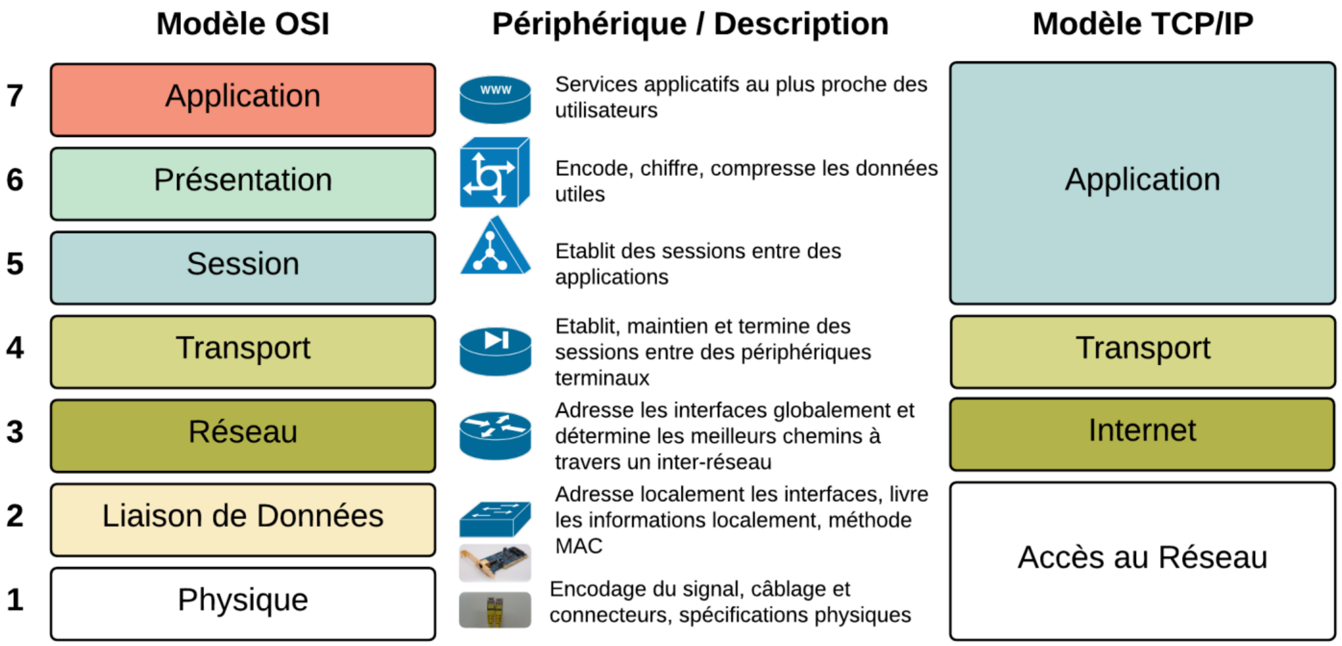
Net Layer
Internet Protocol

2023/2024

Hemza.loucif@univ-msila,dz

Introduction



Introduction

- The Internet Protocol (IP) is the network layer communications protocol in the Internet protocol suite for relaying datagrams across network boundaries. Its routing function enables internetworking, and essentially establishes the Internet.

Introduction

The Subnet Mask

- Part of an IP address identifies the network. The other part of the address identifies the host. A subnet mask is required to provide this distinction:

158.80.164.3 255.255.0.0

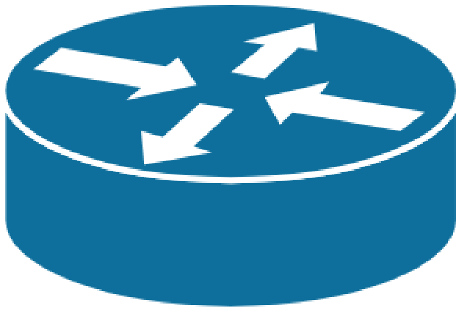
- The subnet mask follows two rules:
  - ❑ If a binary bit is set to a 1 (or on) in a subnet mask, the corresponding bit in the address identifies the network.
  - ❑ If a binary bit is set to a 0 (or off) in a subnet mask, the corresponding bit in the address identifies the host.

