# Komunikasi Data dan Jaringan Komputer

## D3 – Manajemen Informatika

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- **MATA KULIAH : KOMUNIKASI DATA DAN JARINGAN KOMPUTER**
- **KODE MATA KULIAH : MIN516111**
- **SKS : 3(2-1)**
- **SEMESTER : 2**

# Outline

- Subnetting an IPv4 Network
- Addressing Schemes
- Design Considerations for IPv6
- Summary

# Objectives

- Explain why routing is necessary for hosts on different networks to communicate.
- Describe IP as a communication protocol used to identify a single device on a network.
- Given a network and a subnet mask, calculate the number of host addresses available.
- Calculate the necessary subnet mask in order to accommodate the requirements of a network.
- Describe the benefits of variable length subnet masking (VLSM)
- Explain how IPv6 address assignments are implemented in a business network.

# Reasons for Subnetting

**Large networks need to be segmented into smaller sub-networks, creating smaller groups of devices and services in order to**:

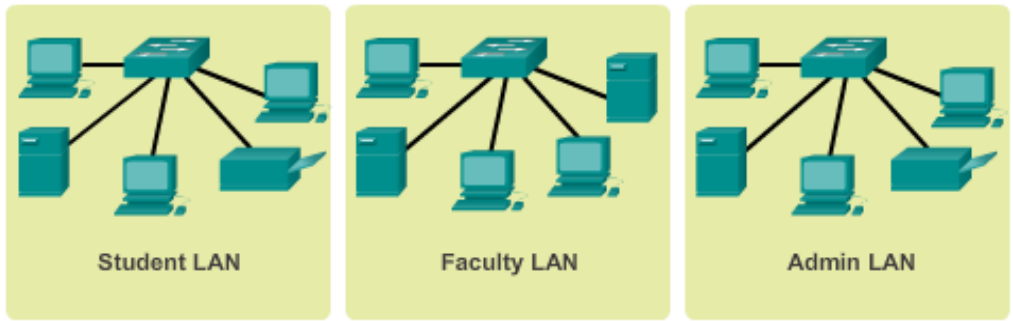
- Control traffic by containing broadcast traffic within subnetwork
- Reduce overall network traffic and improve network performance

**Subnetting** - process of segmenting a network into multiple smaller network spaces called subnetworks or **Subnets.**

**Communication Between Subnets**

- A router is necessary for devices on different networks and subnets to communicate.
- Each router interface must have an IPv4 host address that belongs to the network or subnet that the router interface is connected to.
- Devices on a network and subnet use the router interface attached to their LAN as their default gateway.

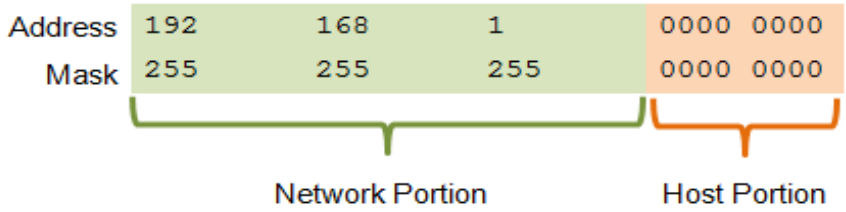
# IP Subnetting is FUNdamental

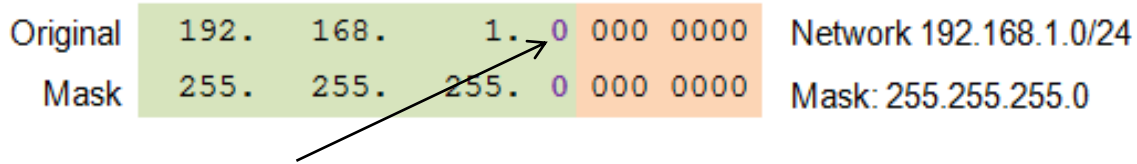



Planning requires decisions on each subnet in terms of size, the number of hosts per subnet, and how host addresses will be assigned.

