Networking 101

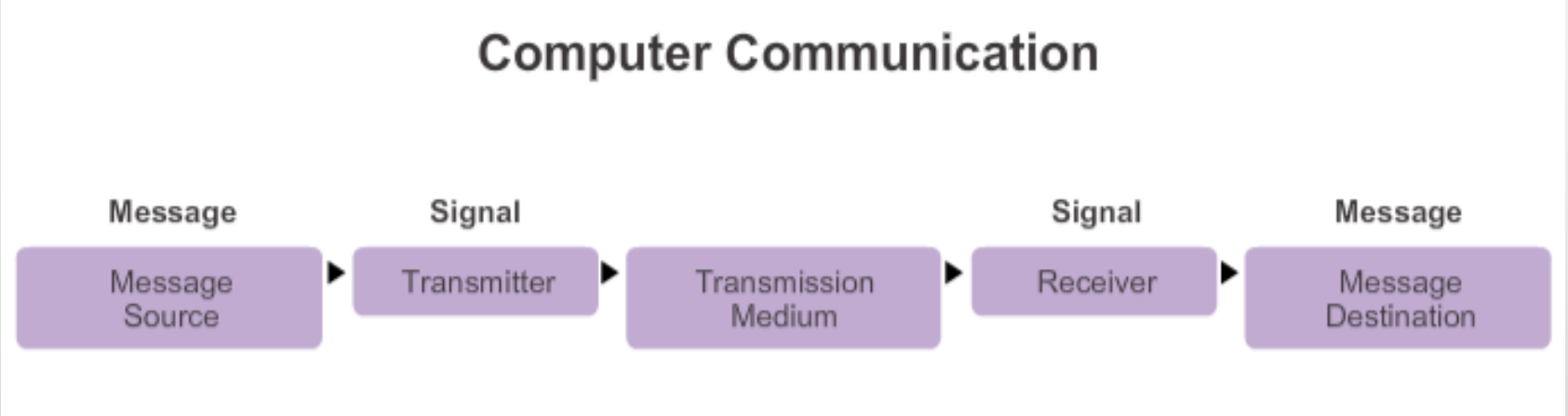
By: Stefan Jagroop

```
Description . . . . . : Intel(R) Dual Band Wireless-AC 3160
Physical Address. . . . . : F4-06-69-70-74-0C
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
IPv6 Address. . . . . : 2620:cc:8000:484:4d53:2c1f:64e0:c0c6(Preferred)
Temporary IPv6 Address. . . . . : 2620:cc:8000:484:c00d:530a:1ff1:dd38(Preferred)
Link-local IPv6 Address . . . . . : fe80::4d53:2c1f:64e0:c0c6%17(Preferred)
IPv4 Address. . . . . : 10.84.110.225(Preferred)
Subnet Mask . . . . . : 255.255.248.0
Lease Obtained. . . . . : Thursday, February 9, 2017 9:38:51 AM
Lease Expires . . . . . : Thursday, February 9, 2017 1:30:06 PM
Default Gateway . . . . . : fe80::208:e3ff:feff:fd94%17
                            10.84.111.254
DHCP Server . . . . . : 128.205.1.203
DHCPv6 IAID . . . . . : 552863337
DHCPv6 Client DUID. . . . . : 00-01-00-01-1C-BE-E5-28-F0-76-1C-A9-BF-59
DNS Servers . . . . . : 128.205.1.200
```

The Internet

- The Internet is governed by a series of protocols that form the rules for how communications should happen
- The Internet is a network of networks.
  - There is no centralized point.
  - There are no boundaries.
- Information that is sent from one location on the internet to another is broken down into smaller, more manageable pieces called “packets”

So Then What Is Networking?



