybe Not

190.16.221.0

10.1.0.255

Question:

How many of these addresses are valid IP numbers for a Host?

172.16.0.255

128.255.1.255

10.0.255.0

Correct Response? **ALL*** How do you know? **The Answer would have told us**

What We Know Already…or Should

- An IP address is 32 bits long—4 separate bytes
- An IP Address is represented in dotted-decimal notation
  - Each byte represents a decimal number separated by a period
  - Example: 10.100.30.4 or (010.100.030.004)
  - Each byte has a total of 256 values—0-255
- The first byte may be the most important to you right now…

WHY?

⇨ **Classification!**

What We Know…or Should (Cont.)

- There are three (3) usable IP address classes—A, B and C
- The first byte identifies the class—"Classification"

Correct Classification is the first critical KEY element of mastering IP subnetting (and finding the **Answer**)

usable

Class	Example	Networks	Hosts
A – 1-127	24. 0 .0 .0	127	16,777,214
B – 128-191	150.18. 0 .0	16,384	65,534
C – 192-223	198.23.210. 0	2,097,152	254
D – 224-239	224.0.0.10	Multicast	
E – 240-255	DOD Reserved		

RESERVED

It is absolutely critical that you memorize the class ranges!

Practice: Classification—What Class?

___ 190.16.21.10

___ 10.1.0.200

___ 192.16.2.210

___ 128.215.3.199

___ 126.7.10.40

Practice: Classification—What Class?

B 190.16.21.10

A 10.1.0.200

C 192.16.2.210

B 128.215.3.199

A 126.7.10.40

Nice Work

What We Know…or Should (Cont.)

- Each IP Address has two parts:
  1. Network Number | 2. Host Number
- The "Class" identifies the 'default' point of separation

  Referred to as the "**Class Boundary**" (note the line position)

usable

Class	Example	Networks	Hosts	
A – 1-127	24. | 0 .0 .0	127	16,777,214	Large Org
B – 128-191	150.18. | 0 .0	16,384	65,534	Medium Org.
C – 192-223	198.23.210. | 0	2,097,152	254	Small Org.

Where you draw the line will ultimately lead you to the…
'Answer'

Practice: Class Boundary—Draw the Line

A 10.1.0.200

B 190.16.21.10

C 192.16.2.210

B 128.215.3.199

A 126.7.10.40

Practice: Class Boundary—Draw the Line

Network | Host

A 10.|1.0.200

Network | Host

B 190.16.|21.10

Network | Host

C 192.16.2.|210

Network | Host

B 128.215.|3.199

Network | Host

A 126.|7.10.40

Nice Work

How The Line Will Lead Us to the Answer

- In a Class address, every number to the ‘left’ of the line is static

  Class Addresses, left in their classful state, yield exactly ‘1’ subnet

  Every number right of the line is ours to use…for what? To make more subnets, implement services, expand, etc.

- All bits in the address to the ‘Left” of the line are set to a binary 1

  This identifies the (1) Network portion of the address and you are left with (2) Host portion of the address (set to ‘0s’ by default)

  The network portion of the address is ‘MASKED’ with ‘1s’

Network | Host

B 190.16 | 21.10

What is this? → 255.255 | . 0 . 0

The Default Subnet Mask …or 'Class' Mask

 17

Subnet Mask—Where We Draw the Line

- Identifies the division of the Network and the Host portion of an IP Address
- Subnet masks are used to make routing decisions

  All hosts in a given IP addressing scheme will use the same mask to provide accurate routing—RFC 950

- The default mask is the number of bits that are reserved by the address class—Default Line position

  Using the default mask will accommodate only one network subnet in the relative class

- A custom Subnet Mask can be defined by an Administrator to accommodate many network subnets

  Hmmm…Maybe by moving the **Line**? You guessed it!

 18

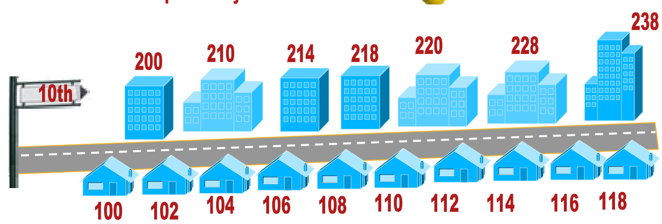
Using the Default 'Class' Mask

Class A: 10
.0.0.0

Yields Only One Subnet (Street) '10th'

With potentially >2.4 million hosts on it

Can anyone say 'Congestion?'



All of your resources (addresses) are on the same Subnet

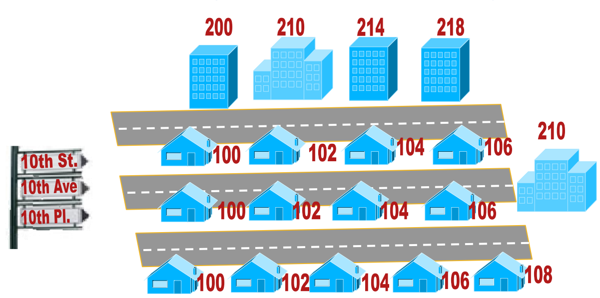
Rules that MUST be followed:

1. *Each subnet must have a unique identifier (street name/number)*
2. *Each node must have an address unique to the subnet (street)*

Using a Custom Subnet Mask

Allows the 10 to be broken up into smaller subnets (streets)

Better traffic management, less waste, less congestion



Have we followed the rules?

