INFO 3605
Fundamentals of LAN Technologies
Lecture 21 – Subnet Design

Naresh Seegobin (M.Sc. CompSci, M.Sc. ProjMgmt, CCNA)

naresh.seegobin@sta.uwi.edu

Based on Chapter 21 of Odom, Wendell. *CCENT/CCNA ICND1 100-105 official cert guide*. Indianapolis, IN: Cisco Press, 2016.

Finding the right network size at home

- Home network typically Class C (192.168.1.x, 192.168.10.x, etc.).
- May want to make this network much smaller
  - as you do not have 254 devices or
  - want a separate network for different devices

Objectives

- The student must be able to:
  - Understand and plan the subnet mask(s) required for an IPv4 network.
  - Configure, verify and troubleshoot IPv4 addressing and subnetting.

Test your knowledge

- An IP subnetting design effort is under way at a company. So far, the senior engineer has decided to use Class B network 172.23.0.0. The design calls for 100 subnets, with the largest subnet needing 500 hosts. Management requires that the design accommodate 50 percent growth in the number of subnets and the size of the largest subnet. The requirements also state that a single mask must be used throughout the Class B network. How many masks meet the requirements?
  a. 0
  b. 1
  c. 2
  d. 3+

Test your knowledge

- An IP subnetting design effort is under way at a company. So far, the senior engineer has decided to use Class B network 172.23.0.0. The design calls for 100 subnets, with the largest subnet needing 500 hosts. Management requires that the design accommodate 50 percent growth in the number of subnets and the size of the largest subnet. The requirements also state that a single mask must be used throughout the Class B network. How many masks meet the requirements?

  a. 0

  b. 1

  c. 2

  d. 3+

Test your knowledge

- . An IP subnetting design requires 200 subnets and 120 hosts/subnet for the largest subnets, and requires that a single mask be used throughout the one private IP network that will be used. The design also requires planning for 20 percent growth in the number of subnets and number of hosts/subnet in the largest subnet. Which of the following answers lists a private IP network and mask that, if chosen, would meet the requirements?
  a. 10.0.0.0/25
  b. 10.0.0.0/22
  c. 172.16.0.0/23
  d. 192.168.7.0/24

Test your knowledge

- An IP subnetting design requires 200 subnets and 120 hosts/subnet for the largest subnets, and requires that a single mask be used throughout the one private IP network that will be used. The design also requires planning for 20 percent growth in the number of subnets and number of hosts/subnet in the largest subnet. Which of the following answers lists a private IP network and mask that, if chosen, would meet the requirements?

  a. 10.0.0.0/25

  b. 10.0.0.0/22

  c. 172.16.0.0/23

  d. 192.168.7.0/24

Test your knowledge

- An engineer has planned to use Class B network 172.19.0.0 and a single subnet mask throughout the network. The answers list the masks considered by the engineer. Choose the mask that, among the answers, supplies the largest number of hosts per subnet, while also supplying enough subnet bits to support 1000 subnets.
  a. 255.255.255.0
  b. /26
  c. 255.255.252.0
  d. /28

Test your knowledge

- An engineer has planned to use Class B network 172.19.0.0 and a single subnet mask throughout the network. The answers list the masks considered by the engineer. Choose the mask that, among the answers, supplies the largest number of hosts per subnet, while also supplying enough subnet bits to support 1000 subnets.

