Networking -- Subnetting

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Subnetting

Formulas for Subnetting

Since Total IPV4 bit = 32bit == Network Bits + Host Bits

Network bits = 32 – Host bits
Host bits = 32 – Network bits

For
Class A → N bit == 8 and H bit == 24
Class B → N bit == 16 and H bit == 16
Class C → N bit == 24 and H bit == 8

Formula's for Binary Numbers

2 power table

2^1 = 2	2^11 = 2048
2^2 = 4	2^12 = 4096
2^3 = 8	2^13 = 8192
2^4 = 16	2^14 = 16384
2^5 = 32	2^15 = 32768
2^6 = 64	2^16 = 65536
2^7 = 128	
2^8 =256	
2^9 = 512	
2^10 = 1024	

BINARY ADDITION

0 + 0 = 0

0 + 1 = 1

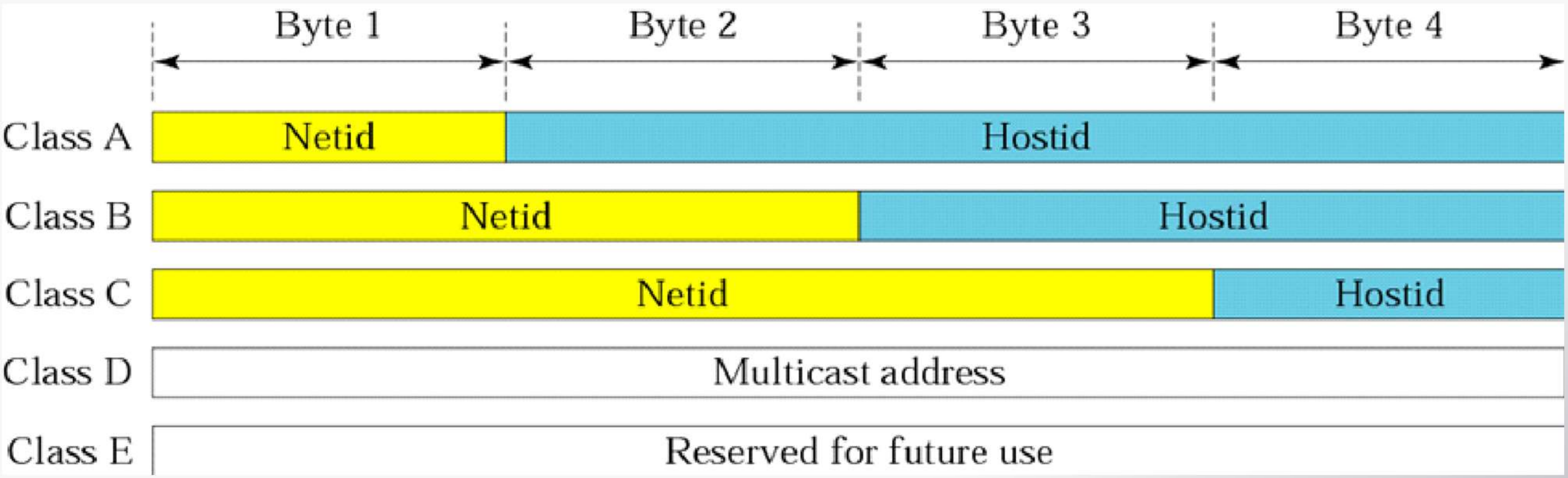
1 + 0 = 1

1 + 1 = 10

BINARY to Decimal Conversion Formula

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Netid and Hostid with Default CLASS