# Basic Subnetting

- Borrowing Bits to Create Subnets
- Borrowing 1 bit $2^1 = 2$ subnets




Borrowing 1 Bit from the host portion creates 2 subnets with the same subnet mask

Subnet 0

Network 192.168.1.**0-127**/**25**

Mask: 255.255.255.**128**

Subnet 1

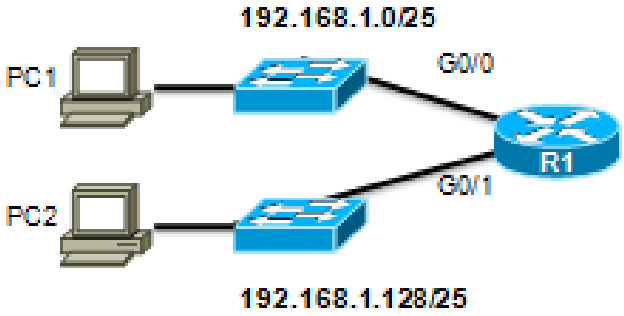
Network 192.168.1.**128-255**/**25**

Mask: 255.255.255.**128**

# Subnets in Use

Subnet 0

Network 192.168.1.**0-127**/**25**




Subnet 1

Network 192.168.1.**128-255**/**25**

Address Range for 192.168.1.0/25 Subnet

Network Address

192. 168. 1. 0 000 0000 = 192.168.1.0

First Host Address

192. 168. 1. 0 000 0001 = 192.168.1.1

Last Host Address

192. 168. 1. 0 111 1110 = 192.168.1.126

Broadcast Address

192. 168. 1. 0 111 1111 = 192.168.1.127

Address Range for 192.168.1.128/25 Subnet

Network Address

192. 168. 1. 1 000 0000 = 192.168.1.128

First Host Address

192. 168. 1. 1 000 0001 = 192.168.1.129

Last Host Address

192. 168. 1. 1 111 1110 = 192.168.1.254

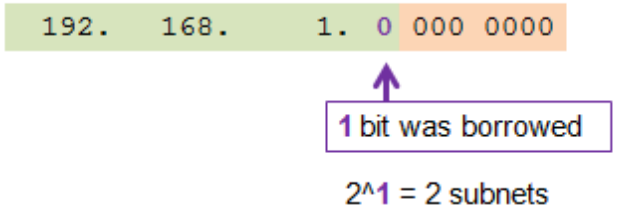
Broadcast Address

192. 168. 1. 1 111 1111 = 192.168.1.255

# Subnetting Formulas

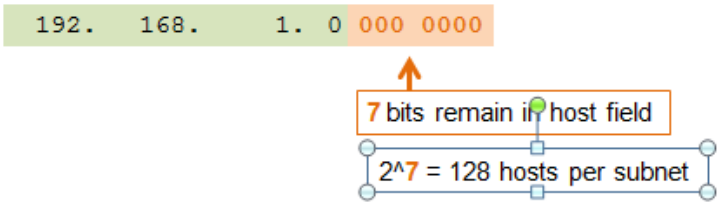
- Calculate Number of Subnets

Subnets = 2^n
(where n = bits borrowed)