  a. 255.255.255.0

  b. /26

  c. 255.255.252.0

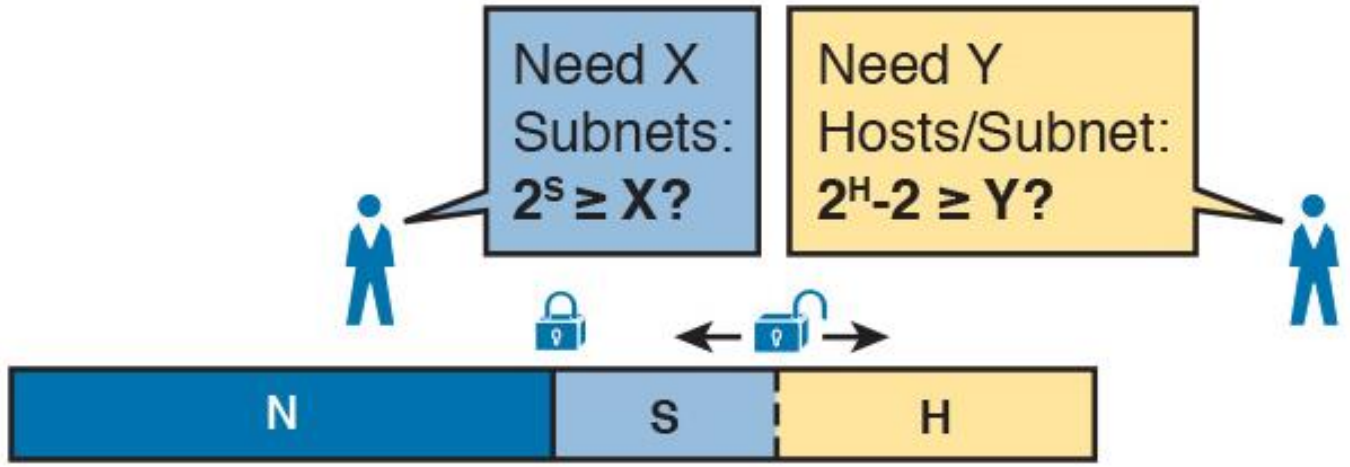
  d. /28

Choosing the Mask(s) to Meet Requirements

- You are using Class B network 172.16.0.0. You need 200 subnets and 200 hosts/subnet. Which of the following subnet mask(s) meet the requirements?
- There are three general cases for a possible solution:
  - No masks meet the requirements.
  - One and only one mask meets the requirements.
  - Multiple masks meet the requirements.

Choosing the Minimum Number of Subnet and Host Bits

- Choosing the Number of Subnet and Host Bits



Choosing the Minimum Number of Subnet and Host Bits

- Powers of 2 Reference for Designing Masks

Number of Bits	2^X	Number of Bits	2^X	Number of Bits	2^X	Number of Bits	2^X
1	2	5	32	9	512	13	8192
2	4	6	64	10	1024	14	16,384
3	8	7	128	11	2048	15	32,768
4	16	8	256	12	4096	16	65,536

Choosing the Minimum Number of Subnet and Host Bits

- Formal Steps:
- **Step 1.** Determine the number of network bits (N) based on the class.
- **Step 2.** Determine the smallest value of S, so that 2^S => X, where X represents the required number of subnets.
- **Step 3.** Determine the smallest value of H, so that $2^H - 2$ => Y, where Y represents the required number of hosts/subnet.

- Satisfy subnet requirements first then host requirements.

No Masks Meet Requirements

- A network engineer is planning a subnet design. The engineer plans to use Class B network 172.16.0.0. The network has a need for 300 subnets and 280 hosts per subnet. Which of the following masks could the engineer choose?

- Use the 3 step process.

No Masks Meet Requirements

- Network Class = B (172.16.0.0)
- No. of Subnets = 300
  - $2^8 = 256 < 300$
  - $2^9 = 512 > 300$ ← Works!!!
  - S = 9

- No. of Hosts = 280
  - $2^8 = 256 < 280$
  - $2^9 = 512 > 280$ ← Works!!!
  - H = 9

- Too few bits for the host part, given the requirements.

One Mask Meets Requirements

- A network engineer is planning a subnet design. The engineer plans to use Class B network 172.16.0.0. The network has a need for 200 subnets and 180 hosts per subnet. Which of the following masks could the engineer choose?

- Use the 3 step process.

One Mask Meets Requirements

- Network Class = B (172.16.0.0)
- No. of Subnets = 200
  - $2^8 = 256 > 200$ ← Works!!!
  - S = 8

- No. of Hosts = 180
  - $2^7 = 128 < 180$
  - $2^8 = 256 > 180$ ← Works!!!
  - H = 8

- One mask meets the requirements

Multiple Masks Meet Requirements

- A network engineer is planning a subnet design. The engineer plans to use Class B network 172.16.0.0. The network has a need for 50 subnets and 180 hosts per subnet. Which of the following masks could the engineer choose?

- Use the 3 step process.

Multiple Masks Meet Requirements

- Network Class = B (172.16.0.0), N = 16
- No. of Subnets = 50
  - $2^6 = 64 > 50$ ← Works!!!
  - S = 6

