IP Addressing & Subnetting

17CS52 - CN: L07/08

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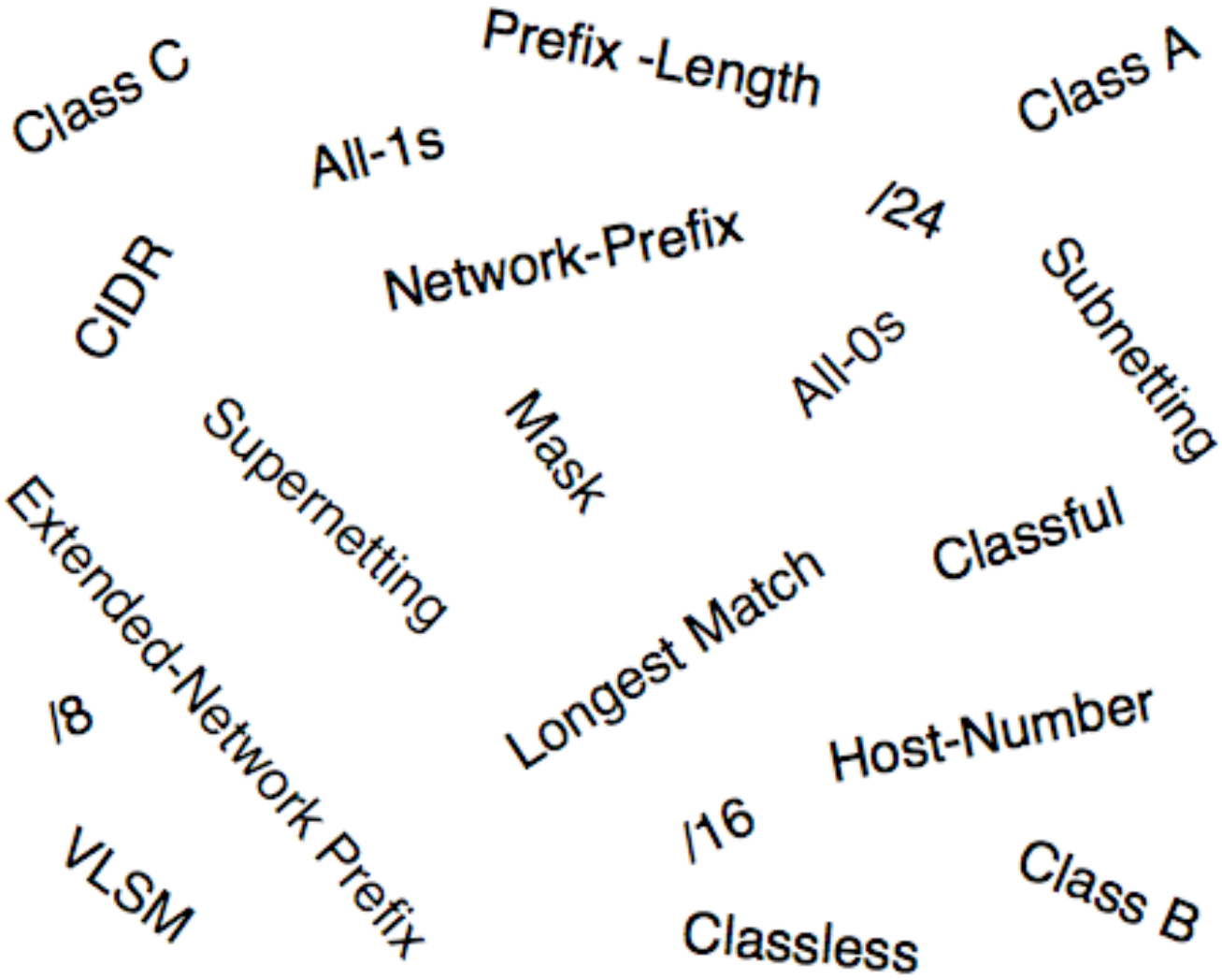
https://www.youtube.com/watch?v=H4IrvTCDu4M
https://www.youtube.com/watch?v=zbOyrZr-SIc

IP Addressing

- Understanding terms to use
  - Naming
    - Identifies what it is
  - Addressing
    - Identifies where it is
  - Routing
    - Identifies how to reach it
- Examples:
  - Name: KS Institute of Technology
  - Address: Raghuvanhalli, Kankapura Road
  - Routing: Need to map to find directions from starting point.

Understanding IP Addressing: Everything You Ever Wanted To Know



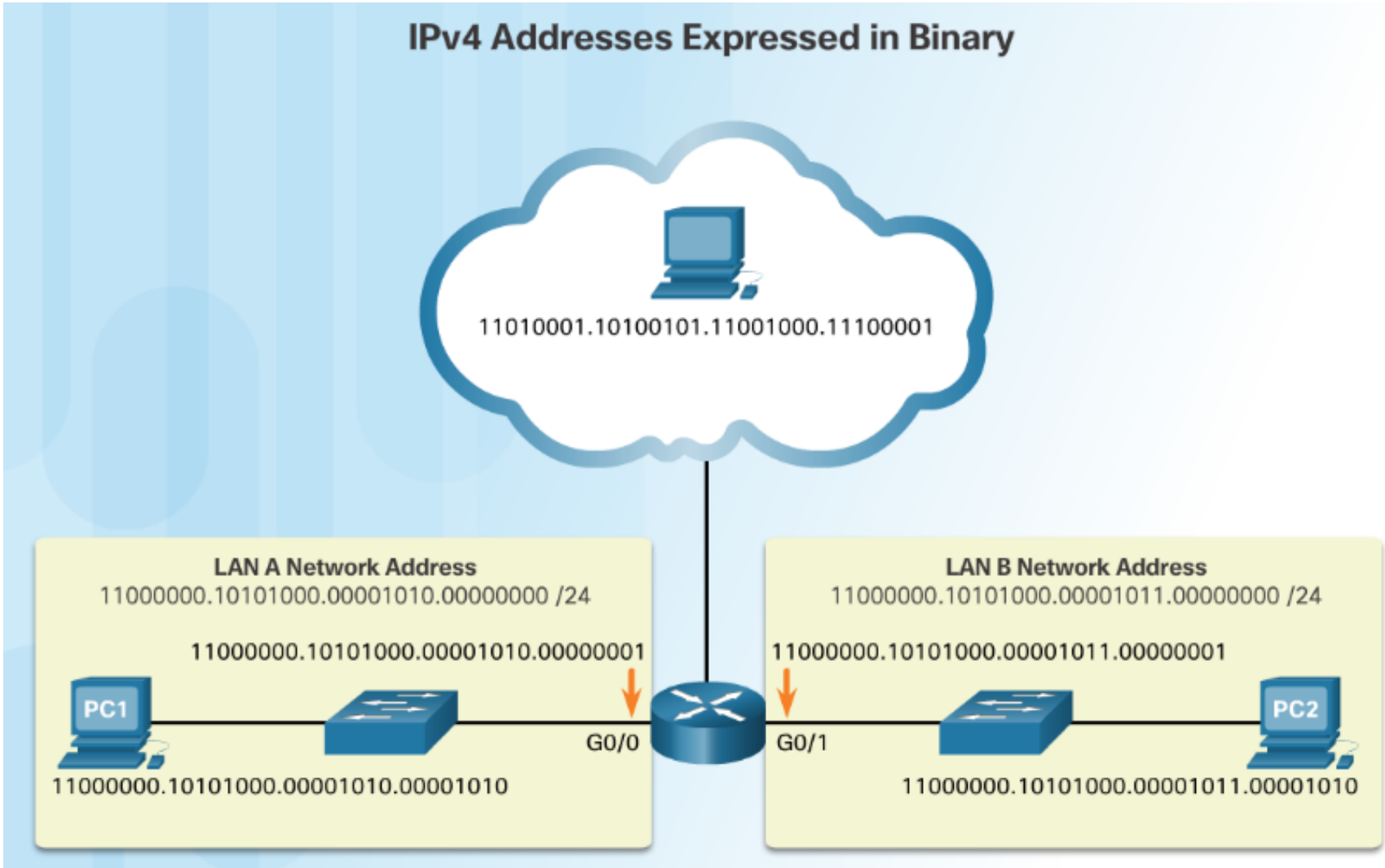
src: Chuck Semeria, NSD Marketing, 3Com Corp, 1996

Example

- Consider the website: www.rprustagi.com
- Name:
  - Identifies the website `rprustagi.com`
- Address (IP Address)
  - `69.161.146.196`
- Route: Use **`traceroute`** to find the route
  - `192.168.1.1`
  - abts-kk-dynamic-001.4.179.122.airtelbroadband.in
  - abts-kk-static-017.33.166.122.airtelbroadband.in
  - `125.62.180.9`
  - `182.79.146.194`
  - …

