SOMNOG7 Network Infrastructure

IP Addressing & Subnetting

- IP Addressing
- Subnetting
- CIDR
- VLSM

IP Addresses

- An IP address is an address used to uniquely identify a device on an IP network.

- The address is made up of 32 binary bits which can be divisible into a network portion and host portion with the help of a subnet mask.

- 32 binary bits are broken into four octets (1 octet = 8 bits)

- Dotted decimal format (for example, 172.16.81.100)

IP Address Classes

- Class A: The first octet is the network portion. Octets 2, 3, and 4 are for subnets/hosts

- Class B: The first two octets are the network portion. Octets 3 and 4 are for subnets/hosts

- Class C: The first three octets are the network portion. Octet 4 is for subnets/hosts

Network Masks

- Distinguishes which portion of the address identifies the network and which portion of the address identifies the node.

- Default masks:

  - ➢Class A: 255.0.0.0
  - ➢Class B: 255.255.0.0
  - ➢Class C: 255.255.255.0

Private Address Range

| Address Class	Reserved Address Space
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

Public and Private IPv4 Addresses

Public

- Required by devices and hosts that connect directly to the Internet

- Must be globally unique

- Routable on the Internet

- Must be assigned by IANA/RIR

Private

- Not routable on the Internet
  - 10.0.0.0/8
  - 172.16.0.0/12
  - 192.168.0.0./16

- Can be assigned locally by an organization

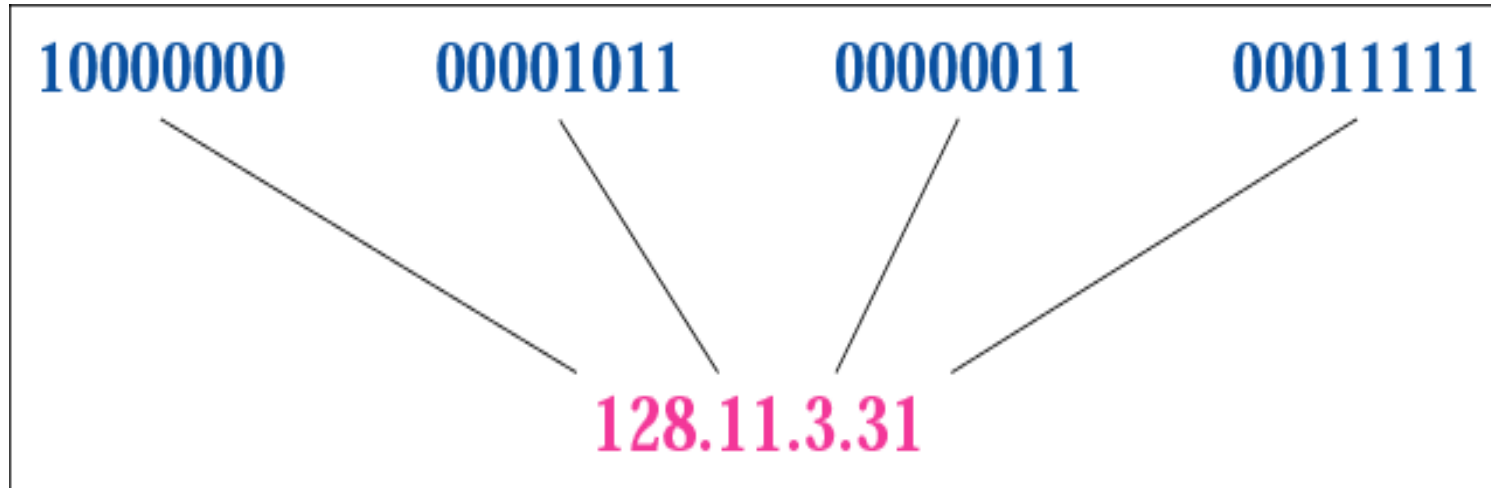- Must be translated to access the Internet
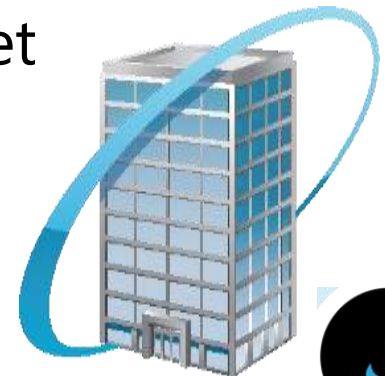
Binary Notation

01110101 10010101 00011101 11101010

Dotted-decimal notation

Example 1

Change the following IP address from binary notation to dotted-decimal notation.