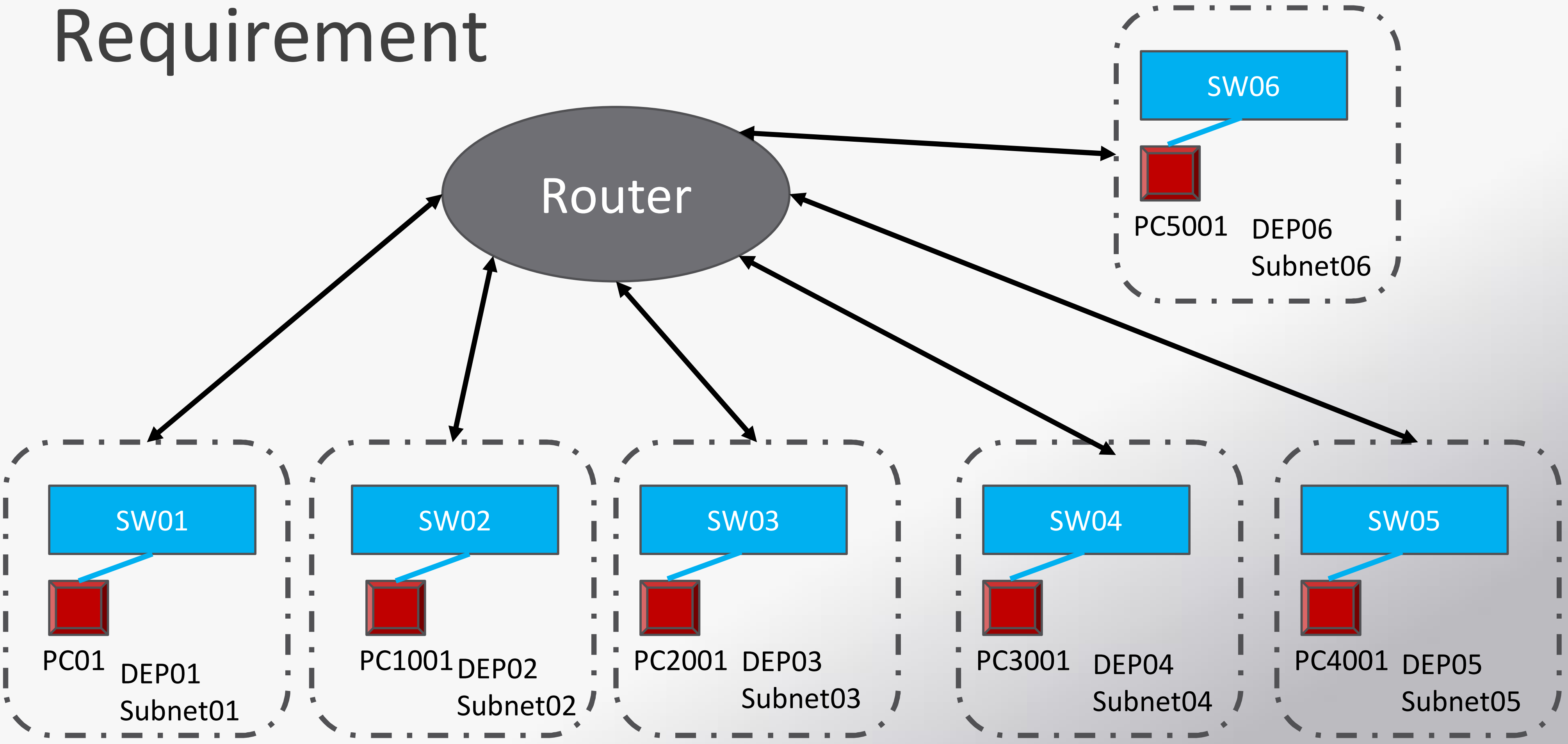


In classful addressing, an IP address in class A, B and C is divided into two parts netid and hostid. These parts are varying length, depending on the class of the address.

Requirement

- A customer has **6 Departments**.
- Customer wants to control the traffic between these Departments.
- Each department should have min capability of **1000** computer/users which would cater the growth for next 10 years
- The Admin is suppose create subnets by using **"172.18.0.0/16"** main network.

Requirement



Subnetting - Examples

Subnetting – Example – 172.18.0.0/16
1000 IP's per Sub-network, 6 Sub-Network.

Given is a Class B network which means

N bit =16, and H = 32-16 bit = 16 bits that is 65536 (2^16) IP's by Default

where in 16 bits are for HOST ID.

But we need to break this network into smaller networks with 1000 IP's (Hosts) in each Sub-Network.

Subnetting – Example – 172.18.0.0/16
1000 IP's per network, 6 Network

Example - 1

Solution:

2^**10** ~ 1000, Means ,

New No. of **H** bits = **10** ,

New No. of N bits = 32 (Total no of IPV4 bits) – 10(H Bit) = 22.