IP Address

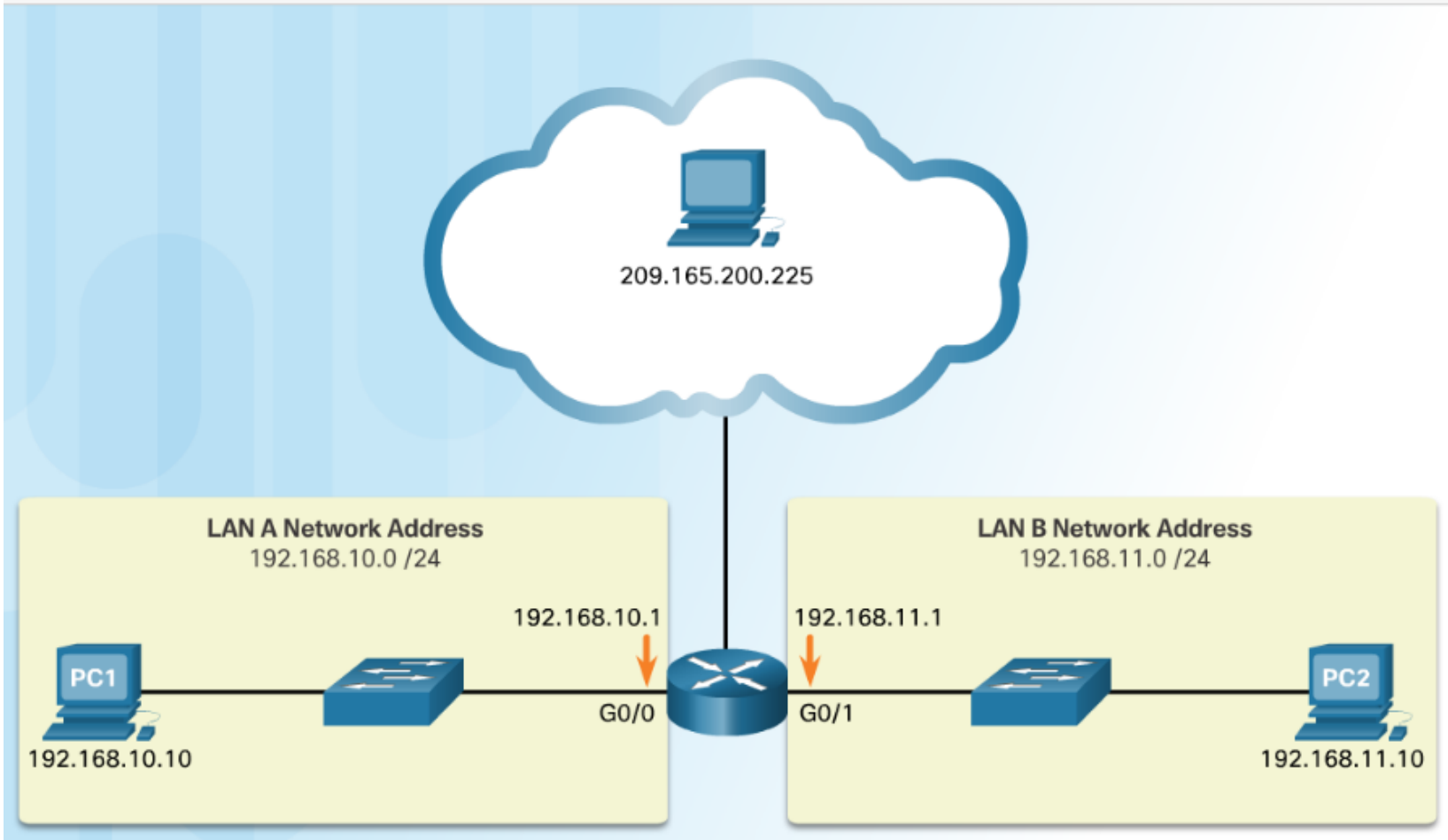
- IPv4 addresses are expressed in 32 binary bits divided into 4 octets (8 bits)



src: CCNA R&S M1: Intro to Networking

IP Address

- IPv4 addresses are commonly expressed in dotted decimal notation i.e. `a.b.c.d/n`
- Example: **`192.168.10.1`**

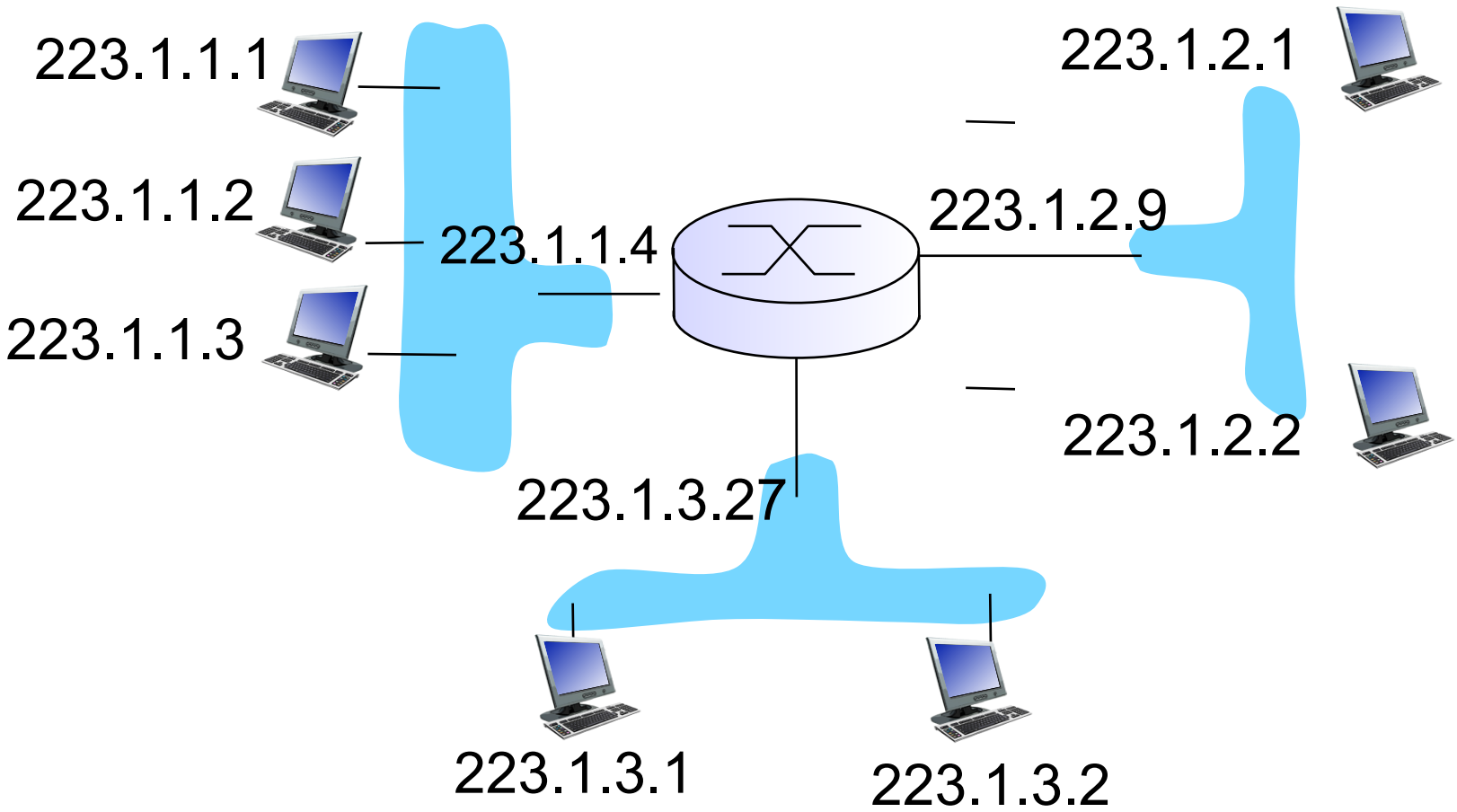


`src: CCNA R&S M1: Intro to Networking`

IP addressing: introduction

- Analogy: A house has mulitple doors opening on different streets. What is its address?
  - Do all doors have same number?
- ***IP address:*** A 32-bit identifier for interface of an host, router *etc*.
- ***interface:*** A connection between host/router and physical link
  - A router typically has multiple interfaces
  - A host typically has one or two interfaces (e.g., wired Ethernet, wireless 802.11)
  - A host also has a loopback address (127.0.0.1)
- *Note: IP addresses associated with each interface*