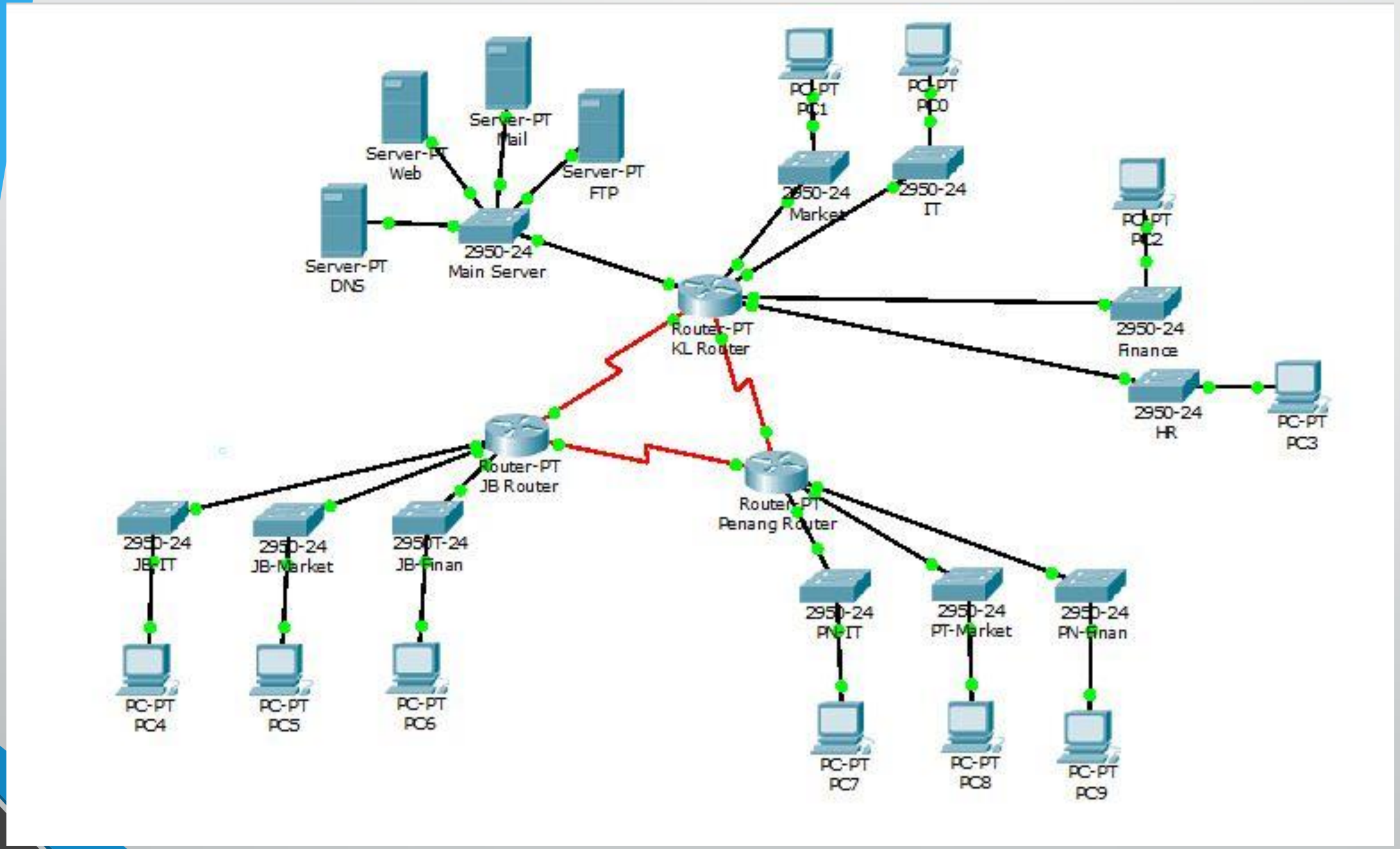
- Networking is a process of connecting two or more computers for sharing information.
  - A way for devices to communicate with one another

Local Area Networks (LAN)

