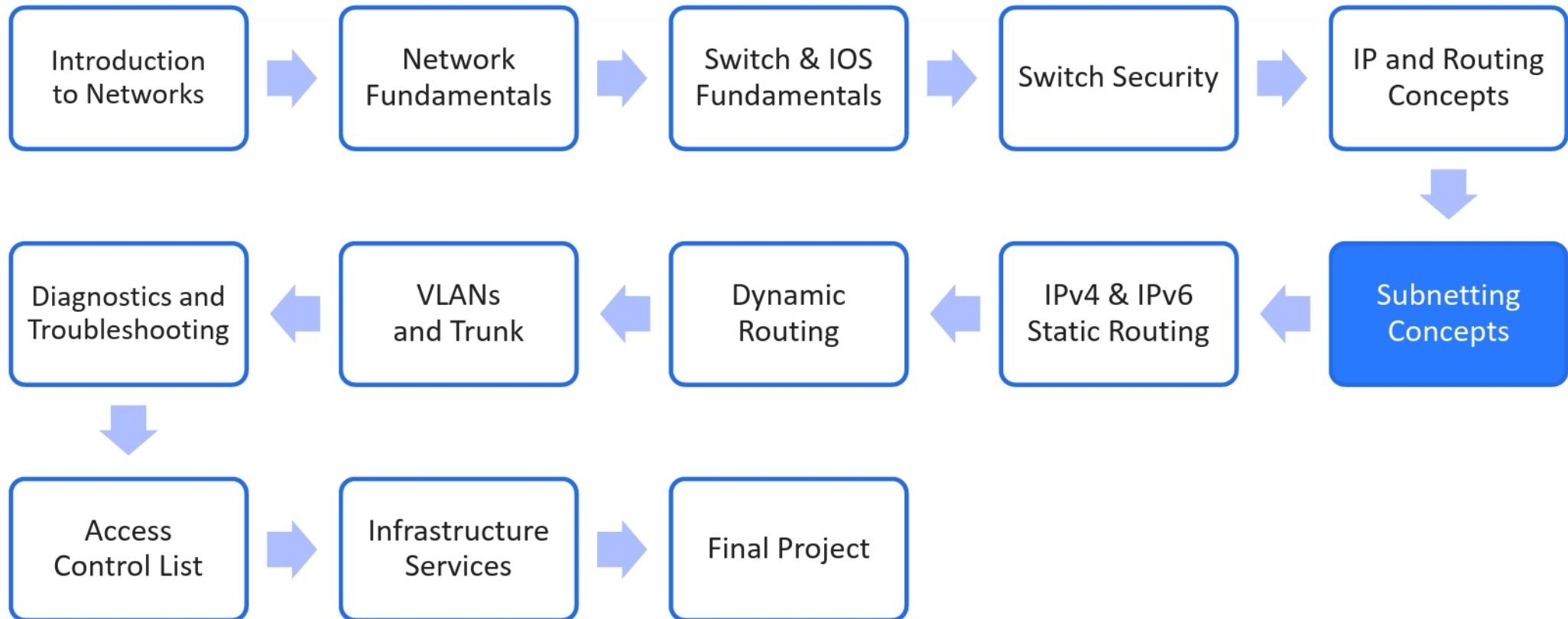


Cybersecurity Professional Program

Subnetting Concepts

Computer Networking

Computer Networking Course Path



Overview

Lesson Objective

The object of this lesson is to understand how IP addresses and subnet masks operate, and how they work together.

The lesson also covers how to configure networks with the correct usage of resources and why it's important to employ CIDR.



Subnetting

CIDR

VLSM

Network Address Scheme Design

Subnetting Concepts

SUBNETTING

Subnetting

Overview

Definition



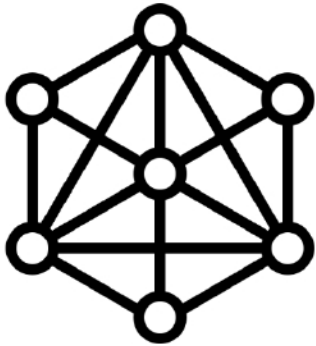
Subnetting means subdividing a network to manage, design, and implement an effective IP addressing plan. When organizations add hundreds and even thousands of hosts to their network, subdividing the network facilitates faster packet delivery and adds filtration by minimizing local traffic.