So, the First Subnetwork is → **172.18.0.0/22**

To find next sub network , we need to add binary "1" to the last bit of the NEW Network bits.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Host IP's in each subnetwork

Example - 1

Network Part | Host Part

172.18. 0000 0000 .00000000/22 → 172.18.0.0/22 – 1st Subnetwork

172.18. 0000 0000 .00000000 → 172.18.0.0 -- **Network ID**

172.18. 0000 0000 .00000001 → 172.18.0.1 -- First usable IP
172.18. 0000 0000 .11111111 → 172.18.0.255 -- usable IP
172.18. 0000 0001 .00000000 → 172.18.1.0 -- usable IP
172.18. 0000 0001 .11111111 → 172.18.1.255 -- usable IP
172.18. 0000 0010 .00000000 → 172.18.2.0 -- usable IP
172.18. 0000 0010 .11111111 → 172.18.2.255 -- usable IP
172.18. 0000 0011 .00000000 → 172.18.3.0 -- usable IP
172.18. 0000 0011 .11111110 → 172.18.3.254 -- Last usable IP

172.18. 0000 0011 .11111111 → 172.18.3.255 -- **Broadcast IP**

Subnetting – Example – 172.18.0.0/16
1000 IP's per network, 6 Network

Example - 1

Solution Continued ...

In our example it would be **"22"** bit for Network and we need add BINARY **"1"** at **22nd bit**.

172.18. 0000 0000 .00000000/22 → 172.18.0.0/22 – 1st Subnetwork
- +1

172.18. 0000 0100 .00000000/22 → 172.18.4.0/22 – 2nd Subnetwork
- +1

172.18. 0000 1000 .00000000/22 → 172.18.8.0/22 – 3rd Subnetwork
- +1

172.18. 0000 1100 .00000000/22 → 172.18.12.0/22 – 4th Subnetwork
- +1

172.18. 0001 0000 .00000000/22 → 172.18.16.0/22 – 5th Subnetwork

:

:

:

172.18. 1111 1100 .00000000/22 → 172.18.252.0/22 – Last Subnetwork

Octets Range
- 1st – 1 – 8
- 2nd – 9 – 16
- 3rd – 17 – 24
- 4th – 25 - 32

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 10

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Host IP's in each subnetwork

Example - 1

172.18. 0000 0000 .0/22 → 172.18.0.0/22 – 1st Subnetwork
172.18. 0000 0000 .0 → 172.18.0.0 -- Network ID – First IP
172.18. 0000 0000 .00000001 → 172.18.0.1 -- First usable IP
172.18. 0000 0011 .11111110 → 172.18.3.254 -- Last usable IP
172.18. 0000 0011 .11111111 → 172.18.3.255 -- **Broadcast IP – Last IP**

172.18. 0000 0100 .0/22 → 172.18.4.0/22 – 2nd Subnetwork
172.18. 0000 0100 .0 → 172.18.4.0 -- Network ID – First IP
172.18. 0000 0100 .00000001 → 172.18.4.1 -- First usable IP
172.18. 0000 0111 .11111110 → 172.18.7.254 -- Last usable IP
172.18. 0000 0111 .11111111 → 172.18.7.255 -- **Broadcast IP – Last IP**

172.18. 0000 1000 .0/22 → 172.18.8.0/22 – 3rd Subnetwork
172.18. 0000 1000 .0 → 172.18.8.0 -- Network ID – First IP
172.18. 0000 1000 .00000001 → 172.18.8.1 -- First usable IP
172.18. 0000 1011 .11111110 → 172.18.11.254 -- Last usable IP
172.18. 0000 1011 .11111111 → 172.18.11.255 -- **Broadcast IP – Last IP**

Subnetting – Example – 172.18.0.0/16
500 IP's per network, 6 Network

Example - 2

2^9 ~ 500, Means , No of H bits = 9 , No of N bits = 32 – 9 = 23.

So, the First Subnetwork is → **172.18.0.0/23**

To find next network , we need to add binary "1" to the last bit of the Network bit.

In our example it would on the **"23"** bit

172.18. 0000 0000 .00000000/23 → 172.18.0.0/23 – 1st Subnetwork

+1

172.18. 0000 0010 . **00000000**/23 → 172.18.2.0/23 – 2nd Subnetwork

+1

172.18. 0000 0100 . **00000000**/23 → 172.18.4.0/23 – 3rd Subnetwork

+1

172.18. 0000 0110 . **00000000**/23 → 172.18.6.0/23 – 4th Subnetwork

+1

172.18. 0000 1000 . **00000000**/23 → 172.18.8.0/23

172.18. 1111 1110 . **00000000**/23 → 172.18.254.0/23 – Last Subnetwork

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 10

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Host IP's in each subnetwork