10000001 00001011 00001011 11101111

Solution

_129.11.11.239_

Example 2

Change the following IP address from dotted-decimal
notation   to   binary notation:

111.56.45.78

Example 2

Change the following IP address from dotted-decimal   notation   to   binary notation:

111.56.45.78

Solution

01101111   *00111000*   *00101101*   *01001110*

Example 3

Find the error in the following IP Address
111.56.045.78

Solution

There are no leading zeroes in
Dotted-decimal notation (045)

Example 3 (continued)

Find the error in the following IP Address
75.45.301.14

Solution

In decimal notation each number <= 255
301 is out of the range

Subnetting

- Subnetting is the process of dividing an IP space into manageable segments of same sizes

- Creates multiple logical networks that exist within a single Class A, B, or C network.

- If you do not subnet, you will only be able to use one network from
your Class A, B, or C network, which is unrealistic

- Each data link on a network must have a unique network ID, with every node on that link being a member of the same network

Benefits of Subnetting

1) Reduced network traffic
2) Optimized network performance
3) Simplified management
4) Facilitated spanning of large geographical distances

How to create subnets

- Determine the number of required network IDs:
  - ➢ One for each subnet
  - ➢ One for each wide area network connection
- Determine the number of required host IDs per subnet:
  - ➢ One for each TCP/IP host
  - ➢ One for each router interface
- Based on the above requirements, create the following:
  - ➢ One subnet mask for your entire network
  - ➢ A unique subnet ID for each physical segment
  - ➢ A range of host IDs for each subnet

Subnetting a Class A/B/C Address

- How many subnets does the chosen subnet mask produce?

- How many valid hosts per subnet are available?

- What are the valid subnets?

- What's the broadcast address of each subnet?

- What are the valid hosts in each subnet?

Practice Example #1C: 255.255.255.128 (/25) Network 192.168.1.0

- How many subnets? Since 128 is 1 bit on (10000000), the answer would be $2^1=$ 2.

- How many hosts per subnet? We have 7 host bits off (10000000), so the equation would be $2^7 - 2 = 126$ hosts.

- What are the valid subnets? 256 – 128 = 128. Remember, we'll start at zero and count in our block size, so our subnets are 0, 128.

- What's the broadcast address for each subnet? The number right before the value of the next subnet is all host bits turned on and equals the broadcast address. For the zero subnet, the next subnet is 128, so the broadcast of the 0 subnet is 127.

- What are the valid hosts? These are the numbers between the subnet and broadcast address

- **Example 1**

255.255.255.128

- **192.168.1.0/25**

- 2^1= 2 Networks

- 2^7− 2 Hosts

Subnet	Subnet 1	Subnet 2
Network ID	192.168.1.0	192.168.1.128
First host address	192.168.1.1	192.168.1.129
Last host address	192.168.1.126	192.168.1.254
Broadcast ID	192.168.1.127	192.168.1.255

Example 2

192.168.1.0/26 255.255.255.192

$2^2 = 4$ Networks

$2^6 - 2$ Hosts

Subnet	Subnet 1	Subnet 2	Subnet 3	Subnet 4
Network ID	0	64	128	192
First address	1	65	129	193
Last address	62	126	190	254
Broadcast ID	63	127	191	255

Example 3

192.168.1.0/27 subnet mask ?
Practice Exercise

VLSM

- VLSM is a process of dividing an IP space into the subnets of different sizes without wasting IP addresses. When we perform subnetting, all subnets have the same number of hosts, this is known as FLSM (Fixed length subnet mask).

- In FLSM all subnets use same subnet mask, this lead to inefficiencies. In real life scenario, some subnets may require large number of host addresses while other may require only few addresses.

Example

Assume that you are a network administrator at SomNOG.

Company have three departments connected with wan links.

- Development department have 74 computers.

- Production department have 52 computers.

- Administrative department have 28 computers.

- All departments are connected with each other via wan link.

- Each wan link requires two IP addresses.

- **First choice with a example class B address space**

- 172.168.1.0/23

- Subnetting of this address space would give us **128 subnets** and **512 hosts** in each subnet. Our network requires only 6 subnets and 160 addresses.

- Every IP address add more dollars in company bill. You would have to pay for 65356 addresses while you need only 160 addresses. Would you consider this address space for company?

- **Second choice with two example class C address spaces**

- 192.168.1.0/25

- 192.168.2.0/26

- Subnetting of first address 192.168.1.0/25 would give us 2 subnets and 128 hosts in each subnet.