IP addressing: introduction



223.1.3.27 = 11011111 00000001 00000011 00011011

223 1 3 27

src: Kurose & Ross: Computer Networks

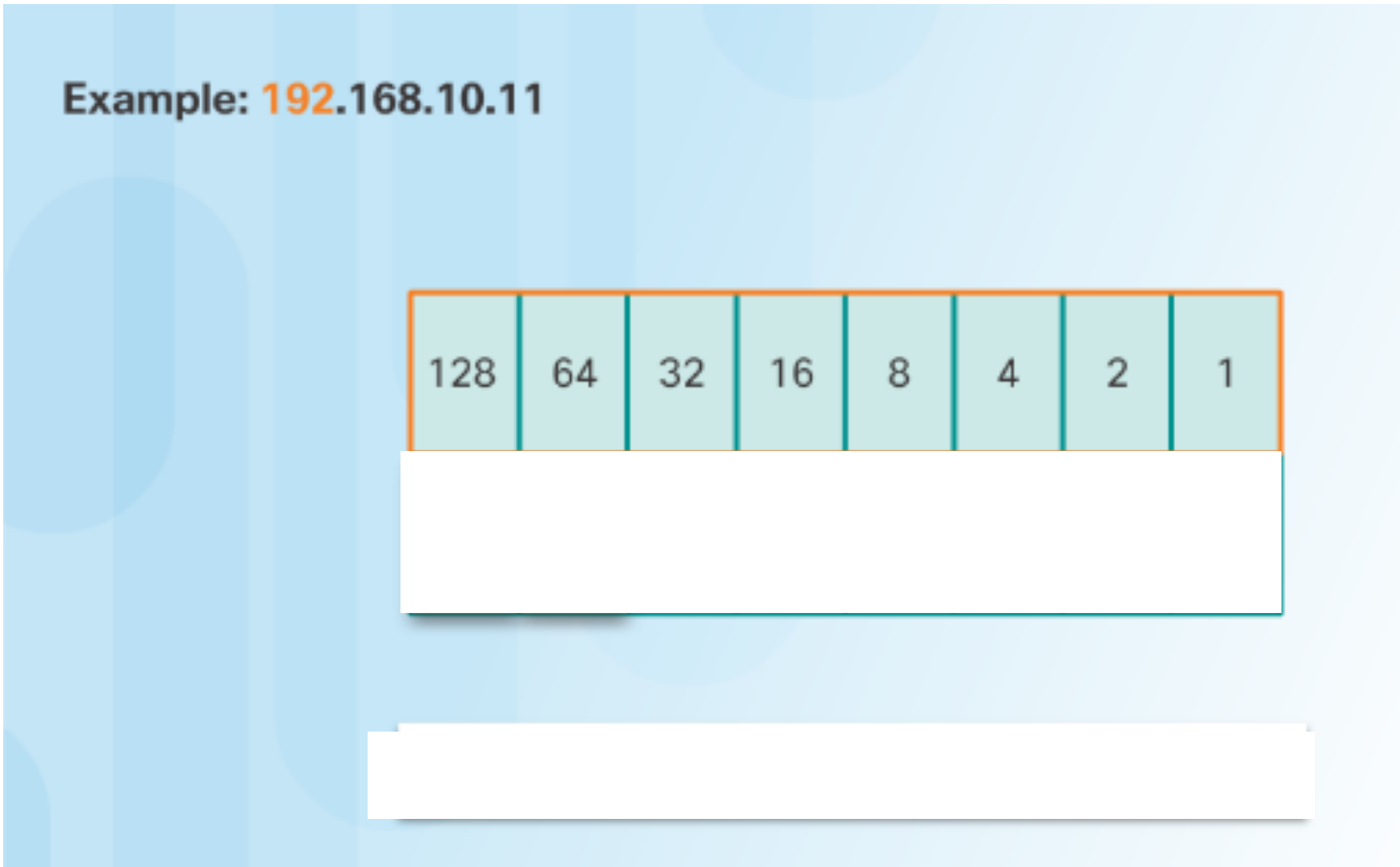
IP addressing: introduction

- *IP address:* 32-bit identifier for host, router *interface*
- *interface:* connection between host/router and physical link
  - router's typically have multiple interfaces
  - host typically has one or two interfaces (e.g., wired Ethernet, wireless 802.11)
- *IP addresses associated with each interface*