Example - 1

172.18. 0000 0000 .0/23 → 172.18.0.0/23 – 1st Subnetwork
172.18. 0000 0000 .0 → 172.18.0.0 -- Network ID – First IP
172.18. 0000 0000 .00000001 → 172.18.0.1 -- First usable IP
172.18. 0000 0001 .11111110 → 172.18.1.254 -- Last usable IP
172.18. 0000 0001 .11111111 → 172.18.1.255 -- **Broadcast IP – Last IP**

172.18. 0000 0010 .0/23 → 172.18.2.0/23 – 2nd Subnetwork
172.18. 0000 0010 .0 → 172.18.2.0 -- Network ID – First IP
172.18. 0000 0010 .00000001 → 172.18.2.1 -- First usable IP
172.18. 0000 0011 .11111110 → 172.18.3.254 -- Last usable IP
172.18. 0000 0011 .11111111 → 172.18.3.255 -- **Broadcast IP – Last IP**

172.18. 0000 0100 .0/23 → 172.18.4.0/23 – 3rd Subnetwork
172.18. 0000 0100 .0 → 172.18.4.0 -- Network ID – First IP
172.18. 0000 0100 .00000001 → 172.18.4.1 -- First usable IP
172.18. 0000 0101 .11111110 → 172.18.5.254 -- Last usable IP
172.18. 0000 0101 .11111111 → 172.18.5.255 -- **Broadcast IP – Last IP**

CIDR

The Subnetworks created on the CLASSFULL (/8, /16 or /24 Default Subnets) are called as CIDR (CLASSLESS INTERDOMAIN ROUTING ADDRESS)

12.0.0.0/8 -- CLASSFULL Network

129.129.0.0/16 – CLASSFULL NETWORK

200.200.200.0/24 – CLASSFULL Network

CIDR

Eg: -- 172.18.0.0/23 -- THE IP and the SUBNET do not match in the class

or 172.18.4.0/23

Subnetting – Example – 192.168.0.0/**20**
200 IP's per network, 6 Network

Example - 3

Solution:

200 ~ 2^8, No of new **H** bit = 8, No of New N bit = 32 -8 =**24**

192.168.0.0/24 H

192.168.0000 0000 00000000/24→ 192.168.0.0/24 – 1st Subnetwork

+1

192.168.0000 0001 00000000/24 → 192.168.1.0/24 – 2nd Subnetwork

+1

192.168.0000 0010 00000000/24 → 192.168.2.0/24

+1

192.168.0000 0011 00000000 /24 → 192.168.3.0/24

+1

192.168.0000 0100 00000000/24 → 192.168.4.0/24

…………

192.168.0000 1111 00000000/24 → 192.168.15.0/24 – Last Subnetwork

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 10

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Subnetting – Example – 192.168.0.0/18
60 IP's per network, 6 Network

Example - 3

Solution:

60 ~ 2^6, No of new **H** bit = 6, No of New N bit = 32 -6 =**26**

192.168.0.0/26 → H

192.168.00000000.00000000/26→ 192.168.0.0/26 – 1st Subnetwork

+1

192.168.00000000.01000000/26 → 192.168.0.64/26 – 2nd Subnetwork

+1

192.168.00000000.10000000/26 → 192.168.0.128/26 – 3rd Subnetwork

+1

192.168.00000000.11000000 /26 → 192.168.0.192/26 – 4th Subnetwork

+1

192.168.00000001.00000000/26→ 192.168.1.0/26 – 5th Subnetwork

+1

192.168.00000001.01000000/26→ 192.168.1.64/26 – 6th Subnetwork

192.168.00111111.11000000/26 → 192.168.63.192/26 – Last Subnetwork

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 10

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Subnetting – Example – 192.168.69.0/20
60 IP's per network, 6 Network

Example - 4

2 Steps

1. Validation

2. Subnetting

1. Validation of the given network.

192.168.0100 | 0101.00000000/20

The given network **is INValid**, because there are binary **"1"** after the line (on the **HOST side**), in the above.