Introduction

- Hosts on the same logical network will have identical network addresses, and can communicate freely. For example, the following two hosts are on the same network:
  - **Host A:** 158.80.164.100 255.255.0.0
  - **Host B:** 158.80.164.101 255.255.0.0
- Hosts that are on different networks cannot communicate without an intermediating device. For example:
  - **Host A:** 158.80.164.100 255.255.0.0
  - **Host B:** 158.85.164.101 255.255.0.0

Introduction

- The subnet mask has remained the same, but the network addresses are now different (158.80 and 158.85 respectively). Thus, the two hosts are not on the same network, and cannot communicate without a router between them.
- Routing is the process of forwarding packets from one network to another.



Introduction

Subnet and Broadcast Addresses

- On each IP network, two host addresses are reserved for special use:
  - The subnet (or network) address
  - The broadcast address
- Neither of these addresses can be assigned to an actual host.

Subnetting

- Subnetting is the process of creating new networks (or subnets) by stealing bits from the host portion of a subnet mask.
- Consider the following Class C network:

192.168.254.0

- The default subnet mask for this network is 255.255.255.0.
- This single network can be segmented, or subnetted, into multiple networks.
- For example, assume a minimum of 10 new networks are required.
- Resolving this is possible using the following magical formula:

$$2^n$$

Subnetting

- Resolving this is possible using the following magical formula:

$$2^n$$

- The exponent 'n' identifies the number of bits to steal from the host portion of the subnet mask.
- The default Class C mask (255.255.255.0) looks as follows in binary:

11111111.11111111.11111111.00000000

- There are a total of 24 bits set to 1, which are used to identify the network.
- There are a total of 8 bits set to 0, which are used to identify the host, and these host bits can be stolen.

Subnetting

- Resolving this is possible using the following magical formula:

$$2^n$$

- Stealing bits essentially involves changing host bits (set to 0 or off) in the subnet mask to network bits (set to 1 or on).
- Remember, network bits in a subnet mask must always be **contiguous** - skipping bits is not allowed.
- Consider the result if three bits are stolen. Using the above formula:

$$2^n = 2^3 = 8 = 8 \text{ new networks created}$$

- However, a total of 8 new networks does not meet the original requirement of at least 10 networks. Consider the result if four bits are stolen:

$$2^n = 2^4 = 16 = 16 \text{ new networks created}$$

Subnetting

- Resolving this is possible using the following magical formula:

$$2^n$$

- A total of 16 new networks does meet the original requirement. Stealing four host bits results in the following new subnet mask:

11111111.11111111.11111111.11110000 = 255.255.255.240

- To determine the number of hosts this results in, for each of the new 16 networks, a slightly modified formula is required:

$$2^n - 2$$

- In our case:

$2^n - 2 = 2^4 - 2 = 14$usable hosts per network

Subnetting

- Thus, subnetting a Class C network with a /28 mask creates 16 new networks, with 14 usable hosts per network.

But, why is the formula for calculating usable hosts $2^n - 2$?

- Because it is never possible to assign a host an address with all 0 or all 1 bits in the host portion of the address. These are reserved for the subnet and broadcast addresses, respectively.
- Thus, every time a network is subnetted, useable host addresses are lost.

Subnetting

Determining the Range of Subnetted Networks

- Determining the range of the newly created networks can be accomplished using several methods.
- Consider the example 192.168.254.0 network again, which was subnetted using a 255.255.255.240 mask:

192.168.254.0: 11000000.10101000.11111110.00000000

255.255.255.240: 11111111.11111111.11111111.11110000

Subnetting

Determining the Range of Subnetted Networks

Binary	*Decimal*	*Binary*	*Decimal*	*Binary*	*Decimal*
.0000 *xxxx*	.0	.0110 *xxxx*	.96	.1100 *xxxx*	.192
.0001 *xxxx*	.16	.0111 *xxxx*	.112	.1101 *xxxx*	.208
.0010 *xxxx*	.32	.1000 *xxxx*	.128	.1110 *xxxx*	.224
.0011 *xxxx*	.48	.1001 *xxxx*	.144	.1111 *xxxx*	.240
.0100 *xxxx*	.64	.1010 *xxxx*	.160		
.0101 *xxxx*	.80	.1011 *xxxx*	.176		