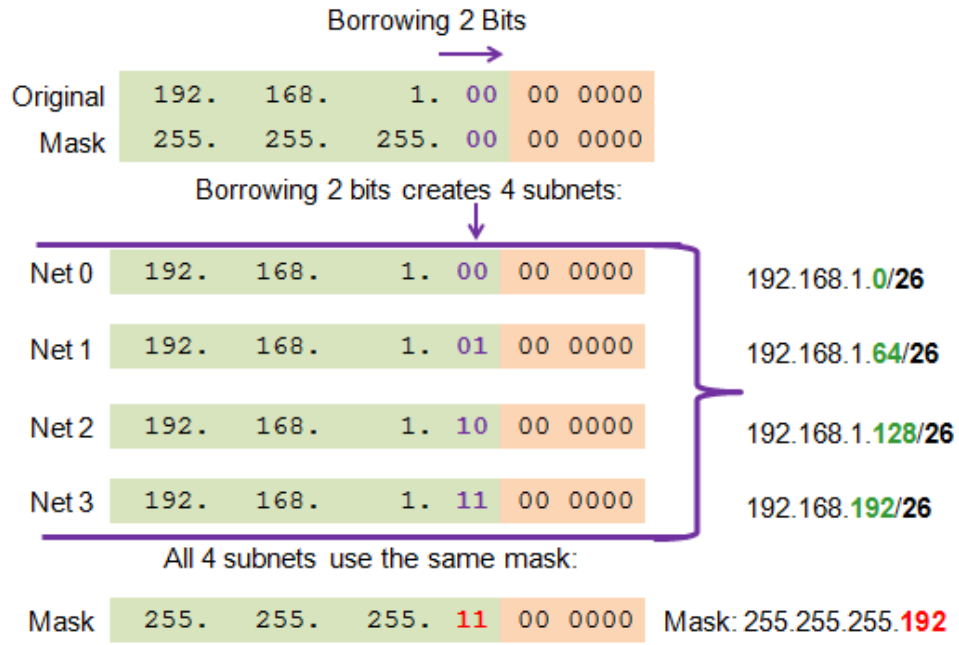

- Calculate Number of Hosts

Hosts = 2^n
(where n = host bits remaining)



# Creating 4 Subnets

- Borrowing 2 bits to create 4 subnets. **$2^2$ = 4 subnets**



# Creating 8 Subnets

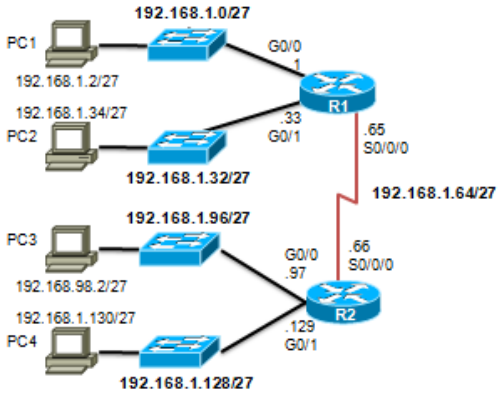
- Borrowing 3 bits to Create 8 Subnets. **$2^3 = 8$ subnets**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Net 0 | Network | 192. | 168. | 1. | 000 | 0 0000 | 192.168.1.1 |
| | Fist | 192. | 168. | 1. | 000 | 0 0001 | 192.168.1.1 |
| | Last | 192. | 168. | 1. | 000 | 1 1110 | 192.168.1.30 |
| | Broadcast | 192. | 168. | 1. | 000 | 1 1111 | 192.168.1.31 |
| Net 1 | Network | 192. | 168. | 1. | 001 | 0 0000 | 192.168.1.32 |
| | Fist | 192. | 168. | 1. | 001 | 0 0001 | 192.168.1.33 |
| | Last | 192. | 168. | 1. | 001 | 1 1110 | 192.168.1.62 |
| | Broadcast | 192. | 168. | 1. | 001 | 1 1111 | 192.168.1.63 |
| Net 2 | Network | 192. | 168. | 1. | 010 | 0 0000 | 192.168.1.64 |
| | Fist | 192. | 168. | 1. | 010 | 0 0001 | 192.168.1.65 |
| | Last | 192. | 168. | 1. | 010 | 1 1110 | 192.168.1.94 |
| | Broadcast | 192. | 168. | 1. | 010 | 1 1111 | 192.168.1.95 |
| Net 3 | Network | 192. | 168. | 1. | 010 | 0 0000 | 192.168.1.96 |
| | Fist | 192. | 168. | 1. | 010 | 0 0001 | 192.168.1.97 |
| | Last | 192. | 168. | 1. | 010 | 1 1110 | 192.168.1.126 |
| | Broadcast | 192. | 168. | 1. | 010 | 1 1111 | 192.168.1.127 |

# Creating 8 Subnets(continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Net 4 | Network | 192. | 168. | 1. | 100 | 0 0000 | 192.168.1.128 |
| | Fist | 192. | 168. | 1. | 100 | 0 0001 | 192.168.1.129 |
| | Last | 192. | 168. | 1. | 100 | 1 1110 | 192.168.1.158 |
| | Broadcast | 192. | 168. | 1. | 100 | 1 1111 | 192.168.1.159 |
| Net 5 | Network | 192. | 168. | 1. | 101 | 0 0000 | 192.168.1.160 |
| | Fist | 192. | 168. | 1. | 101 | 0 0001 | 192.168.1.161 |
| | Last | 192. | 168. | 1. | 101 | 1 1110 | 192.168.1.190 |
| | Broadcast | 192. | 168. | 1. | 101 | 1 1111 | 192.168.1.191 |
| Net 6 | Network | 192. | 168. | 1. | 110 | 0 0000 | 192.168.1.192 |
| | Fist | 192. | 168. | 1. | 110 | 0 0001 | 192.168.1.193 |
| | Last | 192. | 168. | 1. | 110 | 1 1110 | 192.168.1.222 |
| | Broadcast | 192. | 168. | 1. | 110 | 1 1111 | 192.168.1.223 |
| Net 7 | Network | 192. | 168. | 1. | 111 | 0 0000 | 192.168.1.224 |
| | Fist | 192. | 168. | 1. | 111 | 0 0001 | 192.168.1.225 |
| | Last | 192. | 168. | 1. | 111 | 1 1110 | 192.168.1.254 |
| | Broadcast | 192. | 168. | 1. | 111 | 1 1111 | 192.168.1.255 |

