Binary Subnettings

Presented by
Omid Panahi

Champlain
COLLEGE SAINT-LAMBERT

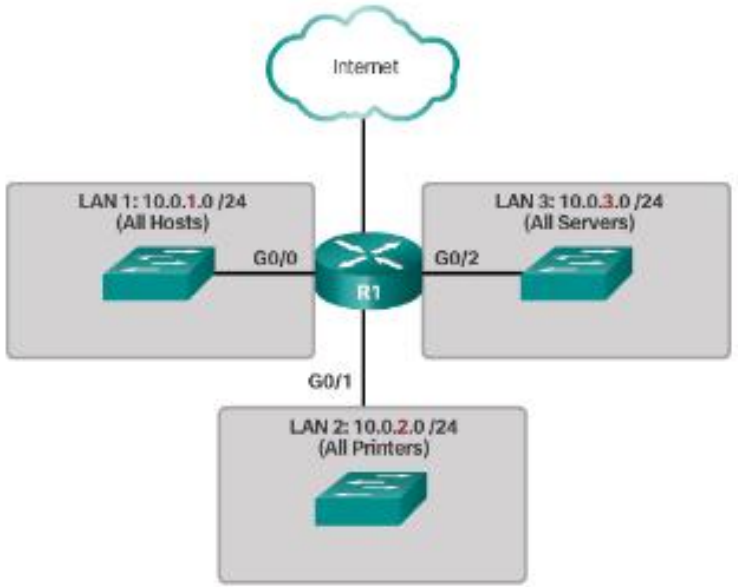
IP Address Classes

Address Class	1st octet range (decimal)	1st octet bits (green bits do not change)	Network(N) and Host(H) parts of address	Default subnet mask (decimal and binary)
A	1-127**	00000000-01111111	N.H.H.H	255.0.0.0
B	128-191	10000000-10111111	N.N.H.H	255.255.0.0
C	192-223	11000000-11011111	N.N.N.H	255.255.255.0
D	224-239	11100000-11101111	NA (multicast)	
E	240-255	11110000-11111111	NA (experimental)	

** All zeros (0) and all ones (1) are invalid hosts addresses.

Network Segmentation

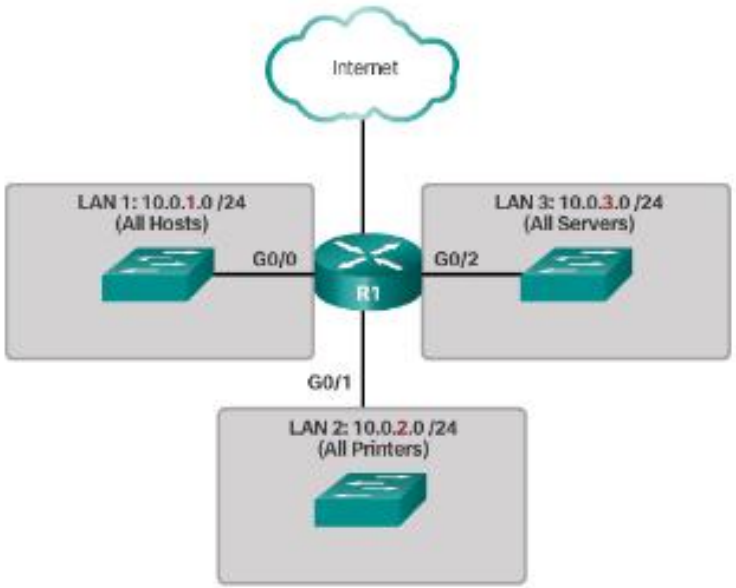
- Broadcast Domains
  - Each router interface connects a broadcast domain.
  - Broadcasts are only propagated within its broadcast domain.
- Problems with Large Broadcast Domains
  - Slow network operations due to the significant amount of broadcast traffic.
  - Slow device operations because a device must accept and process each broadcast packet.