11111111	11111111	11111100	00000000

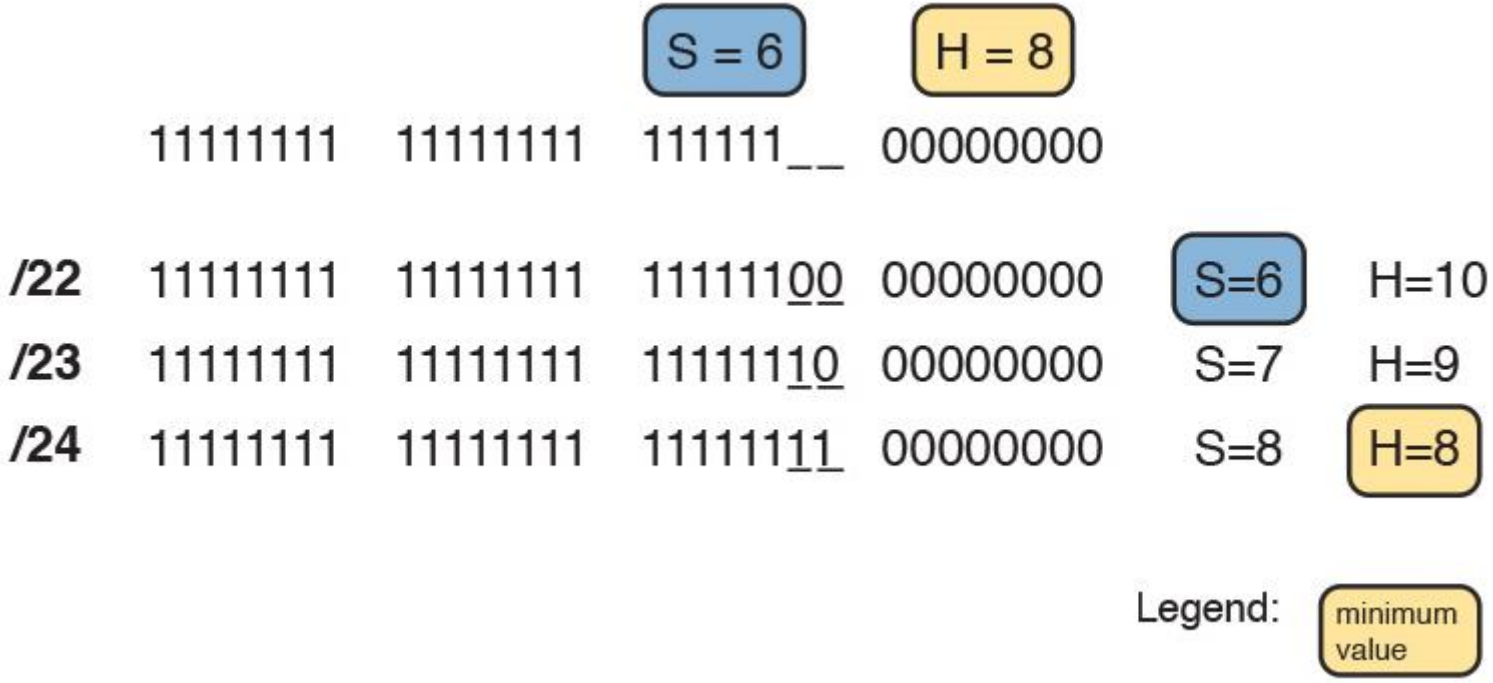
- No. of Hosts = 180
  - $2^7 = 128 < 180$
  - $2^8 = 256 > 180$ ← Works!!!
  - H = 8

11111111	11111111	11111100	00000000

- Incomplete mask with N = 16, S = 6, H = 8, their sum is less than 32.

Multiple Masks Meet Requirements

- Three Masks That Meet the Requirements



Choosing the Best Mask

- **To maximize the number of hosts/subnet:**
  - Use the shortest prefix mask (that is, the mask with the smallest /P value), because this mask has the largest host part.
- **To maximize the number of subnets:**
  - Use the longest prefix mask (that is, the mask with the largest /P value), because this mask has the largest subnet part.
- **To increase both the numbers of supported subnets and hosts:**
  - Choose a mask in the middle of the range, which gives you both more subnet bits and more host bits.

Finding All your Subnet IDs

- Once a subnet mask is chosen all the subnet IDs or networks must be calculated.
- Use of binary math to calculate these.
- Identify a pattern to generate subnet IDs from any given subnet ID and mask.

First Subnet ID: The Zero Subnet

- No matter what Class A, B, or C network you use, and no matter what subnet mask you use, the first (numerically lowest) subnet ID is equal to the network ID.
  - E.g. for the classful network 172.20.0.0, no matter what the mask is, the first subnet ID is 172.20.0.0.
- This first subnet ID in each network goes by two special names: either **subnet zero** or the **zero subnet**