**Subnet Allocation**



# Subnetting Based on Host Requirements

**There are two considerations when planning subnets:**

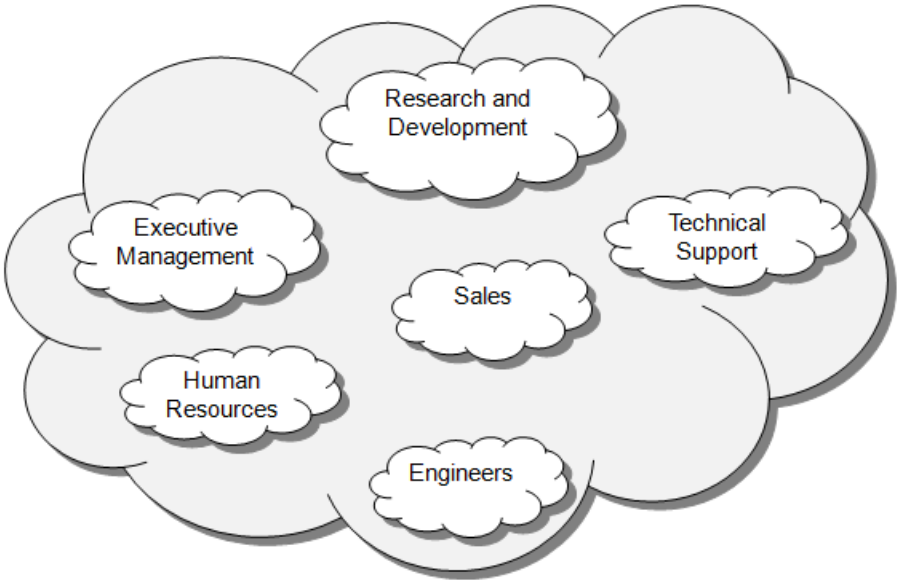
- Number of Subnets required
- Number of Host addresses required
- Formula to determine number of useable hosts
  - **2^n-2**
  - **2^n** (where n is the number the number of host bits remaining) is used to calculate the number of hosts
  - **-2** Subnetwork ID and broadcast address cannot be used on each subnet

# Subnetting Network-Based Requirements

Calculate number of subnets

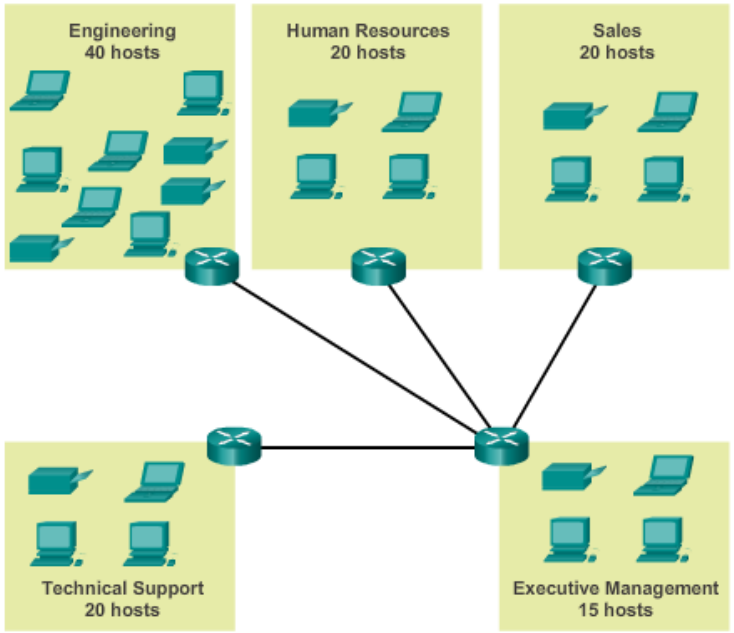
- Formula **2^n** (where n is the number of bits borrowed)

- Subnet needed for each department in graphic



# Subnetting To Meet Network Requirements

- It is important to balance the number of subnets needed and the number of hosts required for the largest subnet.
- Design the addressing scheme to accommodate the maximum number of hosts for each subnet.
- Allow for growth in each subnet.