Convert it to an **VALID** network ID by making all binary value as **"0" on the HOST part.**

192.168.0100 | 0000.00000000/20

The VALID network ID → 192.168.64.0/20

Subnetting – Example – 192.168.64.0/20
60 IP's per network, 6 Network

Example - 4

60 ~ 2^6, No of new H bit = 6, No of New N bit = 32 -6 =**26**

192.168.64.0/26 → H

192.168.0100 0000.0000 0000/26 → 192.168.64.0/26 – 1st Subnetwork

+1

192.168.0100 0000.0100 0000/26 → 192.168.64.64/26 – 2nd Subnetwork

+1

192.168.0100 0000.1000 0000/26 → 192.168.64.128/26

+1

192.168.0100 0000.1100 0000/26 → 192.168.64.192/26

+1

192.168.0100 0001.0000 0000/26 → 192.168.65.0/26

192.168.0100 1111.1100 0000/26 → 192.168.79.192/26 – Last Subnetwork

Valid the Networks

Find whether the below Networks are Valid or NOT!!!!!

10.40.30.0/18 -- ??

10.40.00 011110 . 0/18 – INVALID Network

10.40.00 000000.0/18 → 10.40.0.0/18 -- NOW VALID

170.100.40.0/21 -- ??

170.100.00101 000.0/21 – 170.100.40.0/21 -- VALID NW

200.200.200.0/27 -- ??

200.200.200.000 00000 – VALID NW

Valid the Number of Hosts possible

Subnetting – Example – 192.168.64.0**/20**

Given → N=20 , H = 12.

Formula → Given H bit => Total Bits required for Subnetting

60 IP’s per network, 6 Sub Network

60 Ip’s mean == 2 ^ 6 Approx – Which means we need 6 bits.

+

6 Network == 2 ^ 3 Approx – Which means we need min of 3 network bits.

Total = 6 + 3 = 9 bits (Min) Required for Satisfy the above problem, as part of the Given HOST bits.

Subnetting – Example – 172.18.64.0/18
350 IP's per network, 6 Network

Example - 5

2 Steps

1. Validation

2. Subnetting

Validation of the given network.

172.18.0100 0000.0/18

The given network is Valid, because there are no binary "1" after the line, in the above.

172.18.0101 0000.0/18 → This network is not , bcz there is a binary "1" after the subnet mask (18). To make is valid, change all the binary bits to "0" after "18" (the line) bit.

Subnetting – Example – **172.18.64.0/18**
350 IP's per network, 6 Network

Example - 5

350 ~ 2^9, No of new H bit= 9, no of New N bit = 32-9 =23

172.18.64.0/23

172.18.0100 0000.0/23 → 172.18.64.0/23 – 1st Subnetwork

+1

172.18.0100 0010.0/23 → 172.18.66.0/23 – 2nd Subnetwork

+1

172.18.0100 0100.0/23 → 172.18.68.0/23 00

172.18.0111111 0.0/23 → 172.18.126.0/23 – Last Subnetwork

In AWS – 172.18.64.0/18 – is called the VPC CIDR or Main network

In AZure – 172.18.64.0/18 – is called the VirtualNetwork address space or Main network

In GCP – 172.18.64.0/18 – is called the VPC CIDR or Main network

Subnetting – Example – 170.170.70.0/20
100 IP's per network, 100 Network

Example - 3

Solution: Valid network is 170.170.64.0/20

100 ~ 2^7, No of new **H** bit = 7, No of New N bit = 32 -7 =**25**

170.170.64.0/25 H

170.170.0100 0000.0000 0000/25→ 170.170.64.0/25 – 1st Subnetwork

+1

170.170.0100 0000.1000 0000/25→ 170.170.64.128/25 – 2nd Subnetwork

+1

170.170.0100 0001.0000 0000/25→ 170.170.65.0/25 – 3rd Subnetwork

+1

170.170.0100 0000.1000 0000/25→ 170.170.64.128/25 – 4th Subnetwork

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Is Subnetting solution for IPV4 address shortage?

NO….

Because

We initially had total of approx. "2M" network with the "CLASS" approach

After subnetting we increase that to approx. "800M to 900M" small networks to manage the show.

But Currently we are having approx. … **"25 Billion" Devices online**

How do we take care of this???

Is Subnetting solution for IPV4 address shortage?

To solve the Growing demand of Public IP, IPV6 is the perfect solution

But we are still in the PROCESS of migrating ALL the APPLICATIONS FROM IPV4 to IPV6, which is taking an long time (25 yrs…. And Still we are doing it).