1. *Does each subnet have a unique identifier ?*
2. *Does each node must have an address unique to the subnet ?*

Understanding the Custom Subnet Mask

It Is the key to Mastering the IP Subnetting Process

- Classful Subnetting, Classless (VLSM), CIDR, Supernetting, Summarization, Address Aggregation—you name it
- The Customization of the mask is KEY

We have a few more things to learn first...

Before Starting the IP Subnetting Process

- Determine the 'type' of IP addressing to use
  - Become familiar with reserved addresses (RFC 1918, 2026)
- Determine your network requirements
  - Number of subnets and hosts your implementation requires
- Identify your base address (Class A, B, or C)
- Get to know the Magic Box

Determine the 'Type' of Addressing Scheme to Use

You (or Someone Else) Has Determined the 'Type' of IP Addressing Scheme—Public or Private (RFC 1918)

- Public Addressing Scheme:

  Sufficient number of public addresses have been obtained or currently exist

- **Private Addressing Scheme: Most common** (RFC 1918)

  Sufficient number of public addresses cannot obtained

  Public IP Numbers can be obtained only for the Internet-facing hosts (edge router, firewall, etc.) from the ISP

    NAT is used to access public networks

Reserved Private Addresses

- RFC 1918 addresses

  Not routed by Internet routers (filtered by PE Routers)

Class	Start Address	End Address
Class A	10.0.0.0	10.255.255.255
Class B	172.16.0.0	172.31.255.255
Class C	192.168.0.0	192.168.255.255

- RFC 2026—Link Local Addresses

  169.254.0.1–169.254.255.255

  Auto-assigned IP address to local host if DHCP server cannot be contacted

  Not routed by any router

Other Reserved Addresses

- 127.0.0.1–127.255.255.255
  - Reserved for testing and loopback routines for IP Applications
  - **ping** 1**27.0.0.1**—verifies the local host has properly loaded the IP protocol
- 224.0.0.1–224.0.0.255—Class D Multicast (IANA)
  - Reserved for well known services and network topology mechanisms

Identify Subnetting Requirements

- Identify the maximum number of hosts per subnet :
  - Network saturation and converged service requirements determine maximum hosts in many cases
  - Router Performance and Growth Potential
- Identify the total number of subnets requiring a unique address:
  - Unique address required for each LAN subnet
  - Uniques address required for each WAN subnet
- Identify and Create a Subnet Mask that accommodates the design
  - This is where the movement of the **Line** will come in

Getting to Know the 'Magic Box'

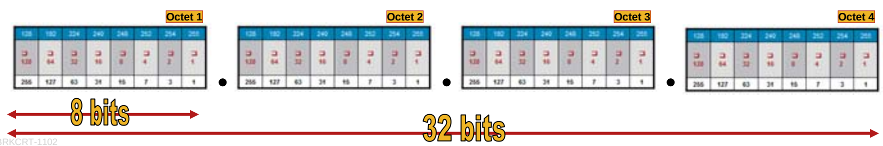
- This is the primary tool that makes the process so easy

  No Math — The box has already done it

  You'll find the **'Answer'** here every time

  This box represents every possible number in a single IP Address Byte (Octet) anywhere in the 32-bit IP number

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1



How the Magic Box Is Built— Most Important

- Begin with eight (8) placeholders. (Use a block…this will make sense later)

❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑

How the Magic Box Is Built (Cont.)

- Add the Binary value of each placeholder, right to left

❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1

- Then Create the Box around it, leaving room for a top and bottom row

How the Magic Box Is Built (Cont.)

- You will now quickly add the numbers across the top, Left to right

  Called adding 'High-Order Bits' in the RFC

0 +

128	192	224	240	248	252	254	255
❑ 128 =	+ ❑ 64 =	+ ❑ 32 =	+ ❑ 16 =	+ ❑ 8 =	+ ❑ 4 =	+ ❑ 2 =	+ ❑ 1 =

- The Top row will represent Subnet Mask Values during the Subnetting process

Hey! I thought you said no Math!

Third-Grade Math doesn't count

How the Magic Box Is Built (Cont.)

- You will now quickly add the numbers across the bottom, **right to left**
  - Called adding 'Low-Order' bits in the RFC

128	192	224	240	248	252	254	255	
❑ 128 +	❑ 64 +	❑ 32 +	❑ 16 +	❑ 8 +	❑ 4 +	❑ 2 +	❑ 1 +	
= 255	= 127	= 63	= 31	= 15	= 7	= 3	= 1	0

- The Numbers in the Bottom row are used to determine the number of Subnets the IP Scheme allows
  - Always add 1 to this number to account for the zero subnet to get an accurate total of networks

The Completed Magic Box!