# Subnetting To Meet Network Requirements (cont)

## Subnets and Addresses

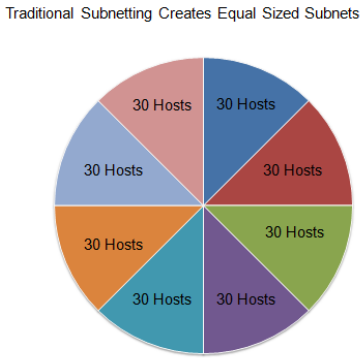
| | | |
|---|---|---|
| | 10101100.00010000.000000**00.00**000000 | 172.16.0.0/22 |
| 0 | 10101100.00010000.000000**00.00**000000 | 172.16.0.0/26 |
| 1 | 10101100.00010000.000000**00.01**000000 | 172.16.0.64/26 |
| 2 | 10101100.00010000.000000**00.10**000000 | 172.16.0.128/26 |
| 3 | 10101100.00010000.000000**00.11**000000 | 172.16.0.192/26 |
| 4 | 10101100.00010000.000000**01.00**000000 | 172.16.1.0/26 |
| 5 | 10101100.00010000.000000**01.01**000000 | 172.16.1.64/26 |
| 6 | 10101100.00010000.000000**01.10**000000 | 172.16.1.128/26 |
| | **Nets 7 – 14 not shown** | |
| 15 | 10101100.00010000.000000**11.10**000000 | 172.16.3.128/26 |
| 16 | 10101100.00010000.000000**11.11**000000 | 172.16.3.192/26 |

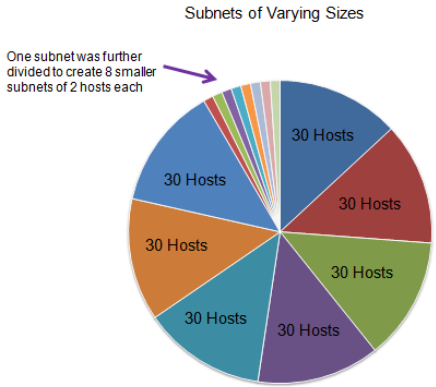
2^4 = 16 subnets

2^6 – 2 = 62 Hosts per subnet

# Traditional Subnetting Wastes Addresses

- Traditional subnetting - same number of addresses is allocated for each subnet.
- Subnets that require fewer addresses have unused (wasted) addresses. For example, WAN links only need 2 addresses.
- Variable Length Subnet Mask (VLSM) or subnetting a subnet provides more efficient use of addresses.