- LANs are the most basic type of network.
- These small networks are the building blocks of the Internet. Can be thought of as a “local neighborhood” of computers or devices
- All devices on the same LAN communicate directly with one another across a “switch” (collision domain).
- Network and LAN segmentation is a fundamental security concept.
- LANs can be organized by :
  - Geographic area Device type
  - Administrative boundary

Wide Area Networks (WAN)

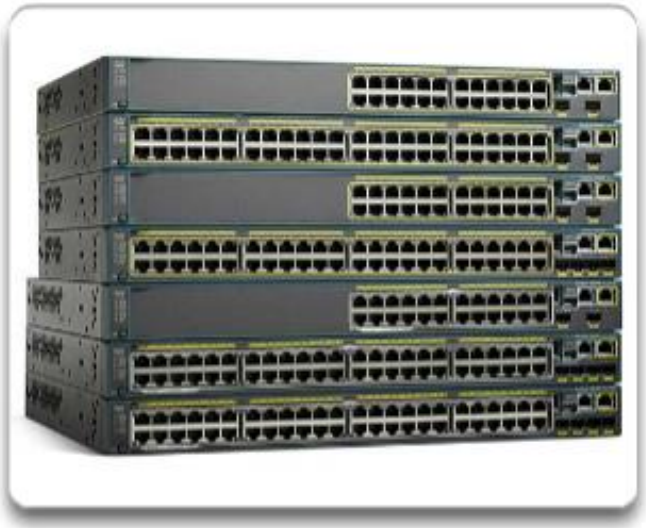
- LANs are connected together to form WANs
  - LANs get connected to WANs through routers.
  - The “Internet” is one big WAN.
  - We can connect LANs to WANs through both wireless and Wired Connections.
  - WANs can span much larger geographic distances than LANs


Server-PT
Mail
Server-PT
Web
Server-PT
FTP
Server-PT
DNS
2950-24
Main Server
PC-PT
PC1
PC-PT
PC0
2950-24
Market
2950-24
IT
PC-PT
PC2
2950-24
Finance
2950-24
HR
PC-PT
PC3
Router-PT
KL Router
Router-PT
JB Router
Router-PT
Penang Router
2950-24
JB-IT
2950-24
JB-Market
2950T-24
JB-Finan
PC-PT
PC4
PC-PT
PC5
PC-PT
PC6
2950-24
PN-IT
2950-24
PT-Market
2950-24
PN-Finan
PC-PT
PC7
PC-PT
PC8
PC-PT
PC9

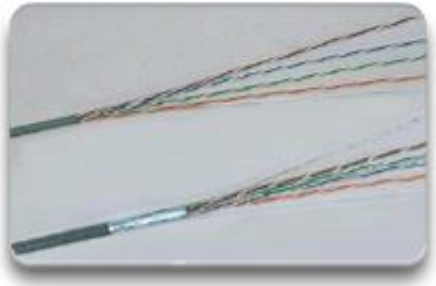
Demilitarized Zone (DMZ)

- A physical or logical sub-network that separates an internal local area network (LAN)
- External-facing servers, resources and services are located in the DMZ so they are accessible from the Internet but the rest of the internal LAN remains unreachable.
- This provides an additional layer of security to the LAN as it restricts the ability of hackers to directly access internal servers and data via the Internet.