Subnetting reduces overall network traffic and improves performance.

Broadcast Domain Issue

Large Broadcast Domains



Large networks containing many hosts poses a problem for broadcast domains, because hosts can generate broadcast messages and affect network performance.

A large amount of traffic generated by broadcast messages causes network operation to slow down.

Each device must accept and process broadcast requests, even if the request is not intended for a particular device.

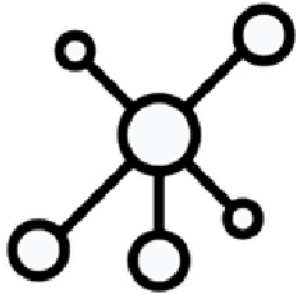


The solution is to reduce the network size, and create smaller broadcast domains by subnetting the network.

Subnetting

Subnetting

Why Subnetting?



Subnetting improves network performance by reducing the overall volume of network traffic.

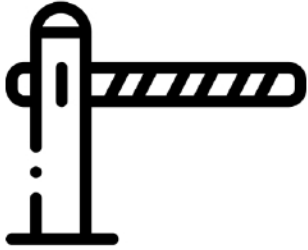
In addition, it enables an administrator to implement security policies and control network growth.

Subnetting creates more manageable network congestion, and simplifies network administration.



Octet Boundary

What is an Octet Boundary?



An Octet Boundary is a subnet created by borrowing one or more of the host bits to be used as network bits.

By extending the subnet mask with bits from the host portion, additional subnets can be created.

The easiest method of network subnetting is to use the octets /8, /16, and /24.

Additional **1** bits mean more **Networks**.

Additional **0** bits mean more **Hosts**.



Octet Boundary

The following table lists attributes of the most common boundaries: /8, /16, and /24.

Subnets

Prefix	Subnet Mask	Binary	Number of Hosts
/8	255.0.0.0	11111111.00000000.00000000.00000000 nnnnnnnn.hhhhhhhh.hhhhhhhh.hhhhhhhh 255 0 0 0	16,777,214
/16	255.255.0.0	11111111.11111111.00000000.00000000 nnnnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh 255 255 0 0	65,534
/24	255.255.255.0	11111111.11111111.11111111.00000000 nnnnnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh 255 255 255 0	254



n = Network portion h = Host portion

Subnetting Concepts

CIDR

CIDR Overview



Since not all networks in an organization are compatible with IPv4 address classes (due to the number of hosts), using these classes, in some cases, may result in a waste of addresses (which are important commodities in any organization).

For example, an organization with a network of 400 hosts must use class B, which means they will waste more than 60,000 addresses.



CIDR

Classless Inter-Domain Routing

Explanation



To resolve this issue, Classless Inter-Domain Routing (CIDR) was defined in RFC 4632. CIDR allows an IP address to use any subnet mask, regardless of predefined classes.

For example, IP address 10.1.1.1, which according to the class-based system should be in class A, can belong to class B or C, in accordance with the user's preference.



CIDR

CIDR Addresses

The following table displays addresses subnetted with different boundaries.

Address Table

Subnet Address	Useable Address Range	Broadcast Address
10.0.0.0/16	10.0.0.1 – 10.0.255.254	10.0.255.255
10.1.0.0/16	10.1.0.1 – 10.1.255.254	10.1.255.255
10.2.0.0/16	10.2.0.1 – 10.2.255.254	10.2.255.255
10.100.0.0/24	10.100.0.1 – 10.100.0.254	10.100.0.255
10.101.0.0/24	10.101.0.1 – 10.101.0.254	10.101.0.255
10.255.255.0/24	10.255.255.1 – 10.255.255.254	10.255.255.255



CIDR Subnetting Example

Example

Network Portion Host Portion

11111111.11111111.11111111.00000000

Network Portion Host Portion

11111111.11111111.11111111.10000000

- For one borrowed bit: $2^{\text{sub-network bits}} = 2^1 = 2$ sub-networks
- For two borrowed bits: $2^{\text{sub-network bits}} = 2^2 = 4$ sub-networks
- And so on ...

As an example, we will use the subnet 10.1.1.0/24. The subnet must appear in binary on the left side.