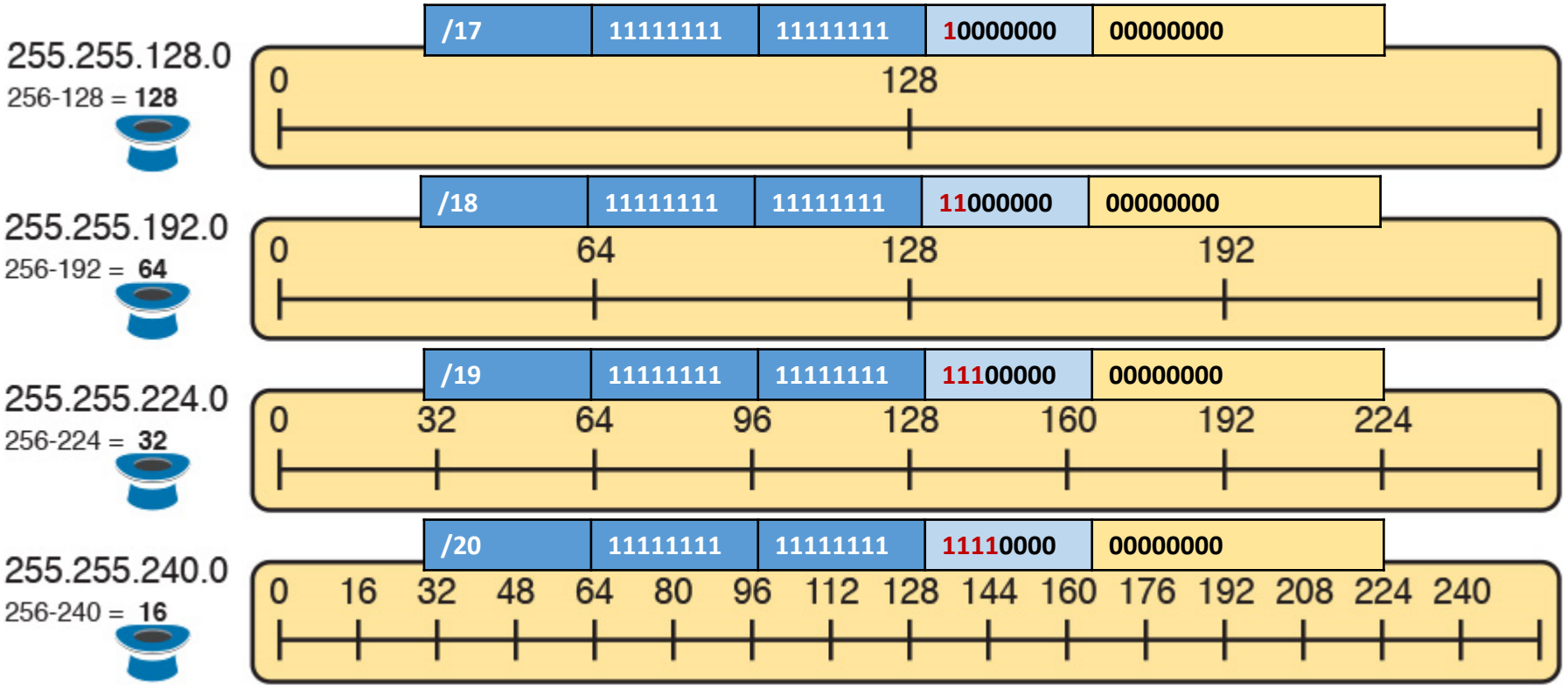
First Subnet ID: The Zero Subnet

- Configuring on a CISCO device.

```
R1# configure terminal
Enter configuration commands, one per line.   End with CNTL/Z.
R1(config)# no ip subnet-zero
R1(config)# interface g0/1
R1(config-if)# ip address 10.0.0.1 255.255.255.0
Bad mask /24 for address 10.0.0.1
```