Subnet Masks	128	192	224	240	248	252	254	255
Block Ranges	❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
	255	127	63	31	15	7	3	1

You'll understand the bottom row in a few minutes...

The Completed Magic Box!

A Cool Trick !

Remember Classification?

Is Where Class B Begins
Is Where Class C Begins
Is Where Class D Begins

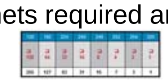
Class A is all numbers <128

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

The Magic Box Really IS Magic !

...and you haven't seen nothin' yet...

Subnetting Keys Review

- Classification
  A, B or C + Class boundary (default Mask)
- Line Position defines the Subnet Mask
  Moved further to the right, more subnets, fewer hosts on each
- Network Subnetting requirements
  Number of subnets required and Largest subnet of hosts
- The Magic Box 
  Provides all of "The Answers" needed to accomplish the subnetting tasks
  What then is "The Answer" we have been searching for?
  "The Magic Number" Defined by the position of the **line**, (the Mask) the magic number is our Network Block Size and the answer to everything. It is inside of the Magic Box.

Applying the Keys to the Classful Subnetting Process (RFC 950)

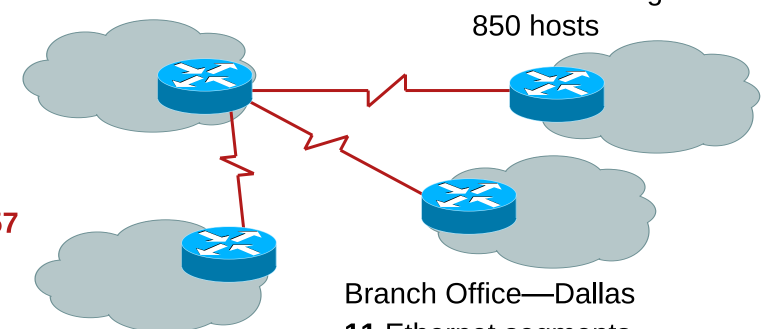
- Classify the address!!!
  - Identify the class A-B-C
  - Draw the initial **Line**
  - Fill in the default mask information
- Obtain information about your network
  - How many total subnet are to be included?
  - On a single subnet, what is the maximum number of hosts allowed?
- Create a custom subnet mask for the entire network
  - Accomplished by moving the **Line** to the right
  - New Subnet Mask number is left of the **Line** Position
- The Line Position provides "**the Answer**"
  - Look in the **Magic Box**—Find the number directly below the chosen mask value—**This is the Magic Number** …will give you everything you need to complete the process
  - **Subnet addresses | Range of host IDs | Broadcast addresses**

Subnetting Example 1: IP Network Design

Central Office—San Diego
23 Ethernet segments—2200 hosts

Branch Office—Denver
8 Ethernet segments—850 hosts

23 +
8 +
12 +
11 +
3 = **57**



Branch Office—Dallas
11 Ethernet segments—950 hosts

Branch Office—Phoenix
12 Ethernet segments—1150 hosts

Maximum number of hosts on any one subnet will be 200

Subnetting Example 1

- Base Address: **172 . 16 . 0 . 0**

Classification: Class B

11111111 . 11111111 . 00000000 . 00000000

255 . 255 . 0 . 0

- Sample design indicates accommodation of 57 subnets (Including WAN) with no more than 200 hosts per subnet (Including router interfaces)

  57 is the key factor here. We need to support at least 57 subnets

Consult Magic Box! Bottom Row

Octet 1 Octet 2

172 . 16 .

255 . 255 .

57 Subnets Needed

Octet 3

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

From Right to Left (as Binary Counts)

How many bits must I go to reach a number larger than 57 ?

Consult Magic Box! Look at the Bottom Row

Octet 1 Octet 2

172 . 16 .

255 . 255 .

57 Subnets Needed

Octet 3

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

From Right to Left (as Binary Counts)

How many bits must I go to reach a number larger than 57 ?

6

Magic Calculation: If I must use 6 bits to exceed 57... I must move the Line 6 bits as well

Octet 1 Octet 2

172 . 16 .

255 . 255 .

Octet 3

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

6

All network bits must stay together
to follow the rules of the RFC

What does the New Line Position Tell Us?

252 is the subnet mask value in octet 3

Octet 1 Octet 2

172 . 16 .

255 . 255 .