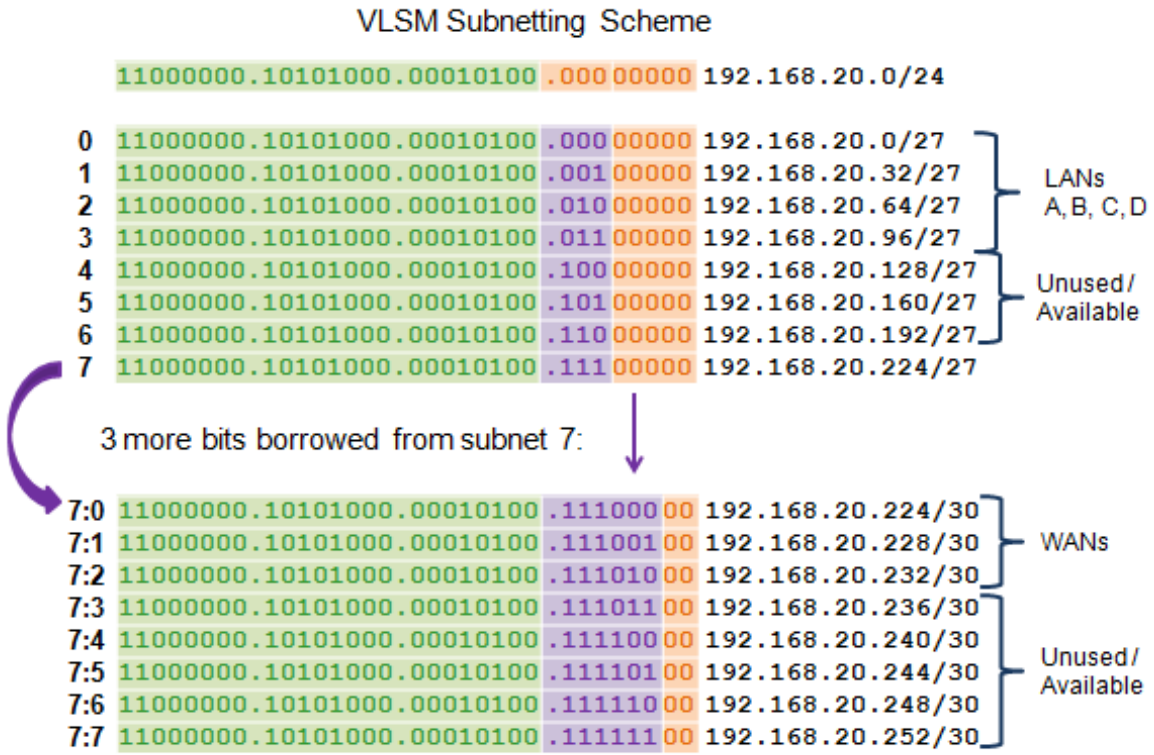


# Variable Length Subnet Masks (VLSM)

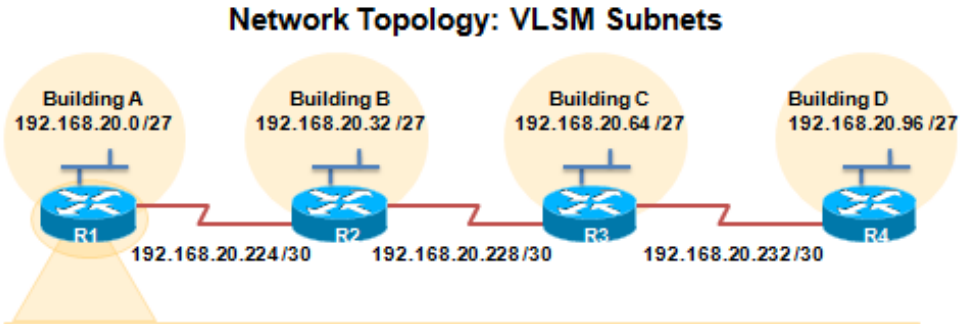
- VLSM allows a network space to be divided in unequal parts.
- Subnet mask will vary depending on how many bits have been borrowed for a particular subnet.
- Network is first subnetted, and then the subnets are subnetted again.
- Process repeated as necessary to create subnets of various sizes.

# Basic VLSM


VLSM Subnetting Scheme
11000000.10101000.00010100.000 00000 192.168.20.0/24
0 11000000.10101000.00010100.000 00000 192.168.20.0/27
1 11000000.10101000.00010100.001 00000 192.168.20.32/27
2 11000000.10101000.00010100.010 00000 192.168.20.64/27
3 11000000.10101000.00010100.011 00000 192.168.20.96/27
4 11000000.10101000.00010100.100 00000 192.168.20.128/27
5 11000000.10101000.00010100.101 00000 192.168.20.160/27
6 11000000.10101000.00010100.110 00000 192.168.20.192/27
7 11000000.10101000.00010100.111 00000 192.168.20.224/27
LANs A, B, C, D
Unused / Available
3 more bits borrowed from subnet 7:
7:0 11000000.10101000.00010100.111000 00 192.168.20.224/30
7:1 11000000.10101000.00010100.111001 00 192.168.20.228/30
7:2 11000000.10101000.00010100.111010 00 192.168.20.232/30
7:3 11000000.10101000.00010100.111011 00 192.168.20.236/30
7:4 11000000.10101000.00010100.111100 00 192.168.20.240/30
7:5 11000000.10101000.00010100.111101 00 192.168.20.244/30
7:6 11000000.10101000.00010100.111110 00 192.168.20.248/30
7:7 11000000.10101000.00010100.111111 00 192.168.20.252/30
WANs
Unused / Available