Finding the Pattern for your Subnets

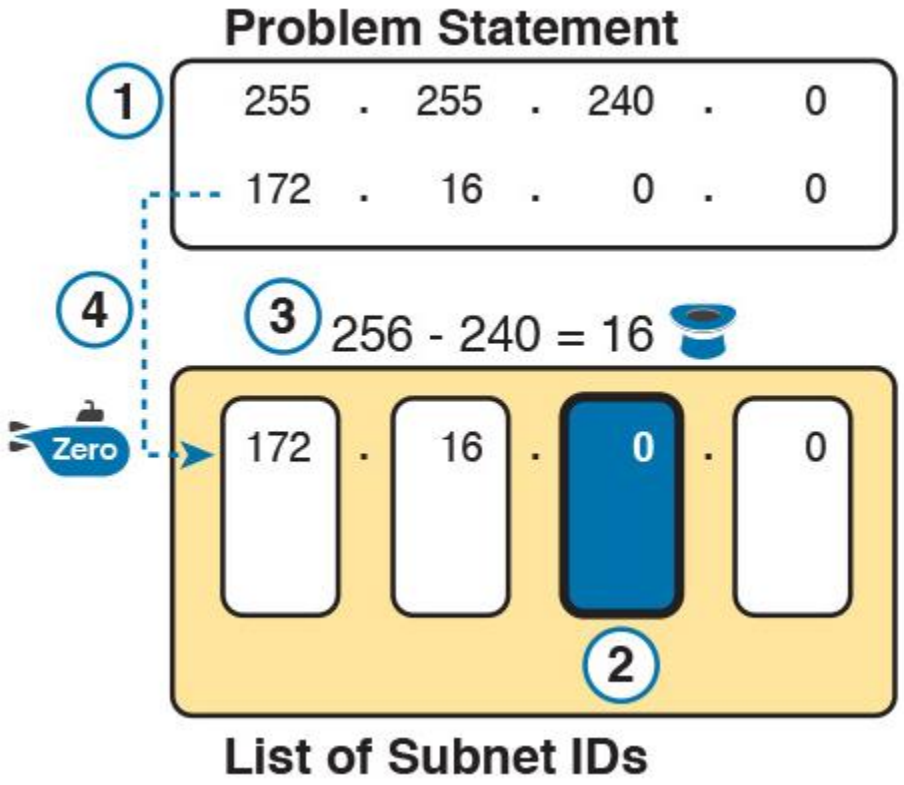
- Patterns with Magic Numbers for Masks /17 – /20

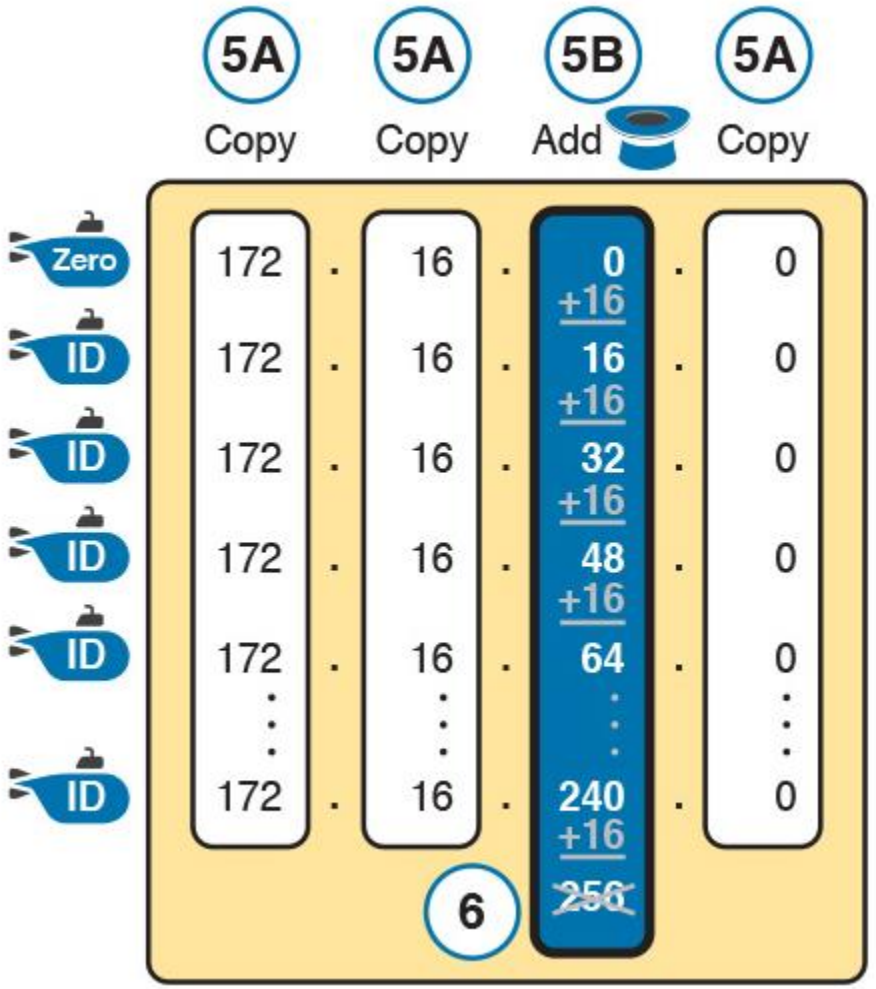


Example 1: Network 172.16.0.0, Mask 255.255.240.0

- Step 1. Mask = 255.255.240.0
  - Network = 172.16.0.0
- Step 2. Identify interesting octet in this case 240 (neither 0 nor 255)
- Step 3. Network Size = 256 – 240 = 16
- Step 4. Zero subnet is 172.16.0.0
- Step 5. A. Network value is 172.16.0.0
- Step 5. B. Next network value add network size. 172.16.16.0
  - Repeat, 172.16.32.0, 172.16.48.0, 172.16.64.0….
- Step 6. Until you reach a network with 256 in the octet.
  - In this case, 172.16.256.0 (out of range)