Octet 3

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

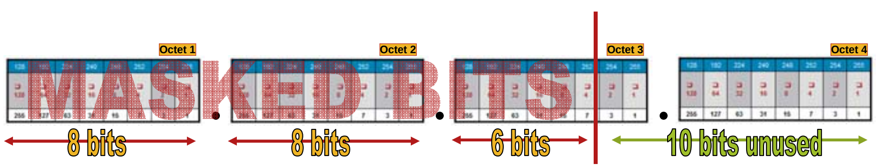
The new, custom subnet mask

255 . 255 . 252 . 0

Total Number of Subnets = 64

63 + 1 (to account for the zero)

What We Are Left With for Host IPs



255 . 255 . 252 . 0

/22 bit Mask - 10 bits for use by hosts

- Remember the original network design requirements:

  57 Subnets total—We ended up with 64

  Maximum **200 Hosts per Subnet**—There are 254 address available in Octet 4 alone (8 bits) and we have 10 bits to use

  Always use your host requirement to check your work when following the classful subnetting procedure

Where We Are in the Process…

- Classify the address!!! DONE
  - Identify the class A-B-C
  - Draw the initial **Line**
  - Fill in the default mask information
- Obtain information about your network DONE
  - How many total subnet are to be included? **57**
  - On a single subnet, what is the maximum number of hosts allowed? **200**
- Create a custom subnet mask for the entire network DONE
  - Accomplished by moving the **Line** to the right
  - New Subnet Mask number is left of the **Line** Position

- The **Line** Position provides "**the Answer**"
  - Look in the Magic Box – Find the number directly below the chosen mask value—**This is the Magic Number** …will give you everything you need to complete the process
  - Subnet addresses | Range of host IDs | Broadcast addresses

Completing the Last Step in the Process

252 is the subnet mask value in octet 3

Octet 3

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

Subnets 64

The Magic Number 4

- The "**Answer**" we have been seeking is '**4**', defined by the mask or **line** position, it is the **Block Size Increment Value** for all subnets, host ranges and broadcast addresses.
  - It will increment 64 times (64 x 4 = 256) in our example

Allocating the Subnet, Host and Broadcast Addresses Using 4, the 'Magic Number'

Base Address: 172.16.0.0

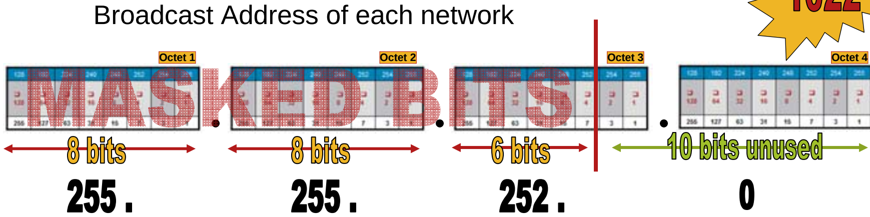
Subnet Address	Host IP Range	Broadcast Address
172.16.0.0	172.16.0.1 - 172.16.3.254	172.16.3.255
172.16.4.0	172.16.4.1 - 172.16.7.254	172.16.7.255
172.16.8.0	172.16.8.1 - 172.16.11.254	172.16.11.255
172.16.12.0	172.16.12.1 - 172.16.15.254	172.16.15.255
172.16.16.0	172.16.16.1 - 172.16.19.254	172.16.19.255
172.16.20.0	172.16.20.1 - 172.16.23.254	172.16.23.255
172.16.24.0	172.16.24.1 - 172.16.27.254	172.16.27.255
172.16.28.0	172.16.28.1 - 172.16.31.254	172.16.31.255
172.16.32.0	172.16.32.1 - 172.16.35.254	172.16.35.255
... +54 more increments to get to the last subnet address...		
172.16.252.0	172.16.252.1 - 172.16.255.254	172.16.255.255

Number of Valid Host IPs Per Subnet

- To determine how many hosts can exist per subnet, continue incrementing the binary number from right to left until you reach 10 bits (1024) and subtract 2

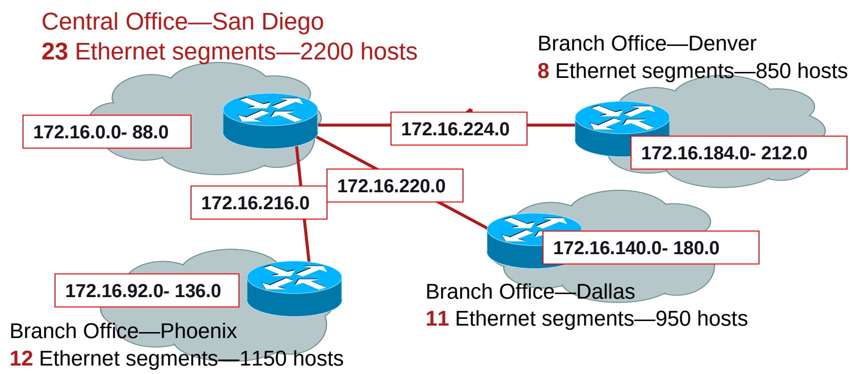
  Remember that binary continues exponentially, so where we have **256** values in octet 4 (8 bits) then **512** (9th bit) then **1024** (10th bit)

  Subtract 2—One for the Subnet address and one for the Broadcast Address of each network