Creating two smaller sub-networks can be done by “borrowing” a bit from the host portion to the network portion.

After subnetting, the new address will be 10.1.1.0/25. Each network address will be assigned 126 host addresses.



CIDR

Subnetting Classless Network

Subnets can borrow bits from any host bit to create additional masks. For each borrowed bit in the fourth octet, the number of sub-networks is doubled, while the number of hosts per subnet is reduced. n = Network Portion, h = Host Portion

Subnets

Prefix	Subnet Mask	Mask in Binary	Networks	Hosts
/25	255.255.255.128	nnnnnnnnn.nnnnnnnnnn.nnnnnnnnnn.nhhhhhhh 11111111.11111111.11111111.10000000	2	126
/26	255.255.255.192	nnnnnnnnn.nnnnnnnnnn.nnnnnnnnnn.nnhhhhhh 11111111.11111111.11111111.11000000	4	62
/27	255.255.255.224	nnnnnnnnn.nnnnnnnnnn.nnnnnnnnnn.nnnhhhhh 11111111.11111111.11111111.11100000	8	30
/28	255.255.255.240	nnnnnnnnn.nnnnnnnnnn.nnnnnnnnnn.nnnnhhhh 11111111.11111111.11111111.11110000	16	14



Case Study 1

Configuration Per Sub-Network

A network manager requests to extend the current network to an additional four sub-networks.
The given IP address and subnet mask is 172.16.0.0/24.

- How would we add four more networks?
- What are the new network addresses?

Network Address	Usable IP Addresses	Broadcast Address
?	?	?
?	?	?
?	?	?
?	?	?

Case Study 1

Configuration Per Sub-Network

A network manager requests to extend the current network to an additional four sub-networks. The given IP address and subnet mask is 172.16.0.0/24.

- Adding four networks: $2^x = 4$?, the answer is 2. That means we need to borrow two bits from the subnet to create an additional four sub-networks.
- RED = new network portion, BLUE = new host portion: 11111111.11111111.11111111.11000000
- The new network addresses are: 172.16.0.0, 172.16.0.64, 172.16.0.128, 172.16.0.192

The total number of host bits dictates the jump in the last octet:
 $2^6 = 64$ addresses

Network Address	Usable IP Addresses	Broadcast Address
172.16.0.0	172.16.0.1 - 172.16.0.62	172.16.0.63
172.16.0.64	172.16.0.65 - 172.16.0.126	172.16.0.127
172.16.0.128	172.16.0.129 - 172.16.0.190	172.16.0.191
172.16.0.192	172.16.0.193 - 172.16.0.254	172.16.0.255

Case Study 2

Configuration Per Sub-Network

A network manager requests to extend the current network by an additional five sub-networks. The given IP address and subnet mask is 192.168.0.0/24.

- How would we add five more networks?
- What are the new network addresses?

Network Address	Usable IP Addresses	Broadcast Address
?	?	?
?	?	?
?	?	?
?	?	?

Case Study 2

Configuration Per Sub-Network

A network manager requests to extend the current network by an additional five sub-networks.
The given IP address and subnet mask is 192.168.0.0/24.

- Adding five networks is not possible, with the closest possible network division being 8.
- $2^x = 8$?, the answer is 3. That means we need to borrow three bits from the subnet to create an additional eight sub-networks.
- RED = new network portion, BLUE = new host portion: **11111111.11111111.11111111.11100000**
- The new network addresses are: 192.168.0.0, 192.168.0.32, 192.168.0.64, 192.168.0.96, and so on.

Note: The table below displays only the first four of eight subnets.

The total number of
host bits dictates the
jump in the last octet:
 $2^5 = 32$ addresses

Network Address	Usable IP Addresses	Broadcast Address
192.168.0.0	192.168.0.1 - 192.168.0.30	192.168.0.31
192.168.0.32	192.168.0.33 - 192.168.0.62	192.168.0.63
192.168.0.64	192.168.0.65 - 192.168.0.94	192.168.0.95
192.168.0.96	192.168.0.97 - 192.168.0.126	192.168.0.127

CIDR

Case Study 3

Network Configuration Per User

A network manager requests a 300-workstation expansion of the network. The workstations are to be installed in a single broadcast domain. The correct given address is 10.0.0.0. The aim of the expansion is to use as few resources as possible.