- Subnetting of second address 192.168.2.0/26 would give us 4 subnets and 64 hosts in each subnet.

- Collectively we are getting 6 subnets and 512 hosts from these two address spaces. We are still wasting more than 300 IP address, and we would have to purchase two address spaces.

Variable Length Subnet Mask

- Variable Length Subnet Mask (VLSM) extends classic subnetting.

- VLSM is a process of breaking down subnets into the smaller subnets, according to the need of individual networks. In above example company have requirement of 6 subnets and 160 host addresses. With VSLM you can fulfill this requirement with single class C address space.

- **VLSM Subnetting**

- In VLSM Subnetting, we do subnetting of subnets according the network requirement.

Steps for VLSM Subnetting

- Find the largest segment. Segment which need largest number of hosts' address.

- Do subnetting to fulfill the requirement of largest segment.

- Assign the appropriate subnet mask for the largest segment.

- For second largest segments, take one of these newly created subnets and apply a different, more appropriate, subnet mask to it.

- Assign the appropriate subnet mask for the second largest segment.

- Repeat this process until the last network.

VLSM Example

- Now you know the steps of VLSM Subnetting. Let's understand it with above example. Our company requires 6 subnets and 160 hosts.

- **Step 1 :-** Oder all segments according the hosts requirement (Largest to smallest).

Subnet	Segment	Hosts
1	Development	74
2	Production	52
3	Administrative	28
4	Wan link 1	2
5	Wan link 2	2
6	Wan link 3	2

Networking Today

- **Step 2 :-** Do subnetting for largest segment. Our largest segment needs 74 host addresses. /25 provide us two subnets with 128 hosts in each subnet.

- **192.168.1.0/25**

Subnet	Subnet 1	Subnet 2
Network ID	192.168.1.0	192.168.1.128
First host address	192.168.1.1	192.168.1.129
Last host address	192.168.1.126	192.168.1.254
Broadcast ID	192.168.1.127	192.168.1.255

- **Step 3 :-** Assign subnet mask to the largest segment. As you can see in above table, subnet 1 fulfill our largest segment requirement. Assign it to our segment.

Segment	Development
Requirement	74
CIDR	/25
Subnet mask	255.255.255.128
Network ID	192.168.1.0
First hosts	192.168.1.1
Last hosts	192.168.1.126
Broadcast ID	192.168.1.127

- **Step 4 :-** Do subnetting for second largest segment from next available subnet. Next segment requires 52 host addresses. Subnetting of /25 has given us two subnets with 128 hosts in each, from that we have assigned first subnet to development segment. Second segment is available, we would do subnetting of this.

- /26 provide us 4 subnets with 64 hosts in each subnet

- **192.168.1.0/26**

Subnet	Subnet 1	Subnet 2	Subnet 3	Subnet 4
Network ID	0	64	128	192
First address	1	65	129	193
Last address	62	126	190	254
Broadcast ID	63	127	191	255

Networking Today

- We cannot use subnet 1 and subnet 2 (address from 0 to 127) as they are already assigned to development department. We can assign subnet 3 to our production department.

Segment	Production
Requirement	52
CIDR	/26
Subnet mask	255.255.255.192
Network ID	192.168.1.128
First hosts	192.168.1.129
Last hosts	192.168.1.190
Broadcast ID	192.168.1.191

- **Step 5 :-** Our next segment requires 28 hosts. From above subnetting we have subnet 3 and subnet 4 available. Do subnetting for the requirement of 28 hosts.
- **192.168.1.0/27**

Subnet	Sub 1	Sub 2	Sub 3	Sub 4	Sub 5	Sub 6	Sub 7	Sub 8
Net ID	0	32	64	96	128	160	192	224
First Host	1	33	65	95	129	161	193	225
LastHost	30	62	94	126	158	190	222	254
Broadcast ID	31	63	95	127	159	191	223	255

Networking Today

Subnets 1 to 6 [address from 0 to 191] are already occupied by previous segments. We can assign subnet 7 to this segment.

Segment	Administrative
Requirement	28
CIDR	/27
Subnet mask	255.255.255.224
Network ID	192.168.1.192
First hosts	192.168.1.193
Last hosts	192.168.1.222
Broadcast ID	192.168.1.223

- **Step 6 :-** Our last three segments require 2 hosts per subnet. Do subnetting for these.