Subnetting Example 1: Applying the Subnets to the Network Locations

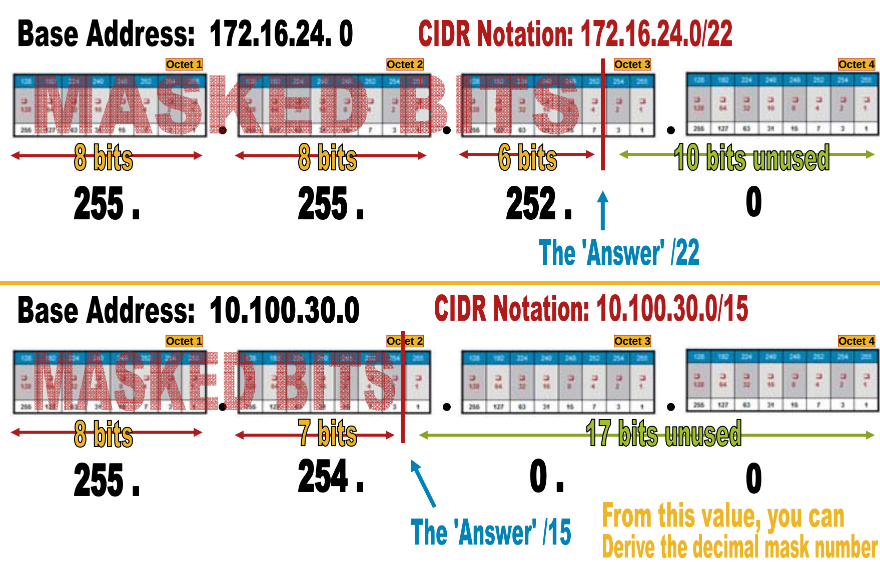
Always Use Contiguous Blocks of Addresses When Assigning Subnet IDs to Each Network Location



Lots of Wasted Addresses...

We'll Take of That With Classless (VLSM) Later...stay tuned

CIDR Notation—Shortcut to the Answer /nn



Magic Box for CIDR Notation and Other Advanced IP Subnetting Concepts

This row is still your Subnet Mask Value:	128	192	224	240	248	252	254	255
	❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
CIDR Notation in the second octet:	/9	/10	/11	/12	/13	/14	/15	/16
CIDR Notation in the third octet:	/17	/18	/19	/20	/21	/22	/23	/24
CIDR Notation in the fourth octet:	/25	/26	/27	/28	/29	/30	/31	/32

Reverse Engineering Any IP Scheme

One of the Most Powerful Troubleshooting Skills
You Can Keep in Your Arsenal

- Given an IP address and mask, what is the subnet address?
- Given an IP address and mask, what is the subnet broadcast address?
- Given an IP address and mask, what are the assignable IP addresses in that network/subnet?
- Given a network number and a static subnet mask, what are the valid subnet numbers?
- Here is all of the information you may be have:

Host 10.48.39.106/21

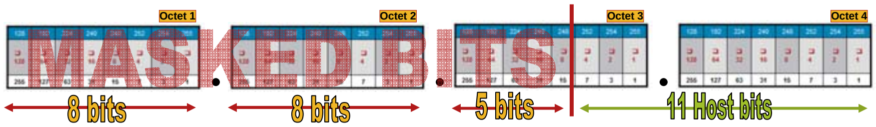
Reverse Engineering by Using the ‘Answer’

- The **‘Answer’** has already been given to you:

Host 10.48.39.106/21

The 'Answer' / 21 = 8 Block

Base Address: 10.48.0.0 / 21 Class A



255 . 255 . 248 . 0

- Second octet will not change since the mask is in the third at /**21**
- To Reverse Engineer, simply start incrementing by **8** until you come to the range the specified host lives in:

  0, 8, 16, 24, 32, 40. (done)

Subnet ID: 10.48.32.0 - Host Range: 10.48.32.1 - 10.48.39.254 - Broadcast: 10.48.39.255

Reverse Engineering Results

Host 10.48.39.106/21

1. Given an IP address and mask, what is the subnet number?

   Subnet ID: 10.48.32.0 -

2. Given an IP address and mask, what is the subnet broadcast address?

   Broadcast: 10.48.39.255

3. Given an IP address and mask, what are the assignable IP addresses in that network/subnet?

   Host Range: 10.48.32.1 - 10.48.39.254 -

4. Given a network number and a static subnet mask, what are the valid subnet numbers?

Any increment of 8, beginning with 0, total of 32 subnets available

8*32=256

Great Job! You Have Passed Level 1!

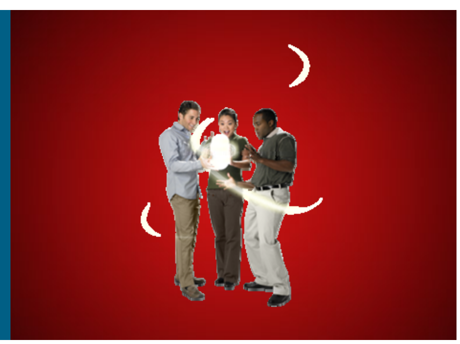
- You have just learned the entire classful subnetting process using no math
  - Everything else from here on out, uses these exact techniques, tools and processes

Bonus Topics !