# VLSM in Practice

- Using VLSM subnets, the LAN and WAN segments in example below can be addressed with minimum waste.
- Each LANs will be assigned a subnet with /27 mask.
- Each WAN link will be assigned a subnet with /30 mask.




```
R1(config)#interface gigabitethernet 0/0
R1(config-if)#ip address 192.168.20.1 255.255.255.224
R1(config-if)#exit
R1(config)#interface serial 0/0/0
R1(config-if)#ip address 192.168.20.225 255.255.255.252
R1(config-if)#end
R1#
```

# VLSM Chart

**VLSM Subnetting of 192.168.20.0 /24**

1

2

| | /27 Network | Hosts |
|---|---|---|
| Bldg A | .0 | .1 - .30 |
| Bldg B | .32 | .33 - .62 |
| Bldg C | .64 | .65 - .94 |
| Bldg D | .96 | .97 - .126 |
| Unused | .128 | .129 - .158 |
| Unused | .160 | .161 - .190 |
| Unused | .192 | .193 - .222 |
| | .224 | .225 - .254 |

| | /30 Network | Hosts |
|---|---|---|
| WAN R1–R2 | .224 | .225 - .226 |
| WAN R2–R3 | .228 | .229 - .230 |
| WAN R3–R4 | .232 | .233 - .234 |
| Unused | .236 | .237 - .238 |
| Unused | .240 | .241 - .242 |
| Unused | .244 | .245 - .246 |
| Unused | .248 | .249 - .250 |
| Unused | .252 | .253 - .254 |

# Planning to Address the Network

Allocation of network addresses should be planned and documented for the purposes of:

- Preventing duplication of addresses
- Providing and controlling access
- Monitoring security and performance

Addresses for Clients - usually dynamically assigned using Dynamic Host Configuration Protocol (DHCP)

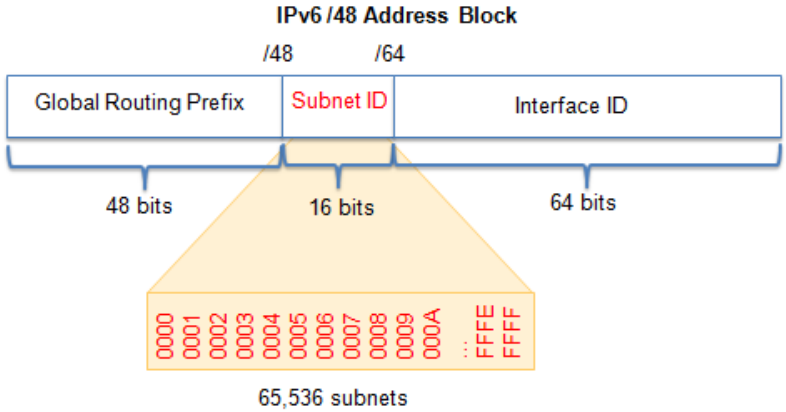
Sample Network Addressing Plan

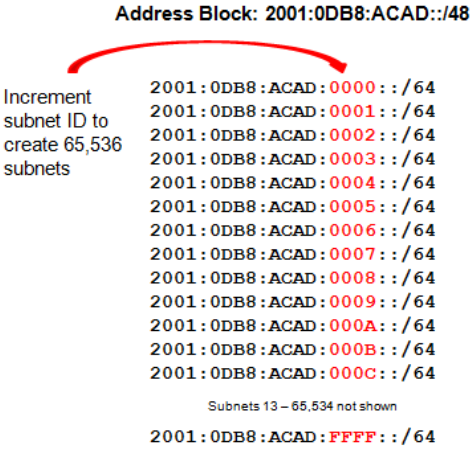
Network: 192.168.1.0/24

| Use | First | Last |
|---|---|---|
| Host Devices | .1 | .229 |
| Servers | .230 | .239 |
| Printers | .240 | .249 |
| Intermediary Devices | .250 | .253 |
| Gateway (router LAN interface) | .254 | |

# Subnetting Using the Subnet ID

An IPv6 Network Space is subnetted to support hierarchical, logical design of the network