And interim solution to work on IPV4 was to DIVIDED the IPV4 address into **“PRIVATE”** and **“PUBLIC”.**

Private IPV4

10.0.0.0 to 10.255.255.255

172.16.0.0 to 172.31.255.255

192.168.0.0 to 192.168.255.255

100.64.0.0 to 100.127.255.255

NATTING and PATTING

PATTING → Converting "Many Private IP" to "one PUBLIC IP"

Means, all the traffic from "192.168.0.0/24" to the internet will use the public IP "100.100.10.21" as the IP to communicate on the INTERNET.

Note: - Any packet in the internet should have Source IP and Destination IP as PUBLIC IP.

Example:

PC1: Request

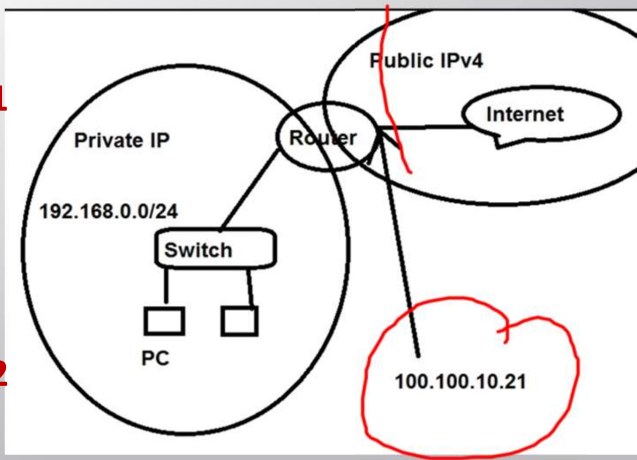
Sep 22 12:01:32.123: NAT: tcp 192.168.1.10:12345 -> 93.184.216.34:80

Sep 22 12:01:32.456: NAT: translating 192.168.1.10:12345 to 100.100.10.21:40001

PC2: Request

Sep 22 12:01:32.123: NAT: tcp 192.168.1.11:12345 -> 93.184.216.34:80

Sep 22 12:01:32.456: NAT: translating 192.168.1.11:12345 to 100.100.10.21:40002



NATTING and PATTING

NATTING → Converting "one Private IP" to "One Public IP"

This is used for HIDDING the Hosting servers in the

Private segment from the attacker on the internet.

IPV4 Address details

Public IPV4's range

0.0.0.0 to 9.255.255.255

11.0.0.0 to 126.255.255.255

128.0.0.0 to 169.253.255.255

169.255.255.255 to 172.15.255.255

172.32.0.0 to 192.167.255.255

192.169.0.0 to 223.255.255.255

Loopback IP

127.0.0.0 to 127.255.255.255

APIPA

169.254.0.0 to 169.254.255.255 – Used on the windows OS, as an Automatic ip address

Subnet values

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

/17 -- 11111111.11111111.10000000.00000000 – 255.255.128.0

/18 -- 11111111.11111111.11000000.00000000 – 255.255.192.0

/19 -- 11111111.11111111.11100000.00000000 – 255.255.224.0

/20 -- 11111111.11111111.11110000.00000000 – 255.255.240.0

/21 -- 11111111.11111111.11111000.00000000 – 255.255.248.0

/22 – 11111111.11111111.11111100.00000000 – 255.255.252.0

/23 – 11111111.11111111.11111110.00000000 – 255.255.254.0

/24 – 11111111.11111111.11111111.00000000 – 255.255.255.0

Subnet Pattern Match

11111111. 11111110. 00000000. 00000000 -- 255.254.0.0 -- /15

11111111. 11111111. 11111110. 00000000 -- 255.255.254.0 -- /23

11111111. 11111111. 11111111. 11111110 -- 255.255.255.254 -- /31

Steps in Choosing IP address

Choose a network that can have **300 IP’s per network and we would need min of 10 networks.**

1. Find the main CIDR
   1. Find the MAIN CIDR Subnet mask
   2. Choose the IP address range
   3. Validate the above IP address range
2. Create the Subnets

Choosing your OWN Network

Choose a network that can have **300 IP's per network and we would need min of 10 networks.**

Solution:

300 ~ 2^9 = 512➔ 9 is the Host bits for every Subnetwork.

10 ~ 2^4 = 16 ➔ 4 bits

Main CIDR , no of H bits == 9 + 4 == 13.