src: Kurose & Ross: Computer Networks

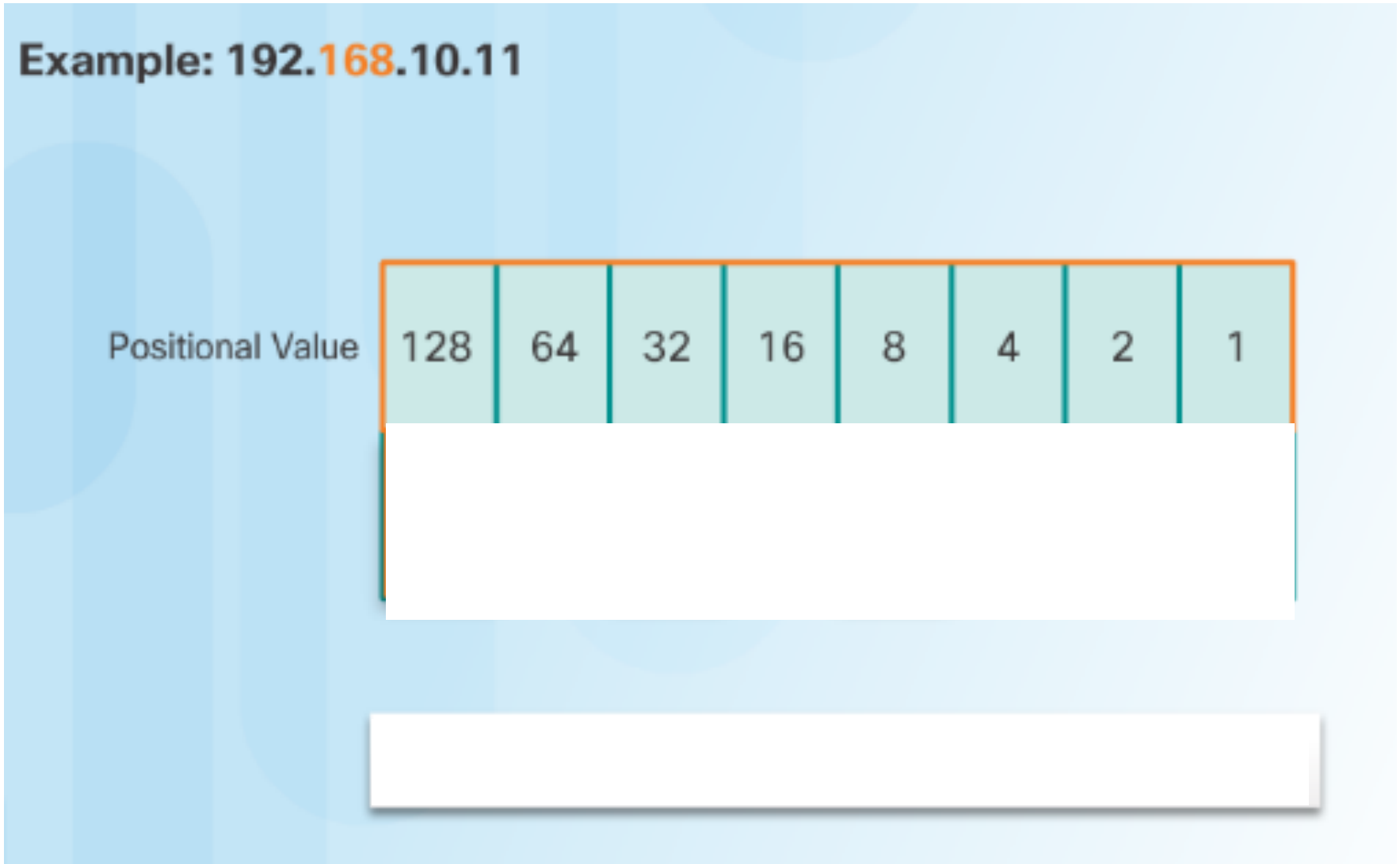
IP Address: Decimal to Binary

- Consider **192.168.10.11**
  - Convert 1st octet



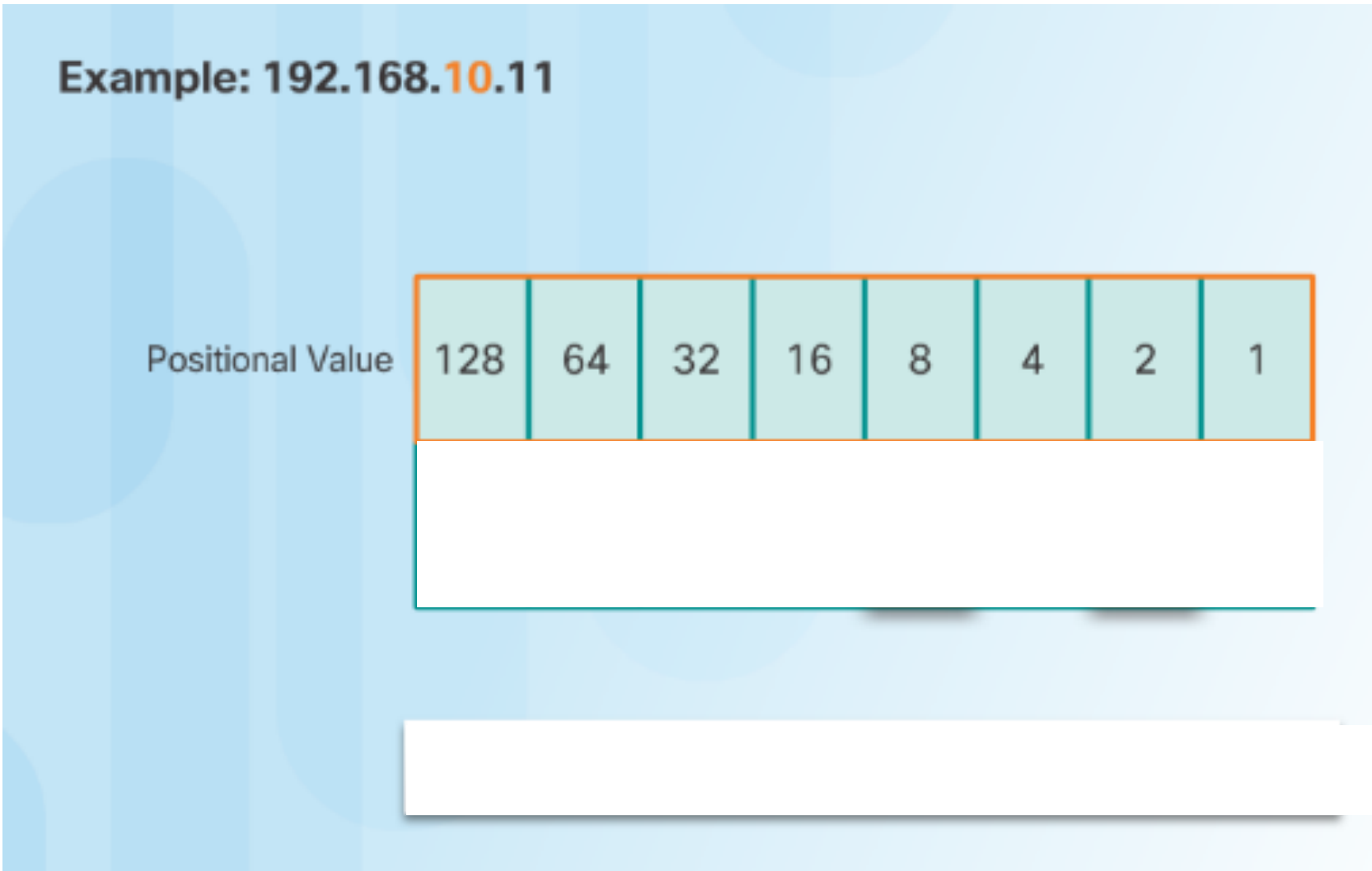
IP Address: Decimal to Binary

- Consider **192.168.10.11**
  - Convert 2nd octet



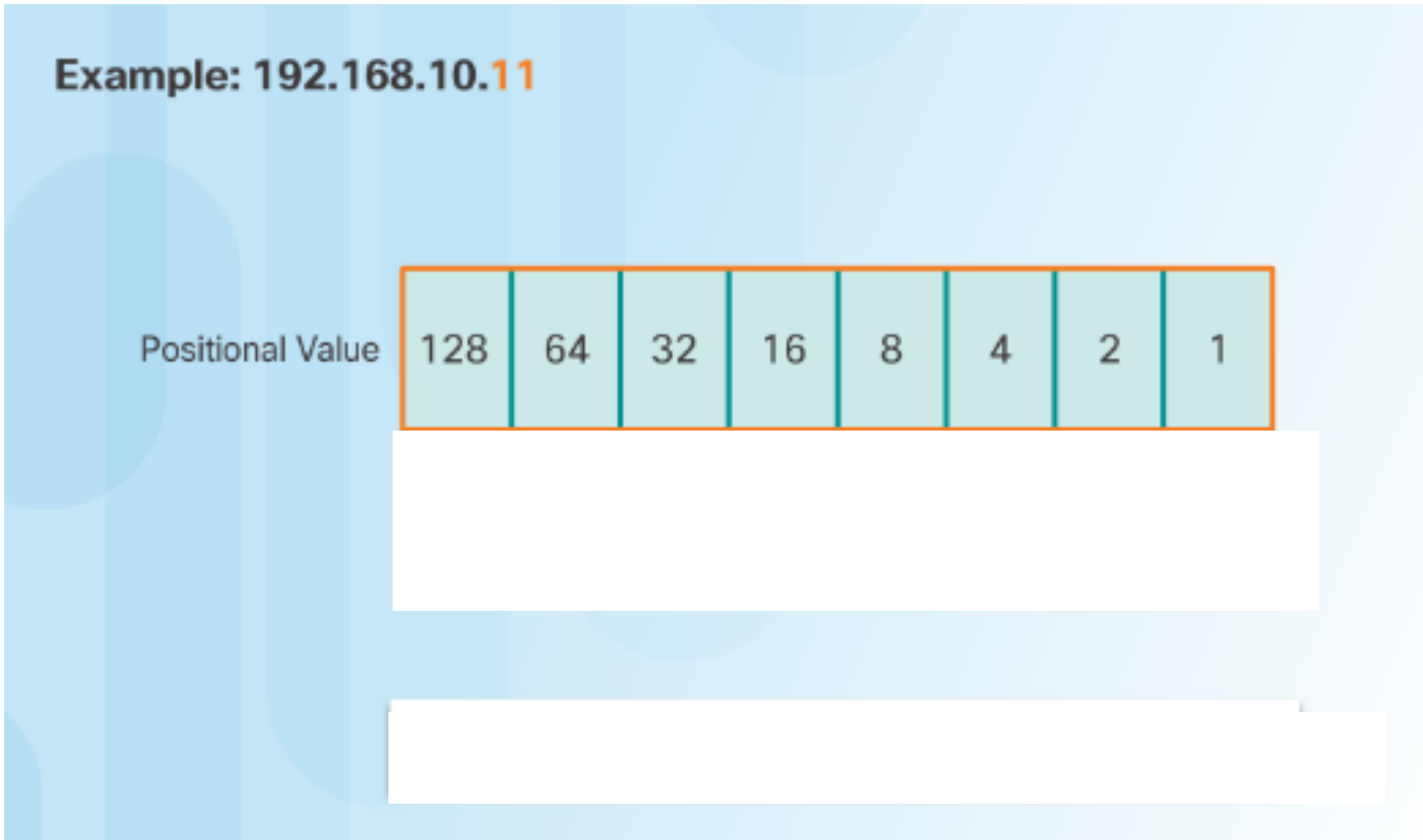
IP Address: Decimal to Binary

- Consider **192.168.10.11**
  - Convert 3rd octet



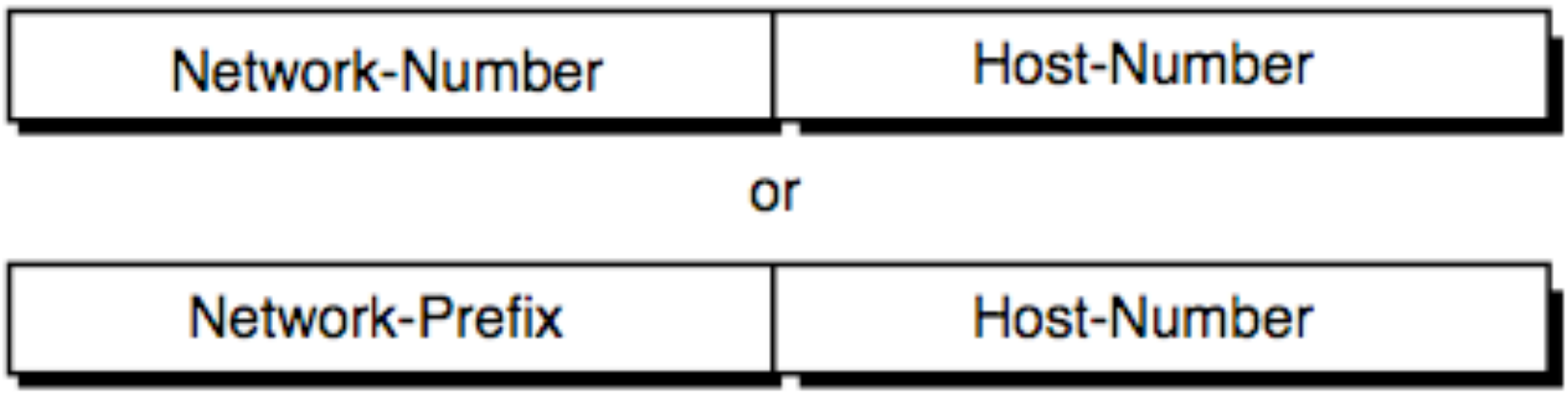
IP Address: Decimal to Binary

- Consider `192.168.10.11`
  - Convert 4th octet

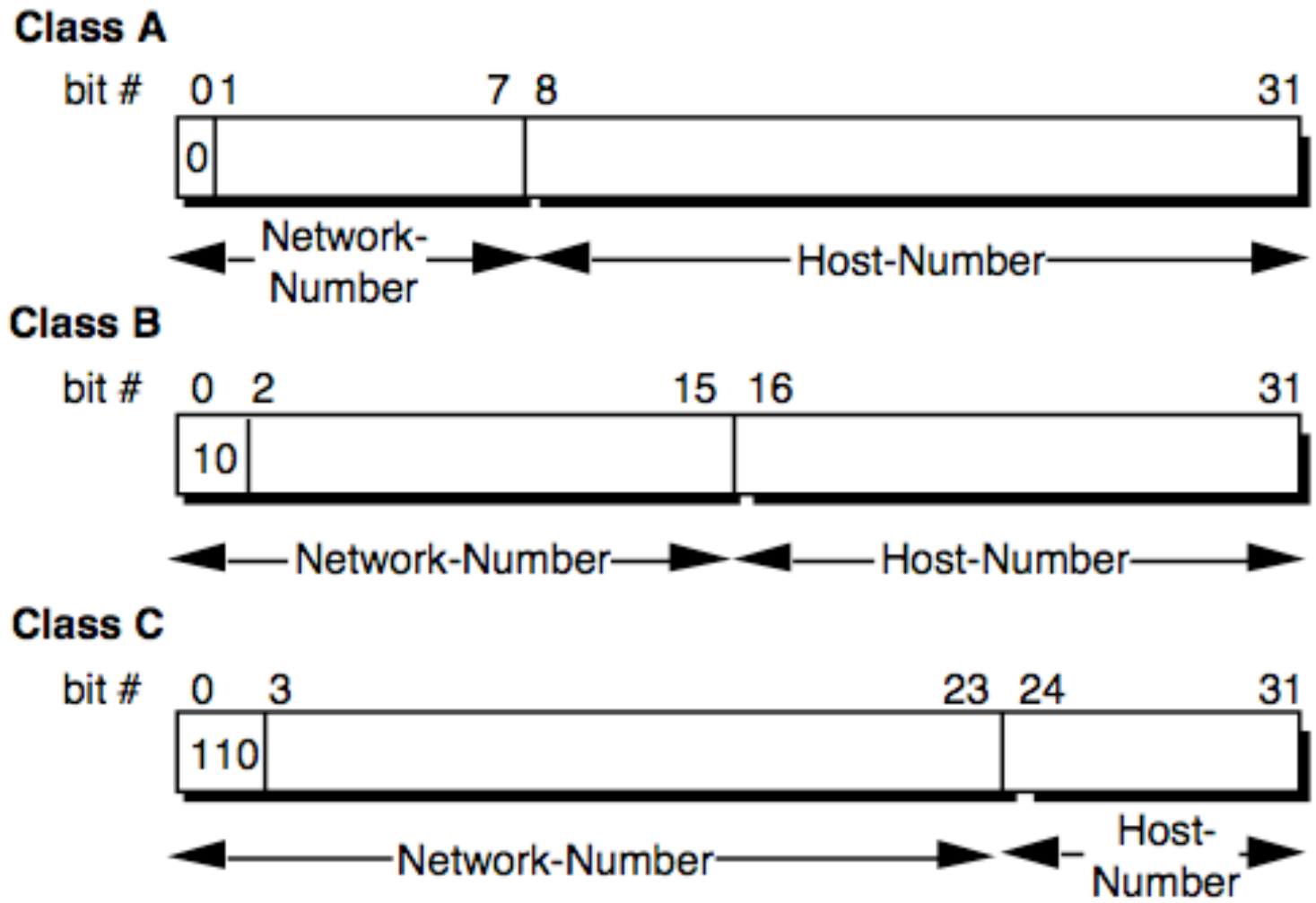


IP Address and Network

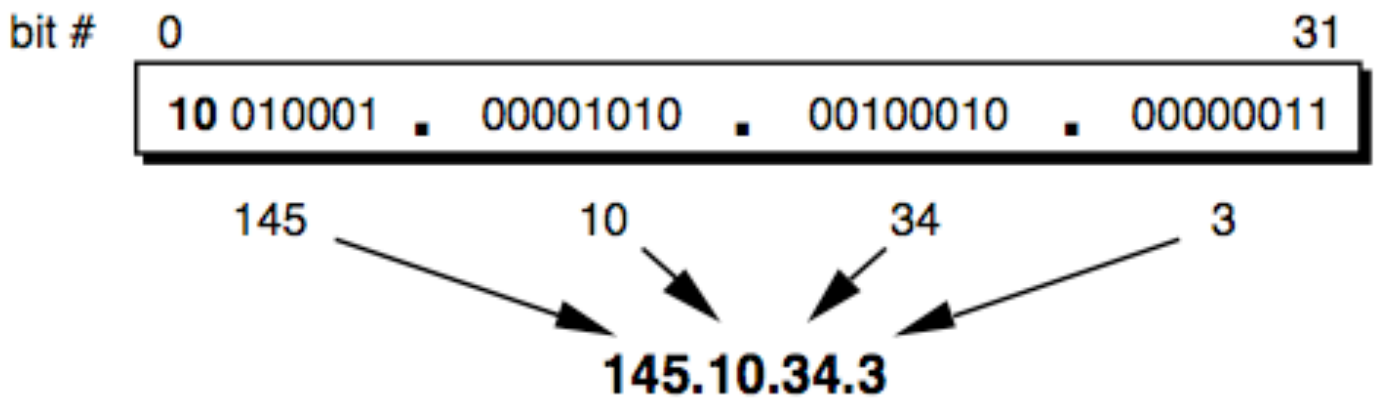
- An IPv4 address is hierarchical.
  - Composed of a Network portion and Host portion.
- All devices on the same network must have the identical network portion.
- The Subnet Mask helps devices identify the network portion and host portion.



Initial IP Addressing (Classful)



Dotted Decimal Notation



Address Class	Dotted-Decimal Notation Ranges
A (/8 prefixes)	1.xxx.xxx.xxx through 126.xxx.xxx.xxx
B (/16 prefixes)	128.0.xxx.xxx through 191.255.xxx.xxx
C (/24 prefixes)	192.0.0.xxx through 223.255.255.xxx

Case Study 01

- A: Take your laptop/desktop and connect to internet on wifi. Identify IP addresses of all interfaces (e.g. loopback and Wifi interface)