# IPV6 Subnet Allocation

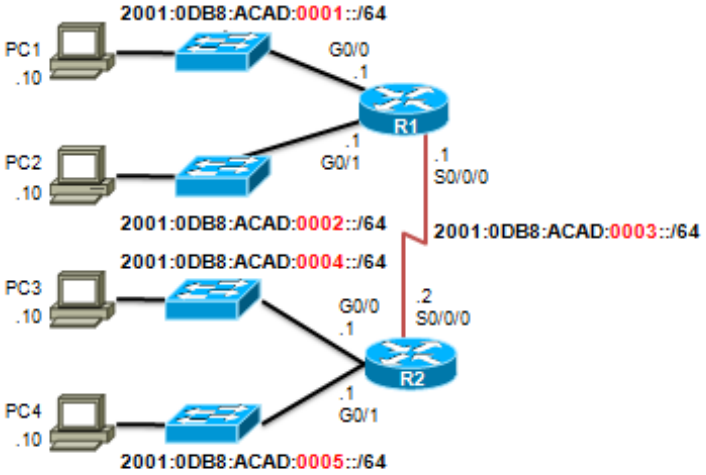
## IPv6 Subnetting

Address Block: 2001:0DB8:ACAD::/48

5 subnets allocated from 65,536 available subnets

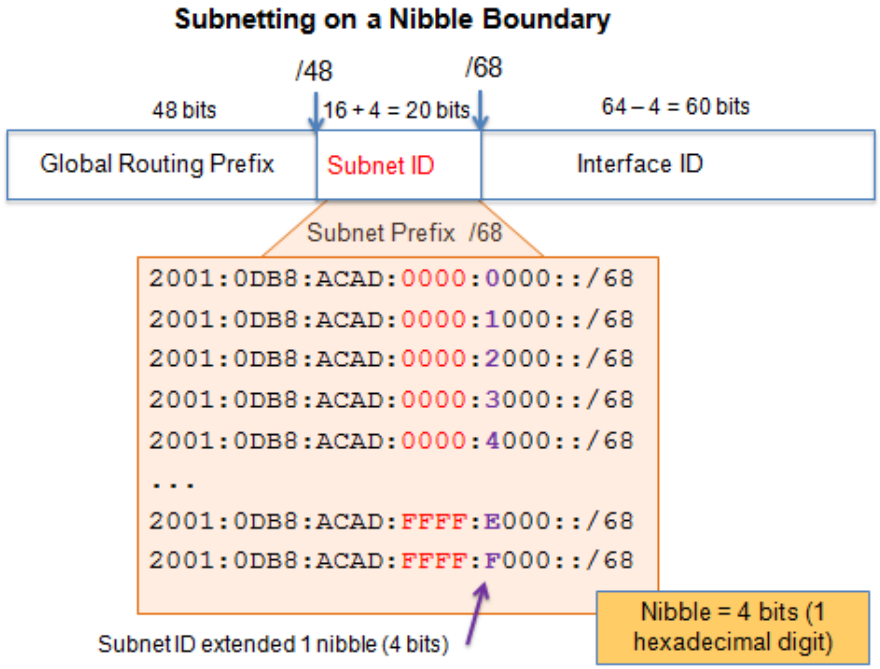
2001:0DB8:ACAD:0000::/64
2001:0DB8:ACAD:0001::/64
2001:0DB8:ACAD:0002::/64
2001:0DB8:ACAD:0003::/64
2001:0DB8:ACAD:0004::/64
2001:0DB8:ACAD:0005::/64
2001:0DB8:ACAD:0006::/64
2001:0DB8:ACAD:0007::/64
2001:0DB8:ACAD:0008::/64
⋮
2001:0DB8:ACAD:FFFF::/64

## IPv6 Subnet Allocation



# Subnetting into the Interface ID

IPv6 bits can be borrowed from the interface ID to create additional IPv6 subnets



# Summary

- Process of segmenting a network, by dividing it into to multiple smaller network spaces, is called subnetting.
- Subnetting a subnet, or using Variable Length Subnet Mask (VLSM) was designed to avoid wasting addresses.
- IPv6 address space is a huge address space so it is subnetted to support the hierarchical, logical design of the network not to conserve addresses.
- Size, location, use, and access requirements are all considerations in the address planning process.
- IP networks need to be tested to verify connectivity and operational performance.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# Buku Referensi:


- William Stallings, Data and Computer Communications Sixth Edition, Prentice Hall. New Jersey, 2007.
- Onno W. Purbo, TCP/IP Standar Desain dan Implementasi. Elex Media Computindo, Jakarta, 1998.
- Cisco