Slides - courtesy of Cisco Systems

Reasons for Subnetting

- Example: Network 10.0.0.0/8 is a very large network with $2^{24} - 2$ hosts and a subnet mask of 255.0.0.0
- Solution: reduce the size of the network to create smaller broadcast domains.
- Because each broadcast domain connects to a different router interface, each domain needs its own network address space.
- The process of breaking an address range into smaller address spaces is called **subnetting.**
- Network administrators can group devices into subnets that are determined by location, organizational unit or device type.



Slides - courtesy of Cisco Systems

Subnetting in an IPv4 Network is not just subnetted on the octet boundary

- Octet Boundaries
  - Subnets can be created based on octet boundaries. (/8, /16 or /24)
- Subnetting on the Octet Boundary
  - Also known as IPv4 Classes.
  - Uses the octet boundaries to separate network from hosts.
- Classless Subnetting
  - Uses address bits to separate network from hosts.
  - Allows for much more flexibility.
- Classless Subnetting Example

Prefix Length	Subnet Mask	Subnet Mask in Binary (n = network, h = host)	# of subnets	# of hosts
/25	255.255.255.128	nnnnnnnn.nnnnnnnn.nnnnnnnn.nhhhhhhh 11111111.11111111.11111111.10000000	2	126

Slides - courtesy of Cisco Systems

For each subnet:

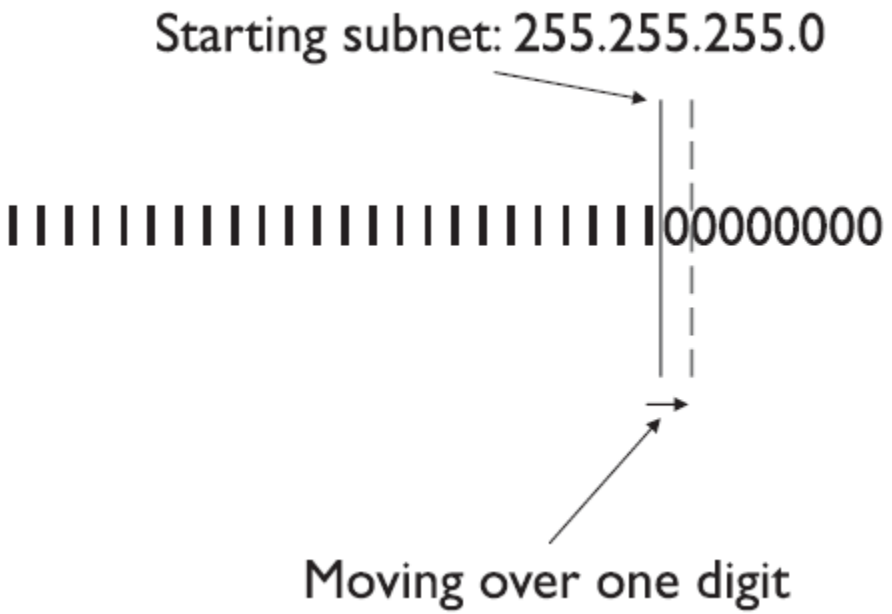
- Rules for subnetting:
  - 2^x = number of subnets, x = the number of bits used for subnetting
  - $2^y - 2$ = number of hosts per subnet, y = the number of bits used for hosts
- Each subnet has the following:
  - A network address – all 0s in the host portion
  - A subnet mask – written in dotted decimal or /x
  - A broadcast address – all 1s in the host portion
  - $2^y - 2$ host addresses,

Subnetting Example

- 192.168.10.0 - assigned address
- subnet the address by borrowing 3 bits from the host portion
  - 192.168.10.**111**00000
  - 2^3 = 8 subnets in this scenario, and are the following:
    - 192.168.10.0 **000**00000 hosts 1-30 (2^5-2) broadcast .31
    - 192.168.10.32 **001**00000 hosts 33-62 broadcast .63
    - 192.168.10.64 **010**00000 hosts 65-94 broadcast .95
    - 192.168.10.96 **011**00000 hosts 97-126 broadcast .127
    - 192.168.10.128 **100**00000 hosts 129-158 broadcast .159
    - 192.168.10.160 **101**00000 hosts 161-190 broadcast .191
    - 192.168.10.192 **110**00000 hosts 193-222 broadcast .223
    - 192.168.10.224 **111**00000 hosts 225-254 broadcast .255

Calculating Subnets

- If we had a /24 subnet and we added <u>one</u> bit, we technically have 2^1 subnets (2) to work with.