- B: Take your smartphone and connect to internet. Identify the IP address assigned to your wifi interface of the phone.
- C: Convert your phone into wifi hotspot and connect your laptop to this hotspot. Note down the IP address of your laptop.

Case Study 02

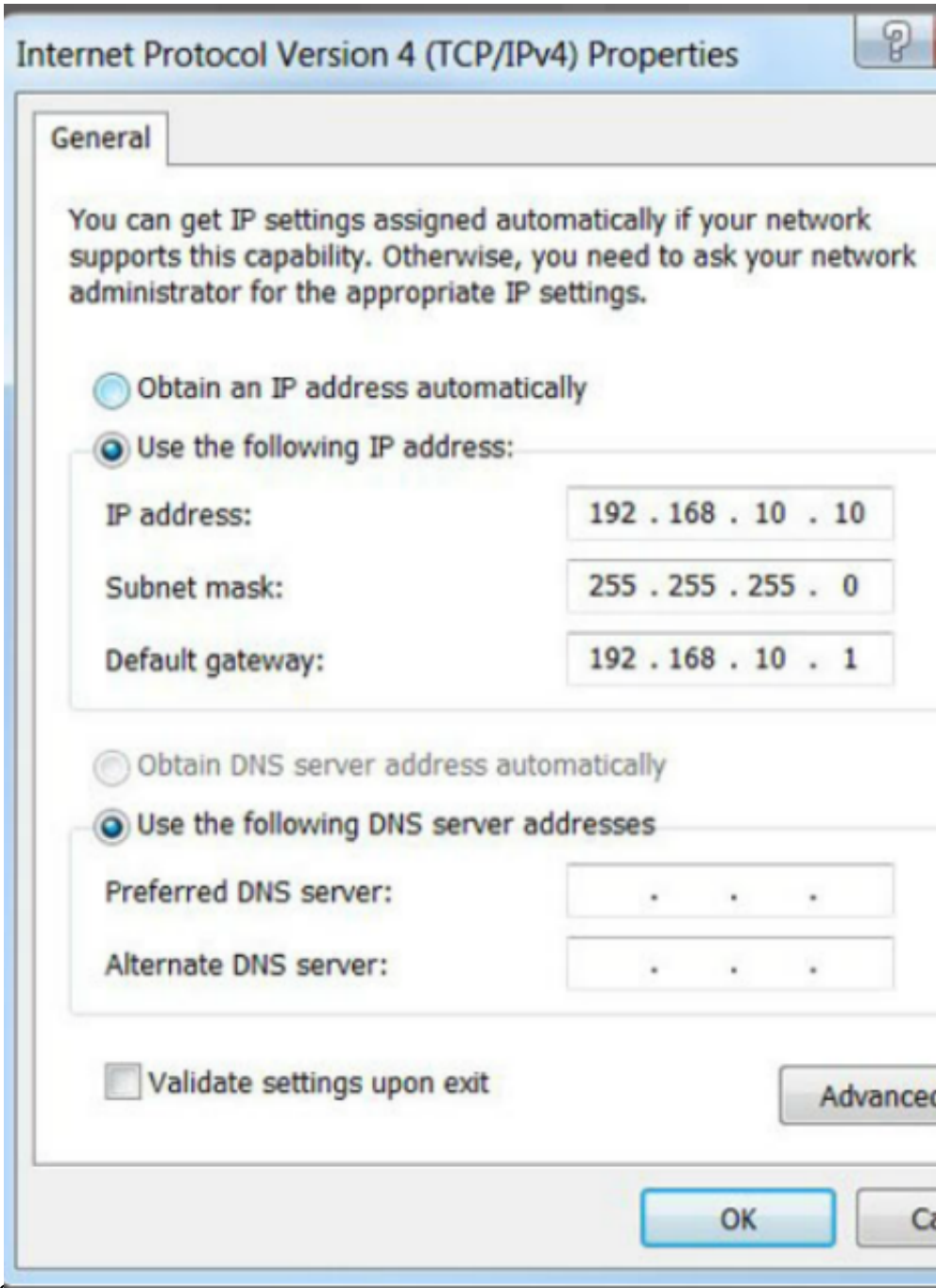
- A: List the 5 websites you use regularly, e.g.
  - google.com, facebook.com, instagram.com, twitter.com, linkedin.com
  - Find the IP addresses of these websites. E.g example to find IP address of rprustagi.com, use `ping` to find the latency and IP Address
    - (Linux/Mac): `ping -c 2` www.rprustagi.com
    - (Windows): `ping -n 2` www.rprustagi.com
- B:Use `traceroute` (Linux) / `tracert`(Window) to find all the routers in the path from your machine to these websites.

IP Subnet

- Consider your house where you stay.
- It is part of a small locality (or even a street)
- Locality is part of sub-city e.g. south Blore.
- Which is further part of Blore, and in turn
  - Karnataka state and country India.
- The house is part of each of these
- Similarly, IP address is hierarchical
  - It is part of small network, which could be part of bigger network and so on. e.g.
  - Lab network, part of dept network, part of college network etc.