- **192.168.1.0/30**

- Valid subnets are:-

- 0,4,8,12,16,20,24,28,32,36,40,44,48,52,56,60,64,68,72,76,80,84,88,9 2,96,100,104,108,112,116,120,124,128,132,136,140,144,148,152,156 ,160,164,168,172,176,180,184,188,192,196,200,204,208,212,216,220 ,224,228,232,236,240,244,248,252,256

- From these subnets, subnet 1 to subnet 56 (Address from 0 - 220) are already assigned to previous segments. We can use 224,228, and 232 for wan links.

Networking Today

Subnet	Subnet 57	Subnet 58	Subnet 59
Network ID	224	228	232
First host	225	229	233
Last host	226	230	234
Broadcast ID	227	231	235

Assign these subnets to wan links.

Wan Link 1

Segments	Wan Link 1
Requirement	2
CIDR	/30
Subnet mask	255.255.255.252
Network ID	192.168.1.224
First hosts	192.168.1.225
Last hosts	192.168.1.226
Broadcast ID	192.168.1.227

Wan Link 2

Segments	Wan Link 2
Requirement	2
CIDR	/30
Subnet mask	255.255.255.252
Network ID	192.168.1.228
First hosts	192.168.1.229
Last hosts	192.168.1.230
Broadcast ID	192.168.1.231

Wan link 3

Segments	Wan Link 3
Requirement	2
CIDR	/30
Subnet mask	255.255.255.252
Network ID	192.168.1.232
First hosts	192.168.1.233
Last hosts	192.168.1.234
Broadcast ID	192.168.1.235

- We have assigned IP addresses to all segments, still we have 20 addresses available. This is the magic of VLSM.
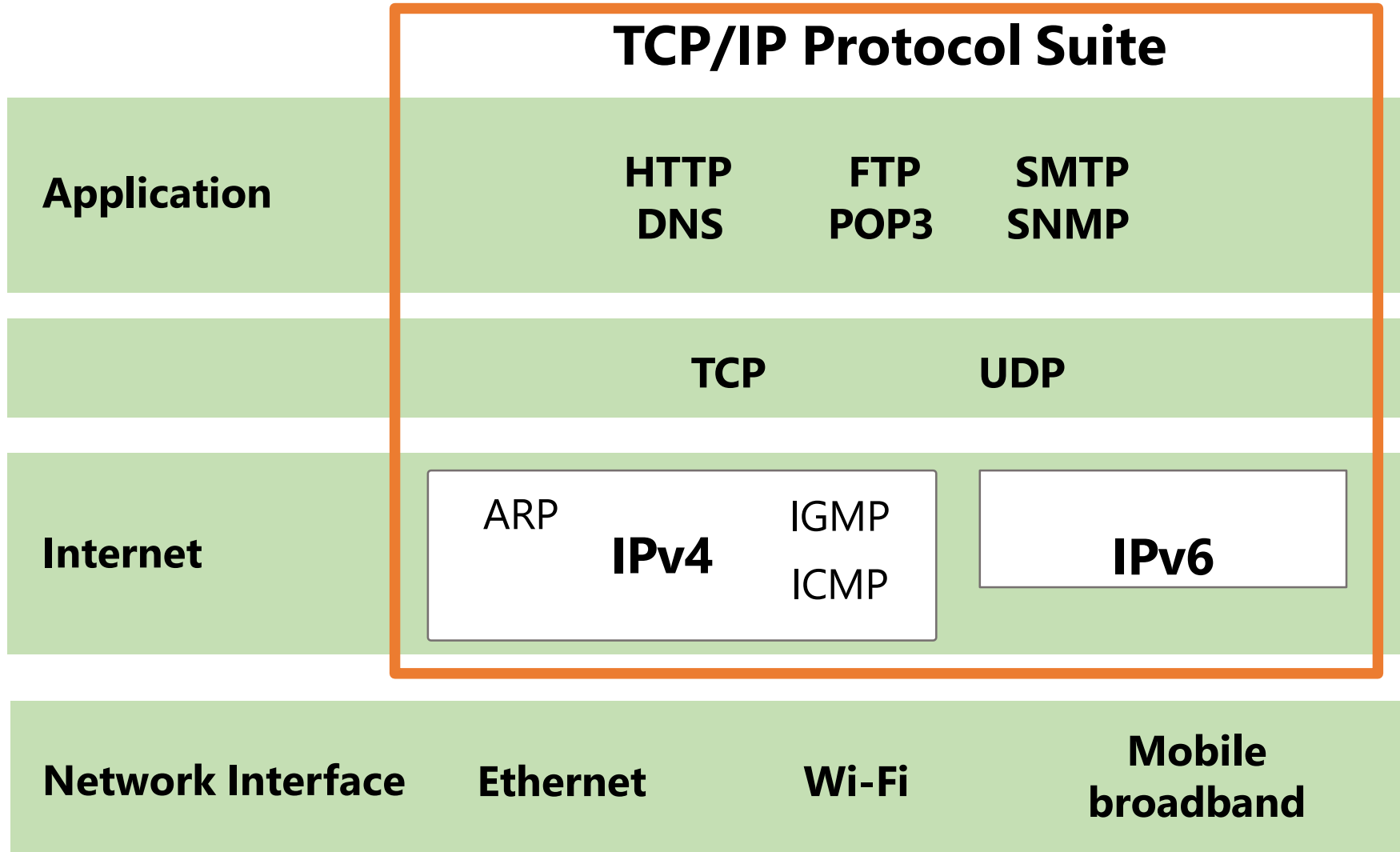