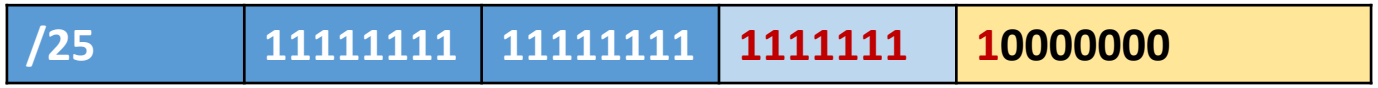
Example 1: Network 172.16.0.0, Mask 255.255.240.0



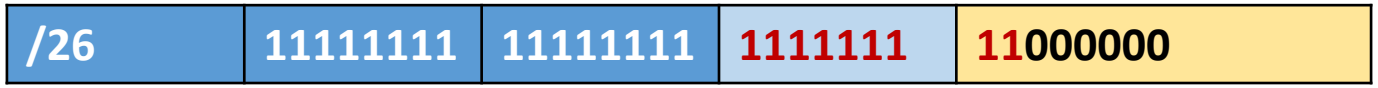


Finding All Subnets with More Than 8 Subnet Bits

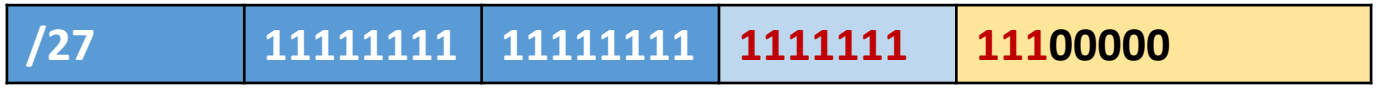
- Process with 9–12 Subnet Bits
- S = 9, Prefix = /25, Network Size = 256 – 128 = 128



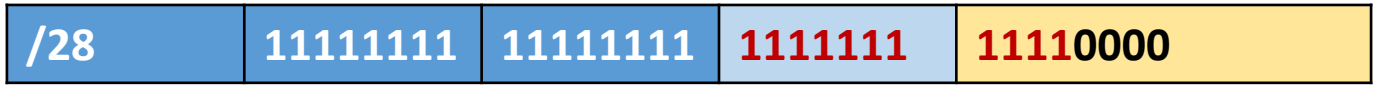
- S = 10, Prefix = /26, Network Size = 256 – 192 = 64



- S = 11, Prefix = /27, Network Size = 256 – 224 = 32

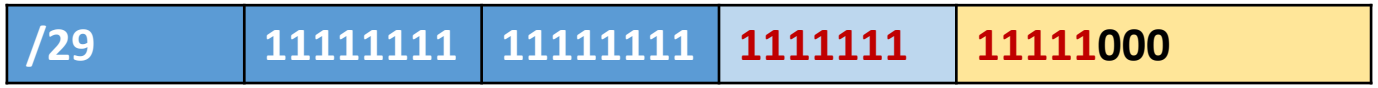


- S = 12, Prefix = /28, Network Size = 256 – 240 = 16

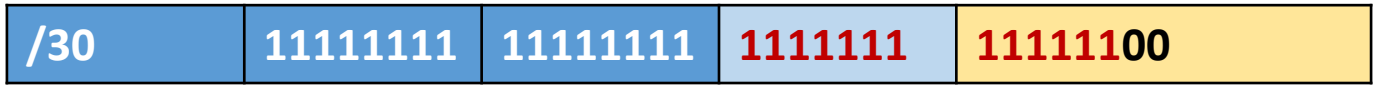


Finding All Subnets with More Than 8 Subnet Bits

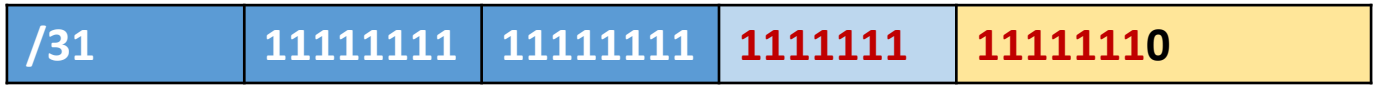
- Process with 13–16 Subnet Bits
- S = 13, Prefix = /29, Network Size = 256 – 248 = 8