- How would we use the least amount of resources possible?
- What is the new network address, network range, and broadcast address?

Case Study 3

Network Configuration Per User

A network manager requests a 300-workstation expansion of the network. The workstations are to be installed in a single broadcast domain. The correct given address is 10.0.0.0. The aim of the expansion is to use as few resources as possible.

- To use the least amount of resources possible, the matching subnet will be /23, because it allows the use of 510 host addresses: $2^9 = 512$, $512 - 2$ (Minus Network address, Broadcast Address) = 510 hosts.
- RED = new network portion, BLUE = new host portion: **11111111.11111111.11111110.00000000**
- The new network address will be 10.0.0.0/23
- The network range is 10.0.0.1/23 – 10.0.1.254/23
- The broadcast address is 10.0.1.255/23

Subnetting Concepts

VLSM

VLSM

VLSM Overview

VLSM



VLSM (Variable Length Subnet Mask) is a method by which a network is subnetted, and the subnets are then subnetted further (when using **only** CIDR, they are not subnetted further).

The process can be repeated several times to divide the subnets into various sizes, to ensure that IP addresses are not wasted.

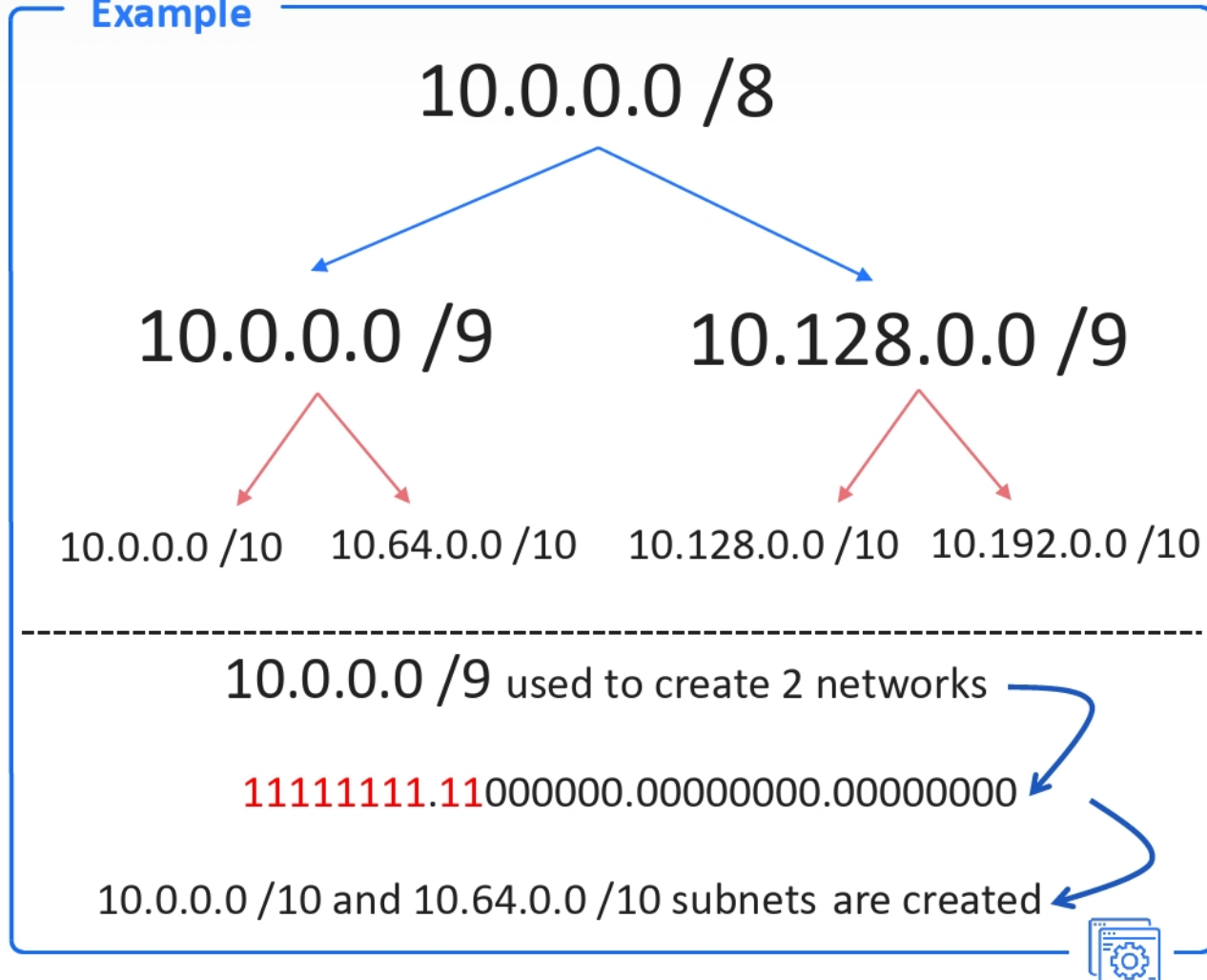
Formulas are applied to calculate the number of hosts and subnets.