/24 subnetted into 4 networks.

11000000 10101000 00000100 00000000

192.168.4.0/26

Range (usable): 192.168.4.1–192.168.4.62

Broadcast: 192.168.4.63

11000000 10101000 00000100 01000000

11000000 10101000 00000100 10000000

11000000 10101000 00000100 11000000

Try to calculate the range of the other 3 subnets.

Subnet Requirements

- Subnet requirements are defined by either the needed amount of:
  - Hosts or
  - Subnets
  - Or both!

- Example:
  - Need a network sub netted so that each segment can have at least 12 hosts and a total of at least 10 subnets. How many bits would you borrow to meet this requirement?

Answer to Previous Question

- Requirement: at least 12 hosts per segment and at least 10 subnetworks
- 192.168.20.11111111
- You must stay within the confines of binary math, therefore for 10 subnetworks, what power of 2 does this fit within?
  - 2^4= 16 therefore, 4 bits (2^n where n= # of bits) will give 16 networks which meets the requirement.
  - 192.168.20.**1111**0000 and 4 bits are left for the hosts
  - 2^4-2=14 so this meets the hosts requirement
  - 192.168.20.**1111**0000 All 0s is the Network address
  - 192.168.20.**1111**1111 All 1s is the Broadcast address

What is the subnet for the following Class C Addresses?:

1. 192.168.7.189 mask: 255.255.255.224
2. 192.168.20.45 mask: 255.255.255.252
3. 192.168.10.102 mask: 255.255.255.240
4. 192.168.99.221 mask: 255.255.255.248
5. 192.168.220.200 mask: 255.255.255.192

Class B Subnetting works the same way

- The only difference is there are more bits
  - 172.16.11111111.11111111
- If 500 hosts were needed:
  - 172.16.11111110.00000000
    - This gives us 2^7 subnets = 127
    - And 2^9-2 hosts = 510
- Notice the subnet is not on the octet
- An example of one subnet in this would be:
  - 172.16.224.0 /23 subnet mask of 255.255.254.0
    - Hosts 172.16.224.1-172.16.225.254
    - Broadcast 172.16.225.255

Class A

- There are 24 bits to borrow from in a Class A network

- 34.11111111.11111111.11111111
- Possible examples are large number of subnets
  - 34.**11111111.111111**00.00000000 2^{14} networks 2^{10}-2 hosts
  - 34.7.8.0/22 subnet mask 255.255.252.0

- Or large amounts of hosts
  - 34.**1111111**0.00000000.00000000 2^{7} networks 2^{17}-2 hosts
  - 34.2.0.0/15 subnet mask 255.254.0.0

Subnetting Exercises

Subnetting Exercises– Class C

- For each question give the following:
  - Subnet Address
  - Subnet Mask
  - 1st and last address
  - Broadcast Address

  - Use 200.1.1.0
    - 6 networks
    - 6th subnet

  - Use 221.7.3.0
    - 55 hosts
    - 3rd subnet

  - Use the 5th Private Class C
    - 10 networks
    - 7th subnet

Subnetting Exercises – Class B

- For each question give the following:
  - Subnet Address
  - Subnet Mask
  - 1st and last address
  - Broadcast Address

4. Use 128.7.0.0
   - 1000 hosts
   - 45th subnet

5. Use 191.45.0.0
   - 190 subnets
   - 200th subnet

6. Use the 7th Private Class B
   - 1900 hosts
   - 27th subnet

Subnetting Exercises – Class A

- For each question give the following:
  - Subnet Address
  - Subnet Mask
  - 1st and last address
  - Broadcast Address