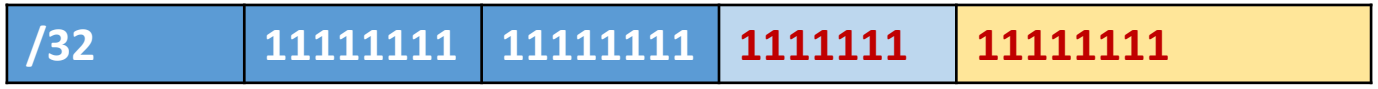
- S = 14, Prefix = /30, Network Size = 256 – 252 = 4



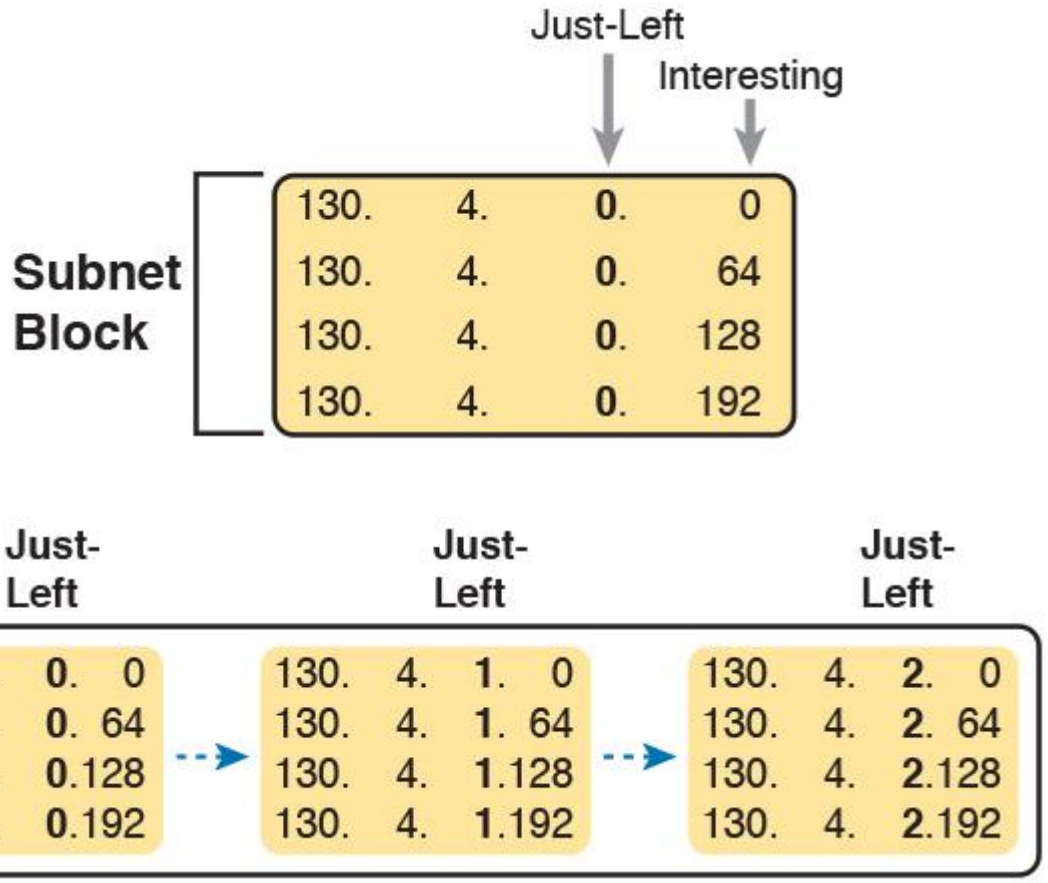
- S = 15, Prefix = /31, Network Size = 256 – 254 = 2