- Level 2—Classless Subnetting (VLSM) **RFC 1817**
- Level 3 —Classless Inter-Domain Routing (CIDR)
  - Supernetting, Address Aggregation, Summary Addressing

RFC 1338 and 1519

Variable Length Subnet Masking—VLSM (RFC 1818)



Subnetting (Classless) VLSM

Variable Length Subnet Masking

- Allows for more efficient use of IP space
- Less waste on smaller subnets where fewer addresses are necessary
- Used frequently if public address are used internally or unplanned growth needs to be accommodated inside of a site
- Defined first in RFP 1009 then ratified as the latest RFC 1878

Understanding VLSM

- Instead of creating a single subnet mask to accommodate your total IP Subnet number (working from the left)
- Identify a subnet mask for each subnet individually (work from the right side)
  - Move the line as far to the right as you can, while leaving just enough room for the Hosts on that subnet
  - Use the bottom row of the Magic Box to complete this task
  - Use the Magic Box separately for each physical subnet

VLSM Problem 1

128 will be the Mask
in the 4th octet

Octet 4

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

127 is bigger than 90
63 is not

Using network 172.16.0.0
Create a Mask for a subnet containing 90 hosts

Subnet Mask for this Problem is (solution) 255.255.255.128 /25 mask

VLSM Problem 2

252 will be the Mask
in the 4th octet

Octet 4

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

3 is bigger than 2
1 is not

Using network 10.0.0.0
Create a Mask for a subnet containing 2 hosts

Subnet Mask for this Problem is (solution) 255.255.255.252 /30 mask

VLSM Problem 3

224 will be the Mask
in the 4th octet

Octet 4

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

31 is bigger than 20
15 is not

Using network 10.0.0.0
Create a Mask for a subnet containing 20 hosts

Subnet Mask for this Problem is (solution) 255.255.255.224 /27 mask

VLSM Problem 4

Start by extending the
Magic Box

254 will be the Mask
in the 3rd octet

Octet 3

254	255
❑ 512	❑ 256
1023	511

Octet 4

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

511 is bigger than 300
255 is not

Using network 10.0.0.0
Create a Mask for a subnet containing 300 hosts

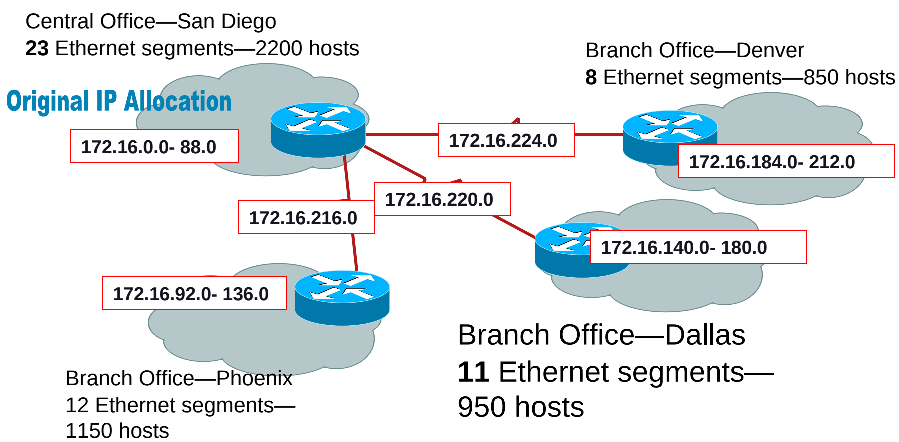
Subnet Mask for this Problem is (solution) 255.255.254.0 /23 mask

Applying VLSM to a Network Design

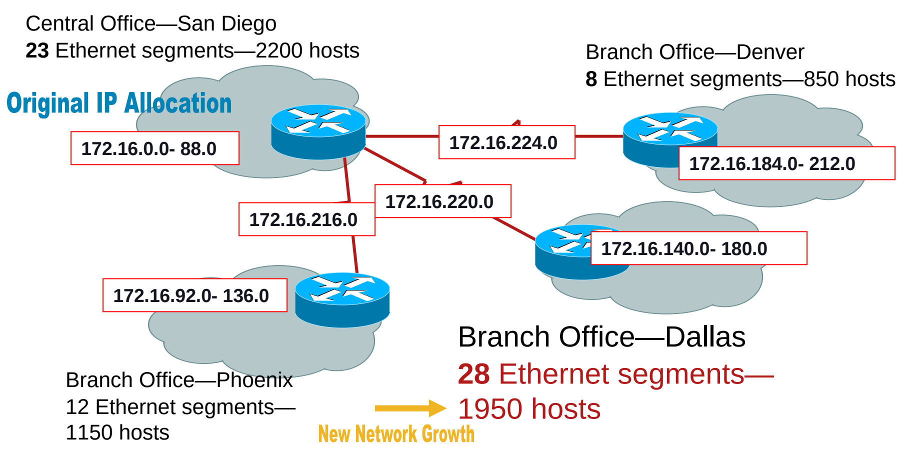
Rules:

- Identify all of the subnets within your operational area and determine their approximate size (Host Population)
- VLSM must be implemented on a standard Binary Block Size: 2, 4, 8,16, 32, and so on
- All Routers and Multi-Layer Switches must be running a routing protocol capable of exchanging Subnet Mask information within their route update packets
  - Classless Routing protocols, like EIGRP, OSPF and RIP2
- When Implementing VLSM, allocate Subnet IDs to the largest networks first, then work your way down to the smallest networks