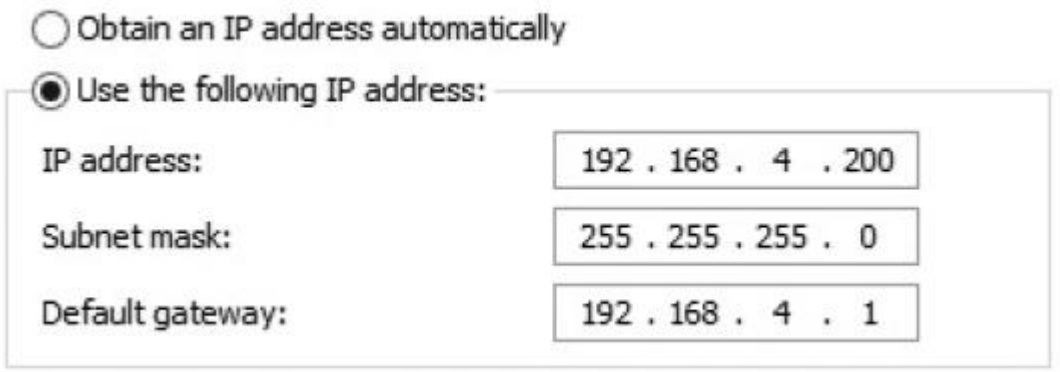
7. Use 2.0.0.0
   - Borrow 9 bits
   - 21st subnet

8. Use the Private Class A Address
   - Borrow 13 bits
   - 100th subnet

Practical Examples

Static IP Addresses

- Some rules:
  - Arrange IP's in a sequential order
  - Try to group servers, computers and other devices in batches.



Linux Example **/etc/network/interfaces**

```
auto eth0
iface eth0 inet static
 address 172.20.20.65
 gateway 172.20.20.1
 netmask 255.255.254.0
```

DHCP

- DHCP is known as "Dynamic IP Addressing".
- When a PC is connect to the network using DHCP, it sends out a DHCP discover packet on the broadcast address asking if there is a DHCP server available.

PORTS

- Servers : PORT 67 (UDP)
- Clients : PORT 68

DHCP Scope

- Usually a range of IP's to distribute (Starting, Maximum).
  - Starting = 192.168.1.100, max = 50
  - Therefore 192.168.1.100-150
- Example DHCP server settings on a CISCO firewall:

Interface	DHCP Enabled	Address Pool	DNS Servers
dmz	Yes	172.21.20.50 - 172.21.20.60	208.67.222.2... 208.67.220.220
dmz_project	No	-	
inside	Yes	172.20.21.1 - 172.20.21.128	172.20.20.60, 208.67.222.222
outside	No	-	
public	Yes	192.168.1.2 - 192.168.1.127	208.67.222.222

DHCP

DHCP Reservation

Usually based on MAC address.

54-27-1E-C4-F1-D4 : 172.20.20.5

If the MAC is in the list of reservations, it will deliver the reserved IP. 172.20.20.5 in this case.

Some devices DO NOT support reservations (CISCO Enterprise Routers), you must use another technique.

Home routers OFTEN DO support reservations.

Failed DHCP

- You will notice a failed request when the PC is assigned an address that starts with 169.254.x.x
- This special IP address is generated by a version of *zero-configuration networking (zeroconf)*.
- Microsoft's implementation is called *Automatic Private IP Addressing (APIPA)*.
- The client only generates the last two octets of an APIPA address.
- No gateway is configured.

DHCP Troubleshooting

To request another DHCP address forcefully:

- **Windows**
  - ipconfig /release
  - ipconfig /renew
- **Linux**
  - sudo ifconfig eth0 down
  - Sudo ifconfig eth0 up