Subnetting

Determining the Range of Subnetted Networks

- To determine the range for the hosts of the first new network:

Binary	Decimal	Binary	Decimal	Binary	Decimal
.0000 0000	.0	.0000 0110	.6	.0000 1100	.12
.0000 0001	.1	.0000 0111	.7	.0000 1101	.13
.0000 0010	.2	.0000 1000	.8	.0000 1110	.14
.0000 0011	.3	.0000 1001	.9	.0000 1111	.15
.0000 0100	.4	.0000 1010	.10		
.0000 0101	.5	.0000 1011	.11		

- The first address has all 0 bits in the host portion (0000), and is the subnet address for this network.
- The last address has all 1 bits in the host portion, and thus is the broadcast address for this network.
- Note that there are exactly 14 usable addresses to assign to hosts.

Subnetting

Determining the Range of Subnetted Networks

- Calculating the ranges of subnetted networks can quickly become **tedious** when using the long binary method.
- The shortcut method involves taking the subnet mask (255.255.255.240 from the previous example), and subtracting the subnetted octet (240) from 256.

$$256 – 240 = 16$$

- Then, simply continue adding 16 to identify the first address of each new network:

0 16 32 48 64 80 96 112 128 144 160 176 192 208 224 240

Subnetting

Determining the Range of Subnetted Networks

- Knowing the first address of each new network makes it simple to determine the last address of each network:

First address of network	0	16	32	48	64	80	96	112	128	144
Last address of network	15	31	47	63	79	95	111	127	143	159

- Only the first 10 networks were calculated, for brevity. The first address of each network becomes the subnet address for that network. The last address of each network becomes the broadcast address for that network.

Subnetting

Determining the Range of Subnetted Networks

- Once the first and last address of each network is known, determining the usable range for hosts is straightforward:

Subnet address	0	16	32	48	64	80	96	112	128	144
	1	17	33	49	65	81	97	113	129	145
Usable Range	↕	↕	↕	↕	↕	↕	↕	↕	↕	↕
	14	30	46	62	78	94	110	126	142	158
Broadcast address	15	31	47	63	79	95	111	127	143	159

- Hosts on the same network (such as 192.168.254.2 and 192.168.254.14) can communicate freely.
- Hosts on different networks (such as 192.168.254.61 and 192.168.254.66) require a router to communicate.

Subnetting

Review:

192.168.10.0/25

255.255.255.128

- How many nets I need?

11111111.11111111.11111111.10000000

Net ID2= Net ID1 + (256-128)

Net ID	**192.168.10.0**	**192.168.10.128**
First Host	192.168.10.1	192.168.10.129
Last Host	192.168.10.126	192.168.10.254
Broadcast	192.168.10.127	192.168.10.255

Subnetting

Review:

192.168.10.0/26

255.255.255.192

- How many nets I need?

11111111.11111111.11111111.11000000

Net ID4= Net ID3 + (256-192)

Net ID	**192.168.10.0**	**192.168.10.64**	**…**	**192.168.10.192**
First Host	192.168.10.1	192.168.10.65	.	192.168.10.193
Last Host	192.168.10.62	192.168.10.126	.	192.168.10.254
Broadcast	192.168.10.63	192.168.10.127	.	192.168.10.255

Subnetting

Review:

192.168.10.0/28

255.255.255.240

- How many nets I need?

11111111.11111111.11111111.11110000

Net ID2= Net ID1 + (256-240)

Net ID	192.168.10.0	192.168.10.16	…	192.168.10.240
First Host	192.168.10.1	192.168.10.17	.	192.168.10.241
Last Host	192.168.10.14	192.168.10.30	.	192.168.10.254
Broadcast	192.168.10.15	192.168.10.31	.	192.168.10.255

Subnetting

What's the NetID which corresponds to this IP : 192.168.0.109/28

Subnetting

Review:

- Ability to organize your resources within a network
- Ability to secure your resources by placing them into separate subnetworks
- Speedup your network (avoid congestions)
- Maintenance will be easier too

1. How many networks I need?
2. How many hosts in each Net?
3. What are the valid subnets?
4. What's the broadcast address?
5. What are the valid hosts in each subnet?