Subnetting Example 2: VLSM Design



Subnetting Example 2: VLSM Design



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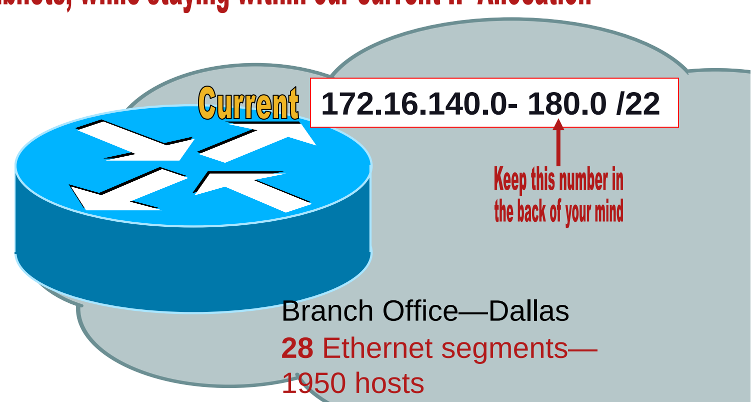
Subnetting Example 2: VLSM Design

We need to make room for at least 28
Subnets, while staying within our current IP Allocation



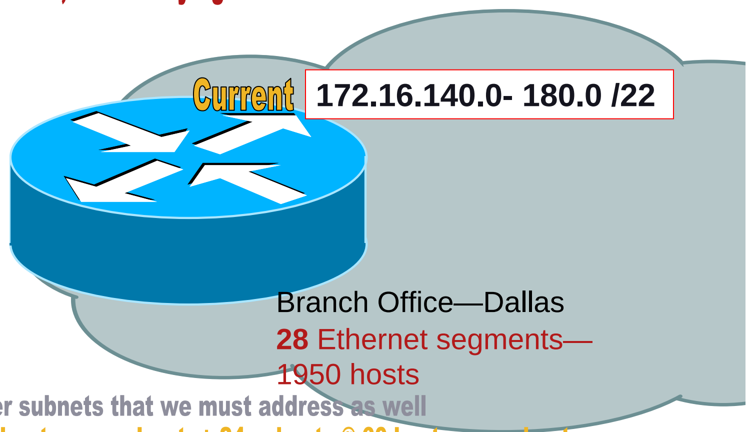
Most of the Subnets in this expanded office need to be small, due to a bandwidth-intensive application service

Max 60 hosts per subnet

 64

Subnetting Example 2: VLSM Design (Cont.)

We need to make room for at least 28 Subnets, while staying within our current IP Allocation



There are 4 larger subnets that we must address as well

4 subnets ~ 115 hosts per subnet + 24 subnets @ 60 hosts per subnet

= ~1950 Network Hosts

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So How Do We Do It?

- EASY…

Octet 4

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

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Computing the Mask for the Large Subnets

- ~114 network device IP addresses required

Octet 4

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

Block Increment
Magic Number

127 is bigger than 114,
63 is not

The Large Subnets Will Have a Subnet Mask of 255.255.255.128

Computing the Mask for the Small Subnets

- 60 network device IP addresses required

Octet 4

128	192	224	240	248	252	254	255
❑ 128	❑ 64	❑ 32	❑ 16	❑ 8	❑ 4	❑ 2	❑ 1
255	127	63	31	15	7	3	1

Block Increment
Magic Number

63 is bigger than 60,
31 is not

The Small Subnets Will Have a Subnet Mask of 255.255.255.192

Address Allocation for Dallas

- Start with the Large Subnets (128 block)

Beginning with 172.16.140.0 as base address

	Subnet ID	Host Range	Broadcast Address
1	172.16.140.0	172.16.140.1 – .140.126	172.16.140.127
2	172.16.140.128	172.16.140.129 – .140.254	172.16.140.255
3	172.16.141.0	172.16.141.1 – .140.126	172.16.141.127
4	172.16.141.128	172.16.141.129 - .141.254	172.16.141.255

This Scheme Allows Up To 126 Hosts On Each Subnet (114 required)

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Address Allocation for Dallas (Cont.)

- Now create the ranges for the small subnets (64 block)

Beginning with 172.16.142.0 as base address (where we left off)

	Subnet ID	Host Range	Broadcast Address
5	172.16.142.0	172.16.142.1 – .142.62	172.16.142.63
6	172.16.142.64	172.16.142.65 – .142.126	172.16.142.127
7	172.16.142.128	172.16.142.129 – .142.190	172.16.142.191
8	172.16.142.192	172.16.142.193 – .142.254	172.16.142.255
9	172.16.143.0	172.16.143.1 – .143.62	172.16.143.63
10	172.16.143.64	172.16.143.65 – .143.126	172.16.143.127
11	172.16.143.128	172.16.143.129 – .143.190	172.16.143.191
12	172.16.143.192	172.16.143.193 – .143.254	172.16.143.255
…	…and so on…	…12 more subnets are built…	…and you end up with…
24	172.16.147.192	172.16.147.193 – .147.254	172.16.147.255

This Scheme Allows Up To 62 Hosts On Each Subnet

Do you remember the 180?