NW bit for main CIDR == 32 – H == 32 – 13 == 19

Eg: -- 192.168.33.0/19 – Here the IP is assumed

192.168.001|00001.00000000/19 – This is INVALID network,

192.168.001 00000.00000000/19 -- 192.168.32.0/19 → THIS IS VALID NW

Subnetting – Example – **192.168.32.0/19**
300 IP's per network, 10 Network

Example - 6

300 ~ 2^9, No of new H bit = 9, No of New N bit = 32 - 9 =**23**

192.168.32.0/23 ⟶ H

192.168.001 00000.0000 0000/23 → 192.168.32.0/23 – 1st Subnetwork

+1

192.168.001 00010.0000 0000/23 → 192.168.34.0/23 – 2nd Subnetwork

+1

192.168.001 00100.0000 0000/23 → 192.168.36.0/23

+1

192.168.001 00110.0000 0000/23 → 192.168.38.0/23

+1

192.168.001 01000.0000 0000/23 → 192.168.40.0/23

192.168.001 11110.0000 0000/23 → 192.168.62.0/23 – Last Subnetwork

Choosing your OWN Network

Choose a network that can have **130 IP's per network and we would need min of 100 networks.**

Solution:

130 ~ 2^8 = 256➔ 8 is the Host bits for every Subnetwork.

100 ~ 2^7 = 128 ➔ 7 bits

Main CIDR , no of H bits == 8 + 7 == 15.

NW bit for main CIDR == 32 – H == 32 – 15 == 17

Eg: -- 192.168.70.0/17 – Here the IP is assumed

192.168.010 00110.00000000/17 – This is INVALID network,

192.168.00000000.00000000/17 → 192.168.0.0/17 → VALID NW

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Subnetting – Example – **192.168.0.0/17**
130 IP's per network, 100 Network

Example - 6

130 ~ 2^8, No of new H bit = 8, No of New N bit = 32 - 8 =**24**

192.168.0.0/24 → H

192.168.0 0000000.0000 0000/24 → 192.168.0.0/24 – 1st Subnetwork

+1

192.168.0 0000001.0000 0000/24 → 192.168.1.0/24 – 2nd Subnetwork

+1

192.168.0 0000010.0000 0000/24 → 192.168.2.0/24 – 3rd Subnetwork

+1

192.168.0 0000011.0000 0000/24 → 192.168.3.0/24 – 4th Subnetwork

+1

192.168.0 0000100.0000 0000/24 → 192.168.4.0/24 – 5th Subnetwork

+1

192.168.0 0000101.0000 0000/24 → 192.168.5.0/24 – 6th Subnetwork

………………………

192.168.011 11111.0000 0000/24 → 192.168.127.0/24 – Last Subnetwork

Choosing your OWN Network

Choose a network that can have **1000 IP's per network and we would need min of 200 networks.**

Solution:

1000 ~ 2^10 = 1024→ 10 is the Host bits for every Subnetwork.

200 ~ 2^8 = 256 → 8 bits

Main CIDR , no of H bits == 10 + 8 == 18.

NW bit for main CIDR == 32 – H == 32 – 18 == 14

Eg: -- 192.168.33.0/14 – Here the IP is assumed

192.101010|00.00100001.0/14 – This is INVALID network,

192.168.0000000.0/14 -- 192.168.0.0/14 → THIS IS VALID NW

Choosing your OWN Network

Choose a network that can have **60 IP's per network and we would need min of 60 networks.**

Main H bit == 6+6 =12

Main N bit = 32 -12 = 20

172.16.26.0/20 -- ???

172.16.16.0/20 – is the valid main network

Subnettnig – 172.16.16.0/20

New Subnet H bit – 6

172.16.16.0/26 – 1st

172.16.16.64/26 – 2nd

172.16.16.128/26 – 3rd

172.16.16.192/26 – 4th

172.16.

172.16.0001 0000.0000 0000/26 → 172.16.16.0/26 – 1st Subnetwork

+1

172.16.0001 0000.0100 0000/26 → 172.16.16.64/26 –2nd Subnetwork

+1

172.16.0001 0000.1000 0000/26 → 172.16.16.128/26 – 3rd Subnetwork

+1

172.16.0001 0000.1100 0000/26 → 172.16.16.192/26 – 4th Subnetwork

+1

172.16.0001 0001.0000 0000/26 → 172.16.17.0/26 – 5th Subnetwork

+1

172.16.0001 0001.0100 0000/26 → 172.16.17.64/26 – 6th Subnetwork