- S = 16, Prefix = /32, Network Size = 256 – 256 = 0



Finding All Subnets with More Than 8 Subnet Bits



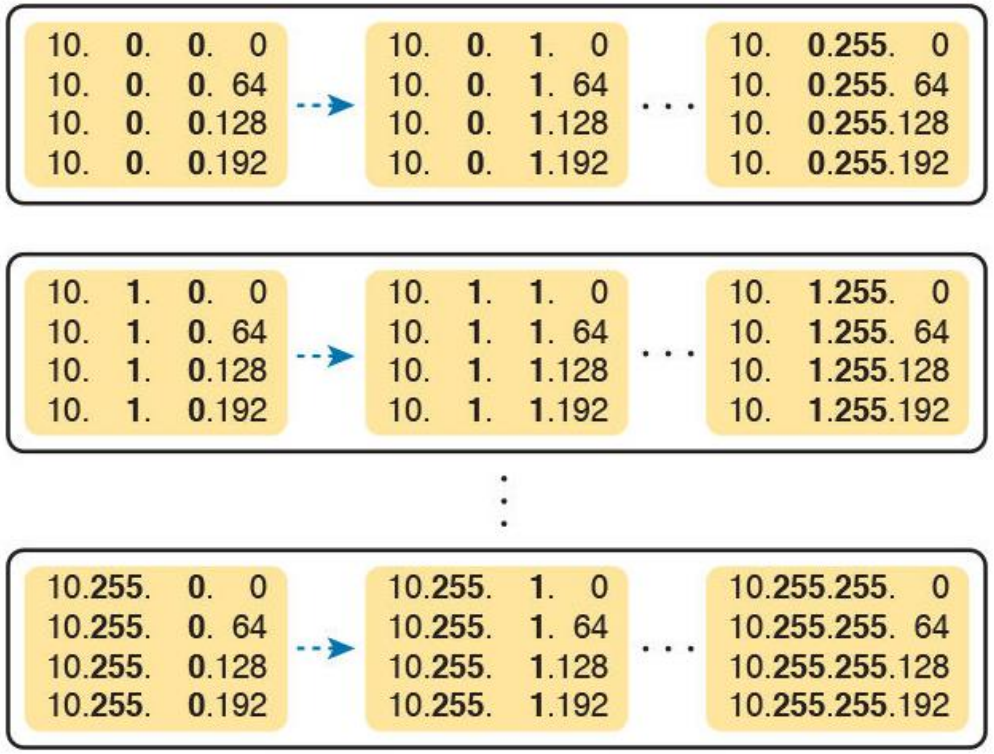
Process with 17 or More Subnet Bits

- Process with 17 or more Subnet Bits.
- Using Class A network with a prefix of /8.
- S = 17, Prefix = /25, Network Size = 256 – 128 = 128

/25	11111111	11111111	1111111	10000000

Process with 17 or More Subnet Bits

- 256 Times 256 Subnet Blocks of Four Subnets



What do you know now?

- An engineer has calculated the list of subnet IDs, in consecutive order, for network 172.30.0.0, assuming that the /22 mask is used throughout the network. Which of the following are true? (Choose two answers.)

  a. Any two consecutive subnet IDs differ by a value of 22 in the third octet.

  b. Any two consecutive subnet IDs differ by a value of 16 in the fourth octet.

  c. The list contains 64 subnet IDs.

  d. The last subnet ID is 172.30.252.0.

What do you know now?

- An engineer has calculated the list of subnet IDs, in consecutive order, for network 172.30.0.0, assuming that the /22 mask is used throughout the network. Which of the following are true? (Choose two answers.)

  a. Any two consecutive subnet IDs differ by a value of 22 in the third octet.

  b. Any two consecutive subnet IDs differ by a value of 16 in the fourth octet.

  c. The list contains 64 subnet IDs.

  d. The last subnet ID is 172.30.252.0.

What do you know now?

- Which of the following are valid subnet IDs for network 192.168.9.0 using mask /29, assuming that mask /29 is used throughout the network?
  a. 192.168.9.144
  b. 192.168.9.58
  c. 192.168.9.242
  d. 192.168.9.9

What do you know now?

- Which of the following are valid subnet IDs for network 192.168.9.0 using mask /29, assuming that mask /29 is used throughout the network?

  a. 192.168.9.144

  b. 192.168.9.58

  c. 192.168.9.242

  d. 192.168.9.9

What do you know now?

- Which of the following is not a valid subnet ID for network 172.19.0.0 using mask /24, assuming that mask /24 is used throughout the network?
  a. 172.19.0.0
  b. 172.19.1.0
  c. 172.19.255.0
  d. 172.19.0.16

What do you know now?

- Which of the following is not a valid subnet ID for network 172.19.0.0 using mask /24, assuming that mask /24 is used throughout the network?

  a. 172.19.0.0

  b. 172.19.1.0

  c. 172.19.255.0

  d. 172.19.0.16

Summary

- Binary values in subnet masks.
- Three step process to find all prefix masks that meet subnet nand host requirements.
- Choosing one subnet mask versus another.
- Process for finding and choosing masks to meet certain requirements.
- Find all subnet IDs when less than 8 subnet bits.
- Find all subnet IDs when greater than 8 subnet bits.

End of Lecture 21, Further Reading, References

- Odom, Wendell. *CCENT/CCNA ICND1 100-105 official cert guide*. Indianapolis, IN: Cisco Press, 2016.