The Subnet Mask

- Identifies the network to which the host belongs
  - Subnet mask - identifies the network/host portion of the IPv4 address.
  - Default gateway -IP address of the local router which connects you to internet



The Subnet Mask

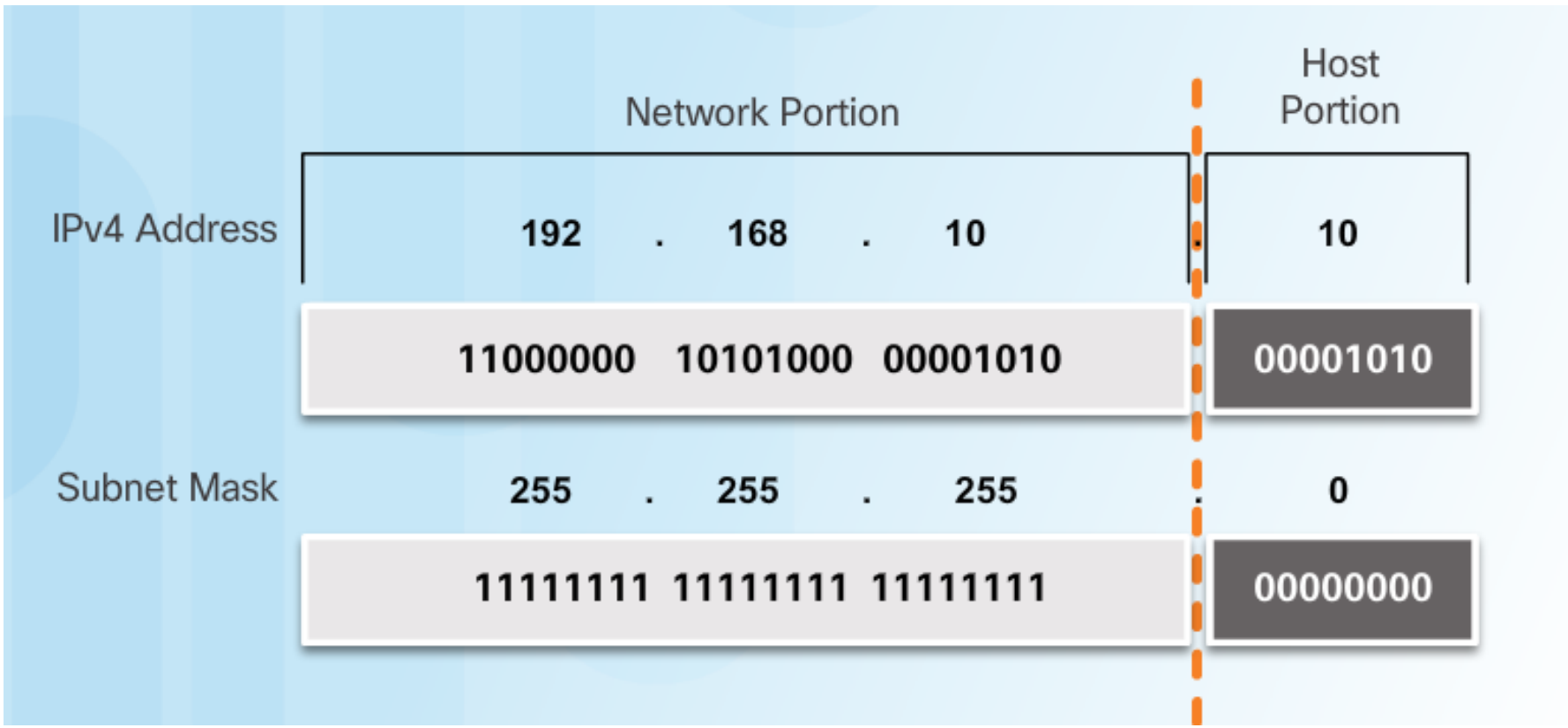
- The subnet mask is specified as /n, which implies that first n bits out of 32 (known as network portion) are set to 1 (from left to right) and remaining bits (known as host portion) are set to 0

```
/8 = 255.0.0.0
   =11111111 00000000 00000000 00000000
/20 = 255.255.240.0
   =11111111 11111111 11110000 00000000
/29 = 255.255.255.248
   =11111111 11111111 11111111 11111000
```

- The Logical AND subnet mask and IP address gives netowrk number of the host.

The Subnet Mask

- It determines the network number of address
- The network number is obtained by performing bitwise AND operation between subnet mask and IP address.



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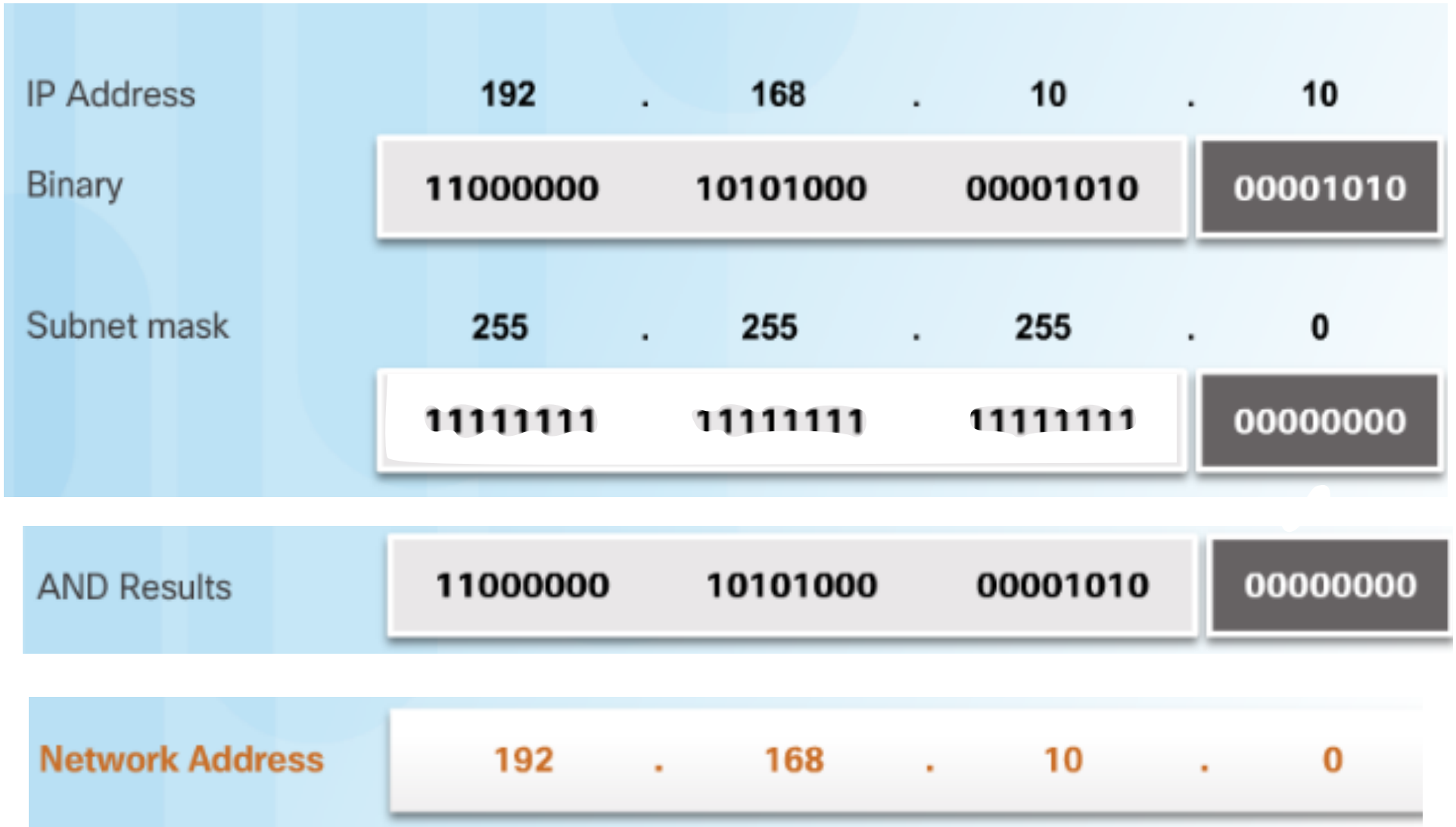
The Subnet Mask