Knowing your address requirements will help determine the range of host addresses.

VLSM Subnetting Example

Example



As an example, we will start with the network address 10.0.0.0/8. This address is subnetted into 2 additional networks.

The subnetting process (CIDR) created the networks 10.0.0.0/9 and 10.128.0.0/9.

After creating the networks, each was subnetted (VLSM) to create additional networks, similar to using CIDR.

VLSM is useful when using CIDR provides too many unused addresses for one network.

Lab NET-06-L1: Subnetting Practice



Lab Mission

The aim of this lab is to provide review questions for all the material covered in the module, including the topics of how to subnet networks and assign IP addresses.



Steps

Subnetting questions

Practice subnetting



Env. & Tools

OS: All platforms

Tools: Calculator (optional)



Related Files

Lab document

Lab NET-06-L1

Subnetting Practice
30–60 Min.



Mission

The aim of this lab is to provide review questions for all the material covered in the module, including the topics of how to subnet networks and assign IP addresses.

Steps

- Subnetting questions
- Practice subnetting

Environment & Tools

- OS: All platforms
- Tools: Calculator (optional)

Related Files

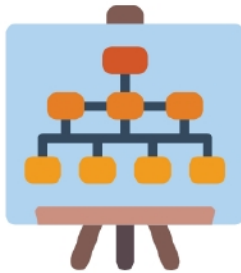
- Lab document

Subnetting Concepts

NETWORK ADDRESS SCHEME DESIGN

Network Planning

How to Plan a Network



A network needs to be well-designed. Addresses must not be assigned randomly!

Planning a network requires examination of how the organization is structured, and how the subnets will be structured.

Planning addresses involves deciding how many hosts per subnet there will be, how large each subnet will be, and how host addresses will be assigned.



Knowing your address requirements will help determine the range of host addresses.

Planning Considerations

Prevent Duplication



In an inter-network structure, each host must have a unique address. Planning and documentation prevent the creation of duplicate addresses.



Access Control



If addresses are randomly assigned, servers that provide resources to internal and external hosts will not be able to control access efficiently and effectively.



Monitor

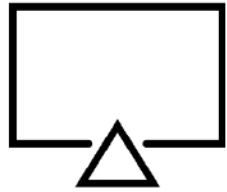


Network traffic is examined for source IP addresses generated or received from packets. With proper planning, finding problematic devices should be a simple process.



Assignable Address Devices

Clients



Most networks use DHCP to dynamically assign addresses, eliminating the need for network staff to do so, and preventing entry errors.

When the address scheme changes, the DHCP server must be reconfigured.

Servers



In most networks, servers must be made available to remote users. The servers are assigned private internal addresses, and the forwarding device will perform additional translations to public addresses (NAT).

Servers are typically configured with static addresses.

Routers/Switches



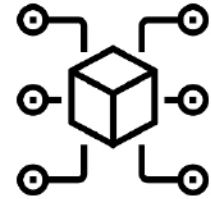
Routers and switches are assigned IP addresses.

Switches can be managed remotely via the cloud.

Routers are assigned IP addresses because they operate in Layer 3.

Routers are typically configured with static addresses.

Gateway



A gateway is a packet-forwarding device, and is typically a firewall or router.

Each interface that serves as a gateway for hosts in the network must be assigned an IP address.



QUESTIONS?



THANK YOU