VLSM (Variable Length Subnet Mask) Subnetting

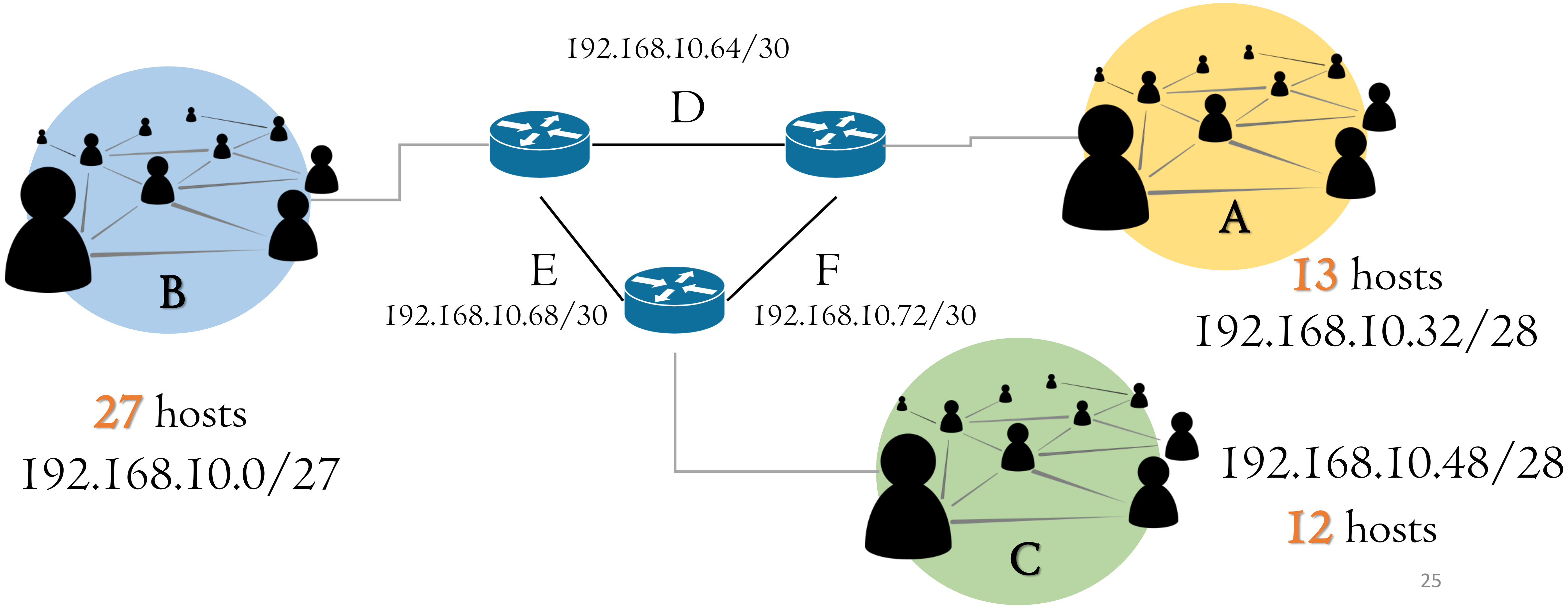
VLMS vs CIDR

- VLSM, for Variable Length Subnet Mask, is a technique used to better manage IP addresses, much like CIDR.
- In fact, VLSM is an extension of CIDR.
- The difference is that CIDR is more used at the internet level and VLSM is more used in a local network, but both allow to minimize the loss of addresses.

To set up a network with variable length masks, it is necessary to be sure that the routers support the protocols compatible with VLSM. A few of these protocols are OSPF, EIGRP, RIPv2, IS-IS.