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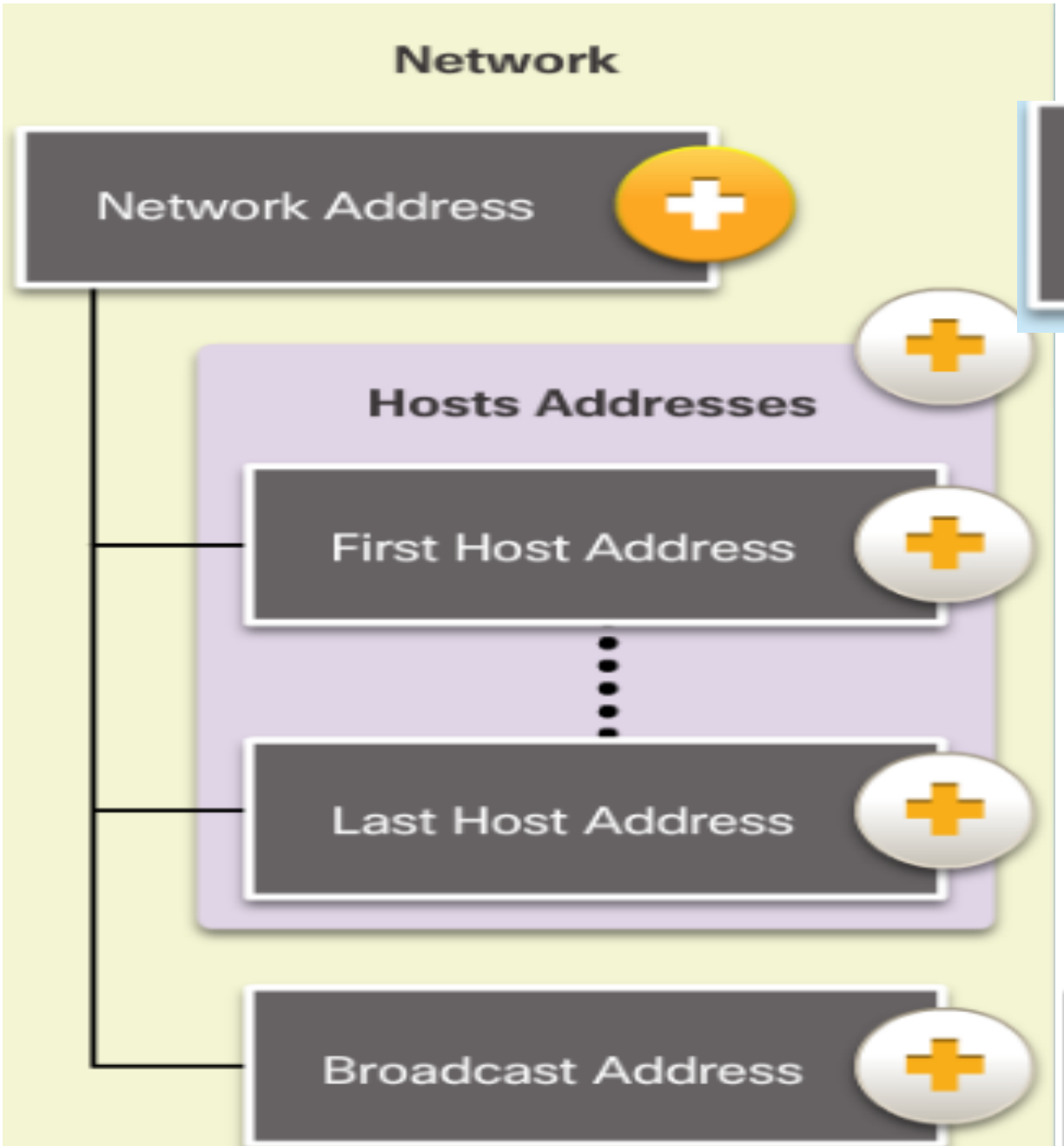
Network, Host, and Broadcast Addresses

- Types of addresses in network `192.168.10.0/24`
  - Network Address -
    - host portion is all `0`s (`.00000000`)
  - First Host address - host portion is all 0s and ends with a `1` (`.00000001`)
  - Last Host address - host portion is all 1s and ends with a `0` (`.11111110`)
  - Broadcast Address -
    - host portion is all `1`s (`.11111111`)
- Total number of assignable addresses: 2^8-2
- Total assignable addresses with mask `/n`: $2^{(32-n)}-2$
  - all `0`s is n/w number, all `1`s is broadcast

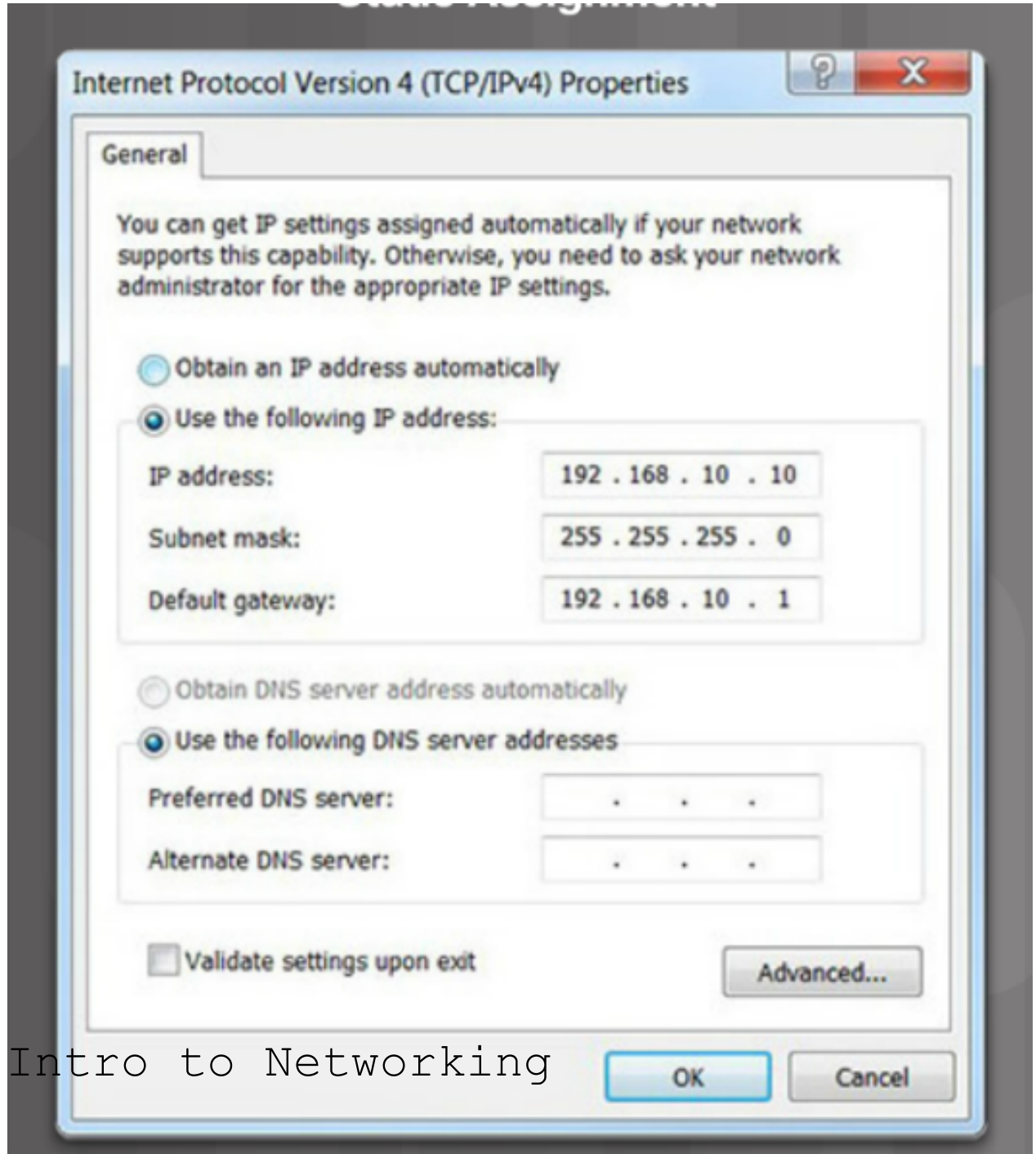
Network, Host, and Broadcast Addresses



src: CCNA R&S M1: Intro to Networking

Static IPv4 Address Assignment to a Host

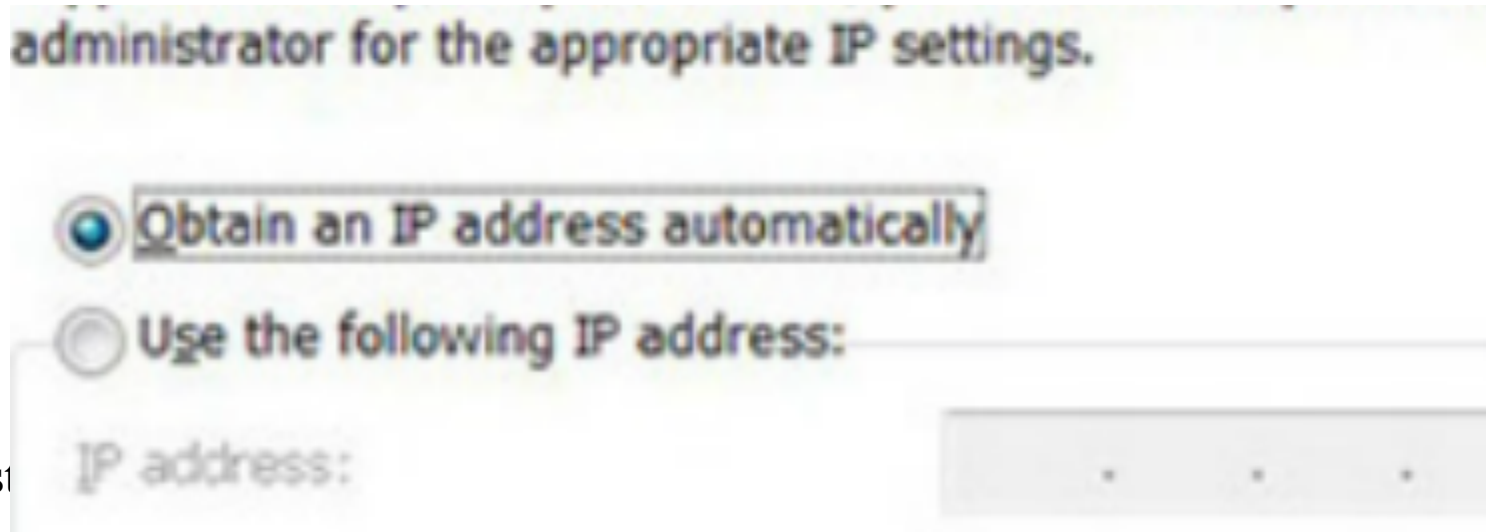
- Some devices like printers, servers and network devices require a fixed IP address.
- Hosts in a small network can also be configured with static addresses.