Address range
192.168.1.0/24
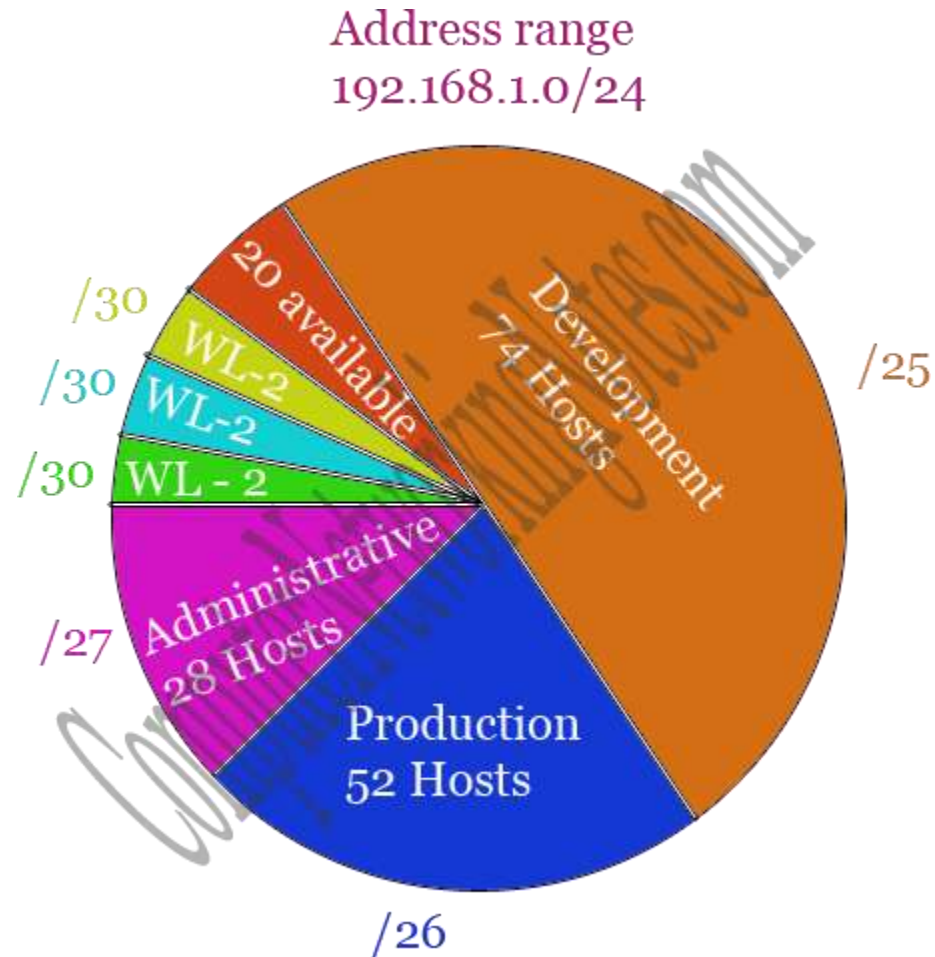
CIDR

- Classless Interdomain Routing
- Improve address space utilization
- Routing scalability in the Internet
- For example, if an ISP owns network 172.16.0.0/16, then the ISP can offer 172.16.1.0/24, 172.16.2.0/24,and so on to customers. Yet, when advertising to other providers, the ISP only needs to advertise 172.16.0.0/16

The TCP/IP Protocol Suite

TCP/IP Protocol Suite

Application	**HTTP FTP SMTP** **DNS POP3 SNMP**
	TCP UDP
Internet	ARP IGMP **IPv4** ICMP **IPv6**
Network Interface	**Ethernet Wi-Fi Mobile broadband**

Networking Today

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Questions?