Partial Netmasks Review

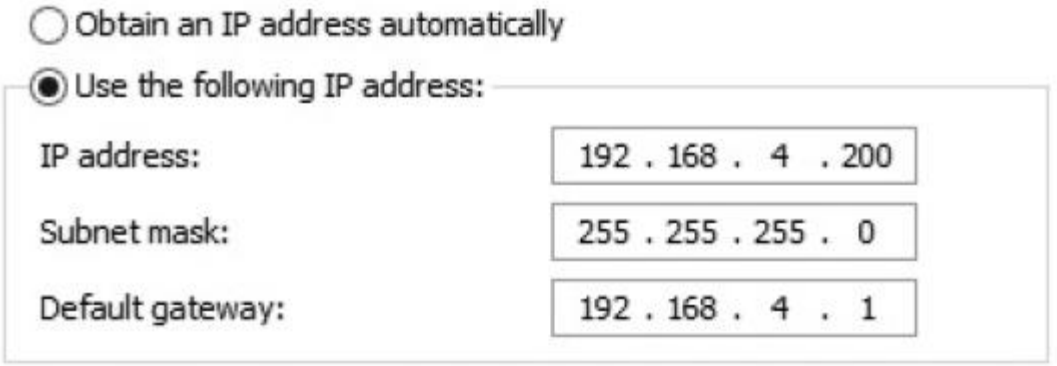
x.x.x.x/25

= 11111111.11111111.11111111.10000000

= 255.255.255.128

Static IP Addresses

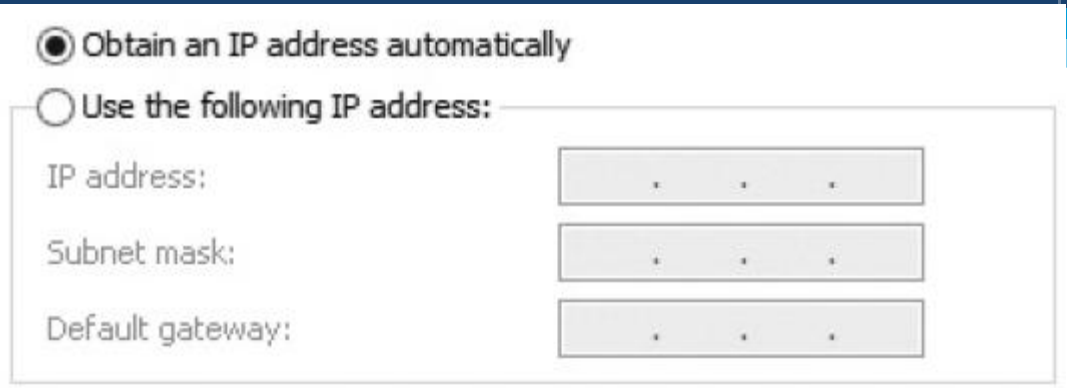
- Some rules:
  - Arrange IP's in a sequential order
  - Try to group servers, computers and other devices in batches.



Linux Example **/etc/network/interfaces**

```
auto eth0
iface eth0 inet static
 address 172.20.20.65
 gateway 172.20.20.1
 netmask 255.255.254.0
```

DHCP



- DHCP is known as "Dynamic IP Addressing".
- When a PC is connect to the network using DHCP, it sends out a DHCP discover packet on the broadcast address asking if there is a DHCP server available.

DHCP Scope

- Usually a range of IP's to distribute (Starting, Maximum).
- Starting = 192.168.1.100, max = 50
- Therefore 192.168.1.100-150

DHCP Reservation

Usually based on MAC address.

54-27-1E-C4-F1-D4 : 172.20.20.5

If the MAC is in the list of reservations, it will deliver the reserved IP. 172.20.20.5 in this case.

Failed DHCP

- You will notice a failed request when the PC is assigned an address that starts with 169.254.x.x
- This special IP address is generated by a version of *zero-configuration networking (zeroconf)*.
- Microsoft's implementation is called *Automatic Private IP Addressing (APIPA)*.
- The client only generates the last two octets of an APIPA address.
- No gateway is configured.

DHCP Troubleshooting

To request another DHCP address forcefully:

- **Windows**
  - ipconfig /release
  - ipconfig /renew
- **Linux**
  - sudo ifconfig eth0 down
  - Sudo ifconfig eth0 up

Special Addresses

- 127.0.0.1 (Called Loopback)
- This is the local host address.

Champlain

COLLEGE SAINT-LAMBERT