src: CCNA R&S M1: Intro to Networking

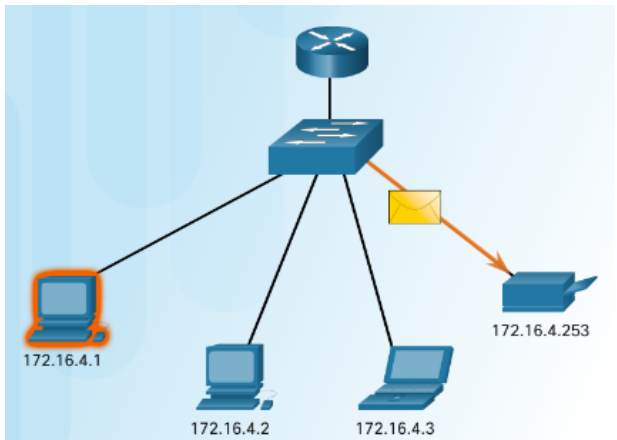
Dynamic IPv4 Address Assignment to a Host

- Most networks use Dynamic Host Configuration Protocol (DHCP) to assign IPv4 addresses dynamically.
- The DHCP server provides an IPv4 address, subnet mask, default gateway, and other configuration information.
- DHCP leases the addresses to hosts for a certain length of time.
- If the host is powered down or taken off the network, the address is returned to the pool for reuse.

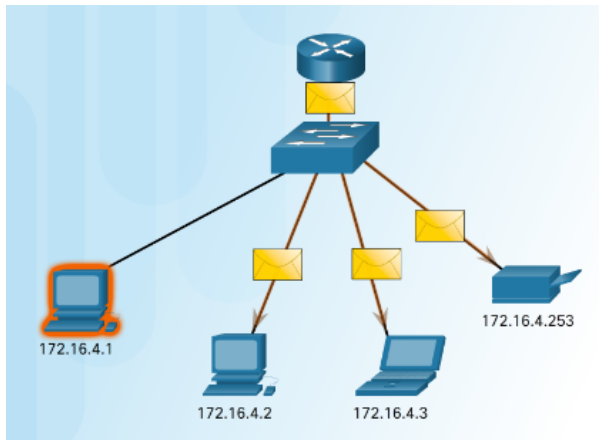


IPv4 Communication

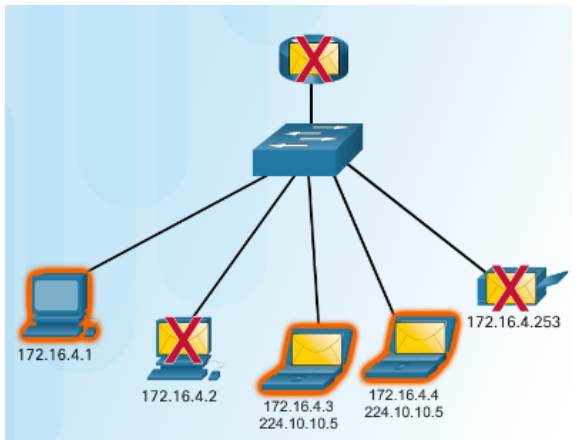
- Address categories



- Unicast – one to one communication.



- Broadcast– one to all.

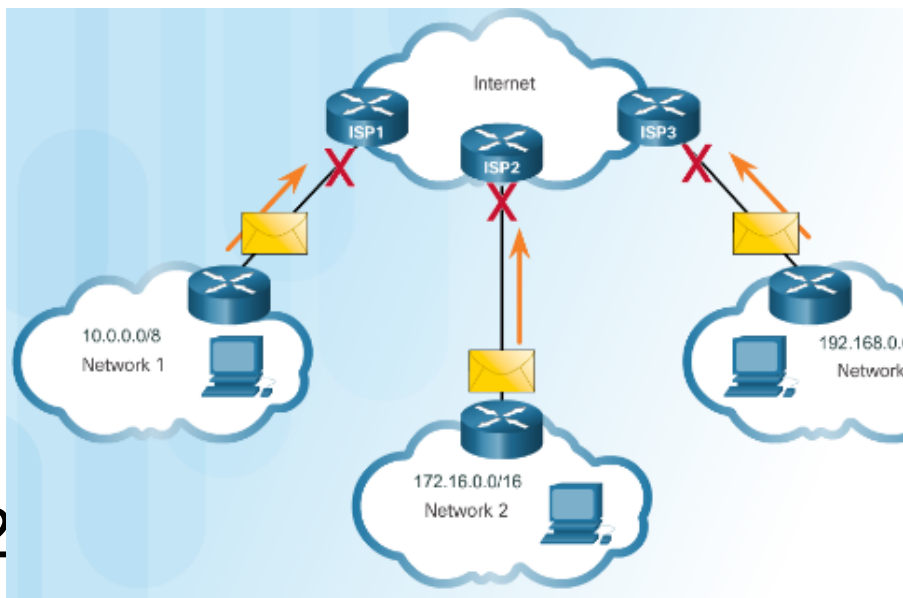


- Multicast – one to a select group.

src: CCNA R&S M1: Intro to Networking

Public and Private IPv4 Addresses

- Private Addresses
  - Not routable
  - Introduced in mid 1990s due to depletion of IPv4 addresses
  - Used only in internal networks.
  - Must be translated to a public IPv4 to be routable.
  - Defined by RFC 1918
- Private Address Blocks
  - 10.0.0.0 /8 or
    - 10.0.0.0 to 10.255.255.255
  - 172.16.0.0 /12 or
    - 172.16.0.0 to 172.31.255.255
  - 192.168.0.0 /16, or
    - 192.168.0.0 to 192.168.255.2



src: CCNA R&S M1: Intro to Networking

Special User IPv4 Addresses

- Loopback addresses (`127.0.0.0/8` or `127.0.0.1`)
  - Used on a host to test if the TCP/IP configuration is operational.
- Link-Local addresses (`169.254.0.0/16` or `169.254.0.1`)
  - Commonly known as Automatic Private IP Addressing (APIPA) addresses.
  - Used by Windows client to self configure if no DHCP server available.
- TEST-NET addresses (`192.0.2.0/24` or `192.0.2.0` to `192.0.2.255`)
  - Used for teaching and learning.

Special User IPv4 Addresses

```
C:\Users\NetAcad> ping 127.0.0.1

Pinging 127.0.0.1 with 32 bytes of data:
Reply from 127.0.0.1: bytes=32 time<1ms TTL=128
Reply from 127.0.0.1: bytes=32 time<1ms TTL=128
Reply from 127.0.0.1: bytes=32 time<1ms TTL=128
Reply from 127.0.0.1: bytes=32 time<1ms TTL=128

Ping statistics for 127.0.0.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\NetAcad> ping 127.1.1.1

Pinging 127.1.1.1 with 32 bytes of data:
Reply from 127.1.1.1: bytes=32 time<1ms TTL=128
Reply from 127.1.1.1: bytes=32 time<1ms TTL=128
Reply from 127.1.1.1: bytes=32 time<1ms TTL=128
Reply from 127.1.1.1: bytes=32 time<1ms TTL=128
```

src: CCNA R&S M1: Intro to Networking

Case Study 03

- A machine has been assigned the IP address `192.168.37.241/27`. Find the following for the network to which this host belongs.
  - Subnet mask (using DDN notation)
  - Network number
  - First assignable IP address
  - Last assignable IP address
  - Broadcast address

Case Study 04

- Connect your laptop/desktop to internet.
  - Mostly this would be assigned using DHCP
- Note down the IP address and subnet mask.
  - e.g. `192.168.1.11/24`
- Change the configuration to static IP and assign the same IP address/mask as before.
  - `ping google.com` (verifies it works).
- Change the IP address by adding `16` to last octet (e.g. `192.168.1.27`) and netmask by adding `4` i.e `/28`
  - You will be unable to access internet
- Restore the mask to its earlie value `/24`, and internet works.
- Analyze the role of subnet masks

Case Study 05

- Take two machines (any of laptops/desktops etc) and call them A and B. If these are windows, disable the firewall.
- Assign the following IP Address (Static config)
  - `A:192.168.1.11/26, B:192.168.1.66/26`
- Ping A and B from each other, check if it fails
- Change both subnet masks to `/25` and ping again.
  - Verify ping is successful.
  - Analyze why it failed earlier
- Experiment with differnet IP Address and netmask
  - Analyze your results (both success & failure)

Case Study 06

- Issue the following command on your terminal.
  - `ping 127.1` (don't type two middle octets).
  - Does ping work successfully? Analyze the results.
- Note: This is called shorthand notation. If the address contains less than `4` octets, then host interprets it by adding required number of `0`s just before last the octet. Examples
  - `127.1` ⇨ `127.0.0.1`
  - `3` ⇨ `0.0.0.3`
  - `127.1.3` ⇨`127.1.0.3`

Summary

- IP Address
- 32 bits (4 octets)
- Decimal dotted notation (DDN)
  IP Subnets
  –netmask (in DDN form) and in `/n` form
- Terms with IP subnet
  –Network number
  –Broadcast address
  –First assignable and last assignable address
- IP Address types:
  –Unicast, multicast and broadcast address