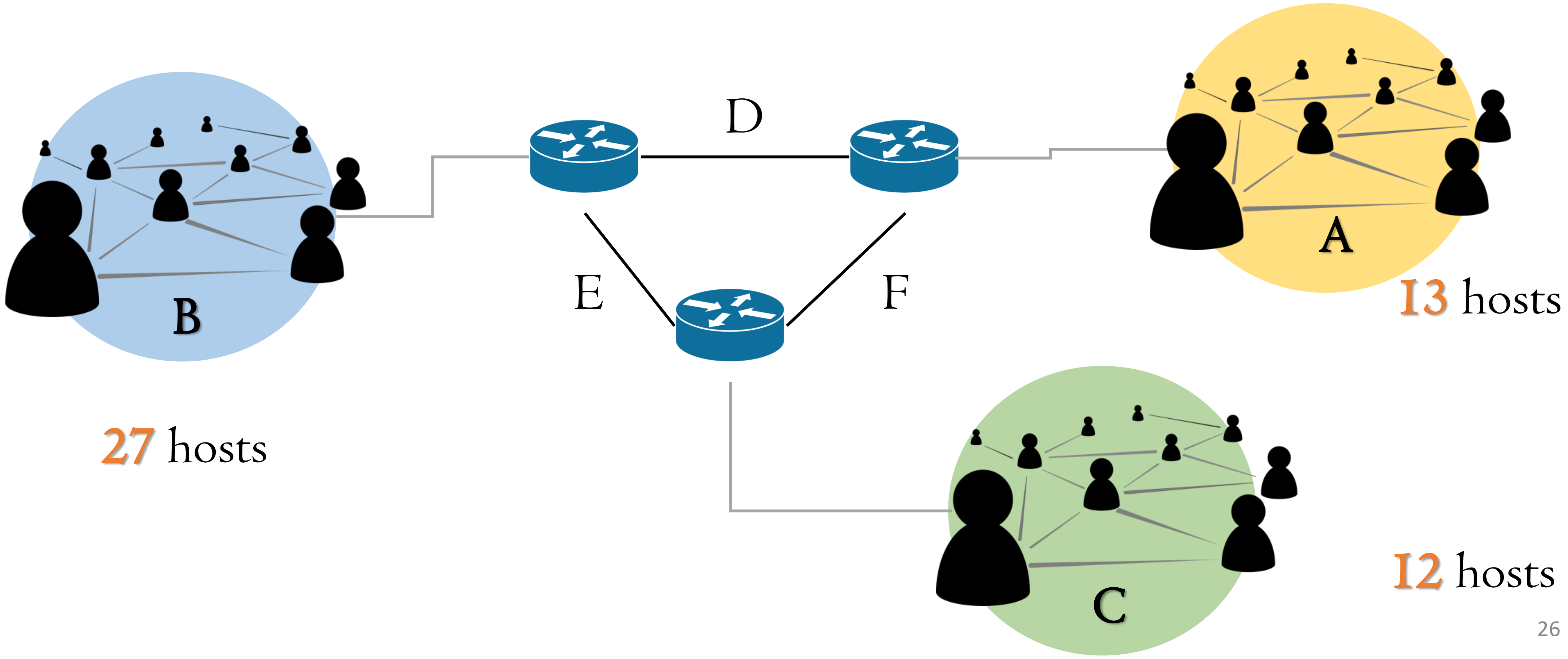
VLSM (Variable Length Subnet Mask) Subnetting

- In VLSM subnetting approach, we focus on the number of hosts in each subnet rather than the number of subnets itself,