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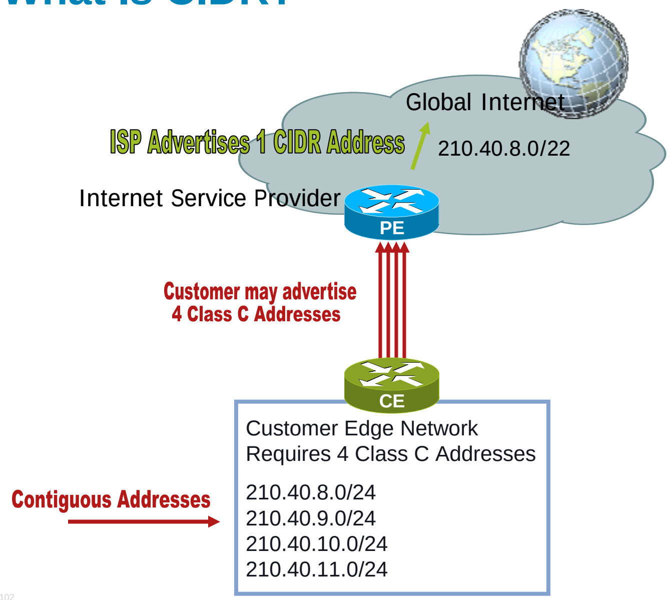
Level 3—RFCs 1338 and 1519

- Same Game…Many Names
  - CIDR—Classless Inter-Domain Routing
  - Supernetting
  - IPv4 Address Aggregation
  - IP Address Summarization
- All of these follow the same basic process
  - Advertise a single IP Subnet Address/Mask on a router which implies multiple IP Subnets
  - 10.0.0.0/8 implies all '10' networks
  - Must have a contiguous 'block' to implement (2, 4, 8, 16, 32, etc)

Classless Interdomain Routing

- One method to help control IP addresses depletion
- Reduce Internet routing table size (BGP Table)
  - Blocks of Contiguous Addresses (4, 8,16, etc) are assigned to ISPs
  - ISPs assign IP addresses to Customers in contiguous blocks
  - Blocks are summarized to reduce router advertisements and route table size
- Check out
  - www.traceroute.org/#USA Scroll down to Route Servers where you can telnet to a live Cisco BGP router and view the complete BGP Table

What Is CIDR?



Supernetting, Summarization, Aggregation Example

Actual Network Addresses

192.168.96.0/24	=	192	.	168	.	01100000	.	0
192.168.97.0/24	=	192	.	168	.	01100001	.	0
192.168.98.0/24	=	192	.	168	.	01100010	.	0
192.168.99.0/24	=	192	.	168	.	01100011	.	0
192.168.100.0/24	=	192	.	168	.	01100100	.	0
192.168.101.0/24	=	192	.	168	.	01100101	.	0
192.168.102.0/24	=	192	.	168	.	01100110	.	0
192.168.103.0/24	=	192	.	168	.	01100111	.	0

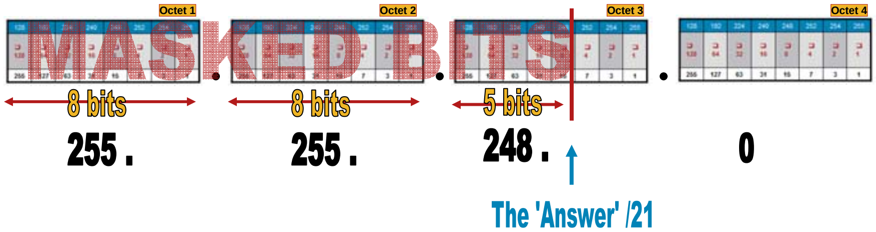
Common Bits

There are 21 bits which all of the networks have in common
Therefore, the best summary address would be:

192.168.96.0/21

Supernetting, Summarization, Aggregation Example (Cont.)

Base Address: 192.168.96.0

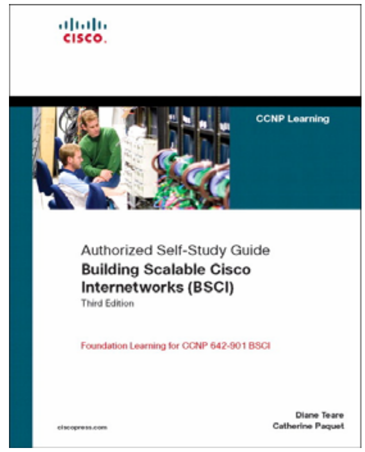


CIDR Notation: 192.168.96.0/21

Q and A

Recommended Reading

- Continue your Networkers at Cisco Live learning experience with further reading from Cisco Press
- Check the Recommended Reading flyer for suggested books



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