VLSM (Variable Length Subnet Mask) Subnetting

Suppose we have: 192.168.10.0 /24

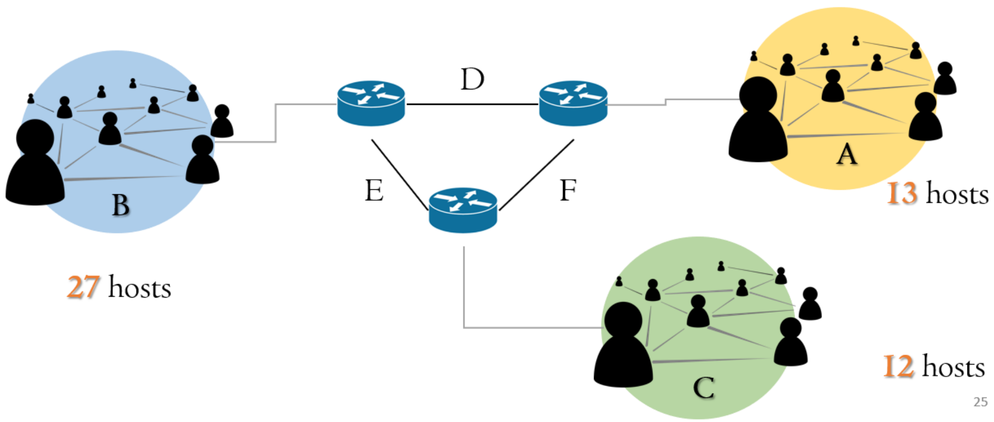


VLSM (Variable Length Subnet Mask) Subnetting

Suppose we have: 192.168.10.0 /24

Step 01: Focus on the subnet that has the most number of hosts

27 hosts → 5 bits will be reserved for hosts in the last octet, which means 3 bits will remain to subnets



192.168.10.0 /24 : 11111111.11111111.11111111.00000000

192.168.10.0 /27 : 11111111.11111111.11111111.nnnhhhhh

192.168.10.0 /27 : 11111111.11111111.11111111.11100000

VLSM (Variable Length Subnet Mask) Subnetting

Suppose we have: 192.168.10.0 /24

Step 01: Focus on the subnet that has the most number of hosts

27 hosts → 5 bits will be reserved for hosts in the last octet, which means 3 bits will remain to subnets

192.168.10.0 /27 : 11111111.11111111.11111111.11100000

224

+ 32

Net ID	192.168.10.0	192.168.10.32	…	192.168.10.224
First Host	192.168.10.1	192.168.10.33	.	192.168.10.223
Last Host	192.168.10.30	192.168.10.62	.	192.168.10.254
Broadcast	192.168.10.31	192.168.10.63	.	192.168.10.255

VLSM (Variable Length Subnet Mask) Subnetting

Suppose we have: 192.168.10.0 /24

Step 02: Focus on the subnet that has the second most number of hosts

13 hosts → 4 bits will be reserved for hosts in the last octet, which means 4 bits will remain to subnets

But

We will subnet one of the precedent subnets, in other words, we will do supernetting

192.168.10.32 /28 : 11111111.11111111.11111111.11110000

Net ID	**192.168.10.0**	**192.168.10.32**	**…**	**192.168.10.224**
First Host	192.168.10.1	192.168.10.33	.	192.168.10.223
Last Host	192.168.10.30	192.168.10.62	.	192.168.10.254
Broadcast	192.168.10.31	192.168.10.63	.	192.168.10.255

VLSM (Variable Length Subnet Mask) Subnetting

Suppose we have: 192.168.10.0 /24

Step 02: Focus on the subnet that has the second most number of hosts

13 hosts → 4 bits will be reserved for hosts in the last octet, which means 4 bits will remain to subnets

But We will subnet one of the precedent subnets, in other words, we will do supernetting

192.168.10.32 /28 : 11111111.11111111.11111111.11110000

Net ID	**192.168.10.32**
First Host	192.168.10.33
Last Host	192.168.10.46
Broadcast	192.168.10.47

VLSM (Variable Length Subnet Mask) Subnetting

Suppose we have: 192.168.10.0 /24

Step 03: Focus on the subnet that has the third most number of hosts

12 hosts → 4 bits will be reserved for hosts in the last octet, which means 4 bits will remain to subnets

But

We will use one of the precedent subnets

192.168.10.48 /28 : 11111111.11111111.11111111.11110000

Net ID	192.168.10.48
First Host	192.168.10.49
Last Host	192.168.10.62
Broadcast	192.168.10.63

VLSM (Variable Length Subnet Mask) Subnetting

Suppose we have: 192.168.10.0 /24

Step 04: Focus on the last subnet that has the minimum number of hosts

2 hosts → **2** bits will be reserved for hosts in the last octet, which means 6 bits will remain to subnets

192.168.10.64 /30 : 11111111.11111111.11111111.11111100

D	192.168.10.64/30	192.168.10.65/30
	192.168.10.67/30	192.168.10.66/30
E	192.168.10.68/30	192.168.10.69/30
	192.168.10.71/30	192.168.10.70/30
F	192.168.10.72/30	192.168.10.73/30
	192.168.10.75/30	192.168.10.74/30