Interfaces and Ports



Copper



Fiber Optics

Wireless

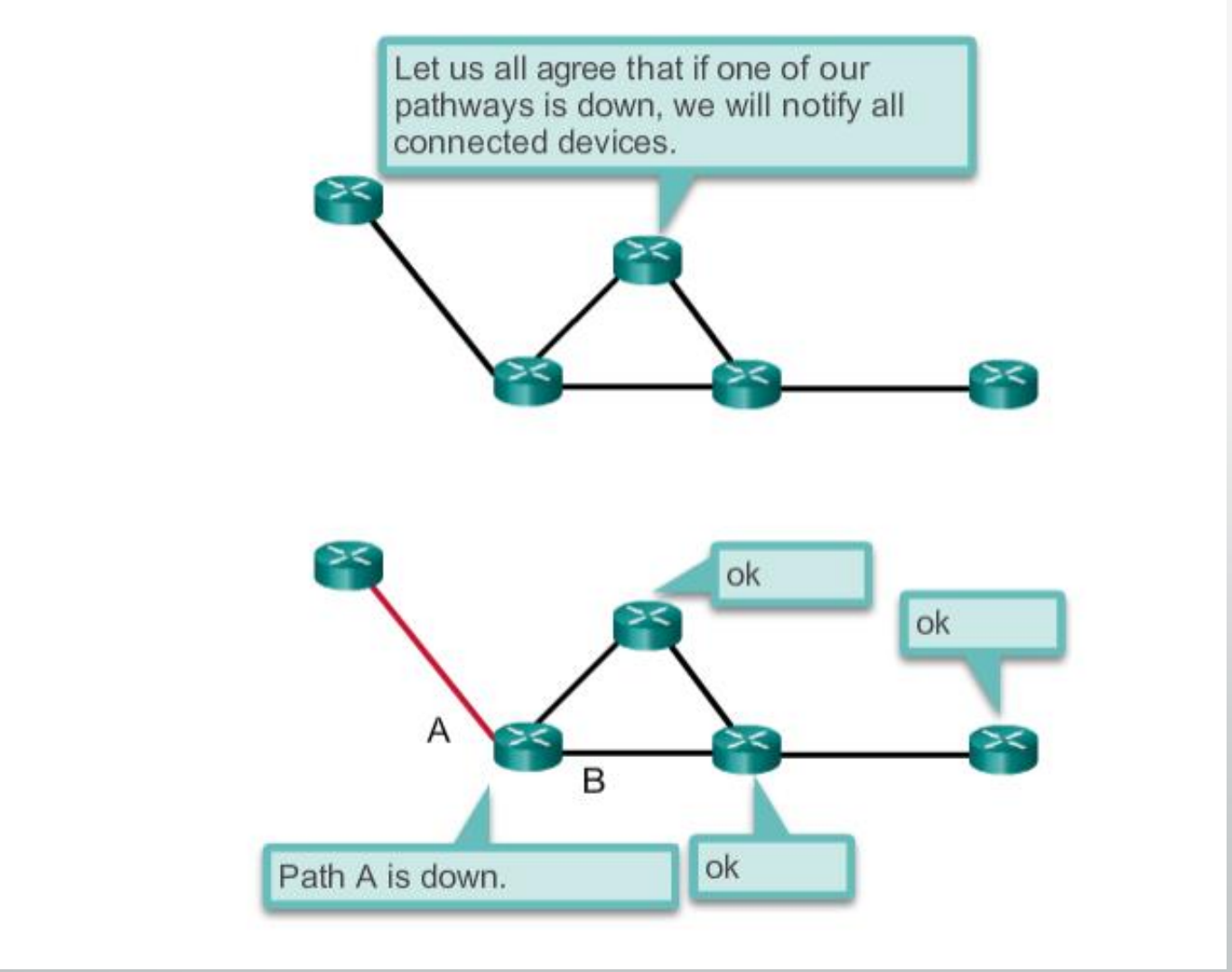
Ports (logical, not physical)

- Associated with a protocol type, used for connections along with an IP Address
  - HTTPS : PORT 443
  - HTTP: 80, 8080
  - FTP: 21
  - SSH: 22
  - TELNET:23
  - DNS-:53

Network Protocols

- Routers use these to communicate with one another
  - Send messages to one another
  - Establish communication
  - Establish Routing tables
- Examples:
  - BGP- Border Gateway Protocol
  - RIP- Routing Information Protocol
  - EIGRP- Enhanced Interior Gateway Routing Protocol
  - OSPF- Open Shortest Path First

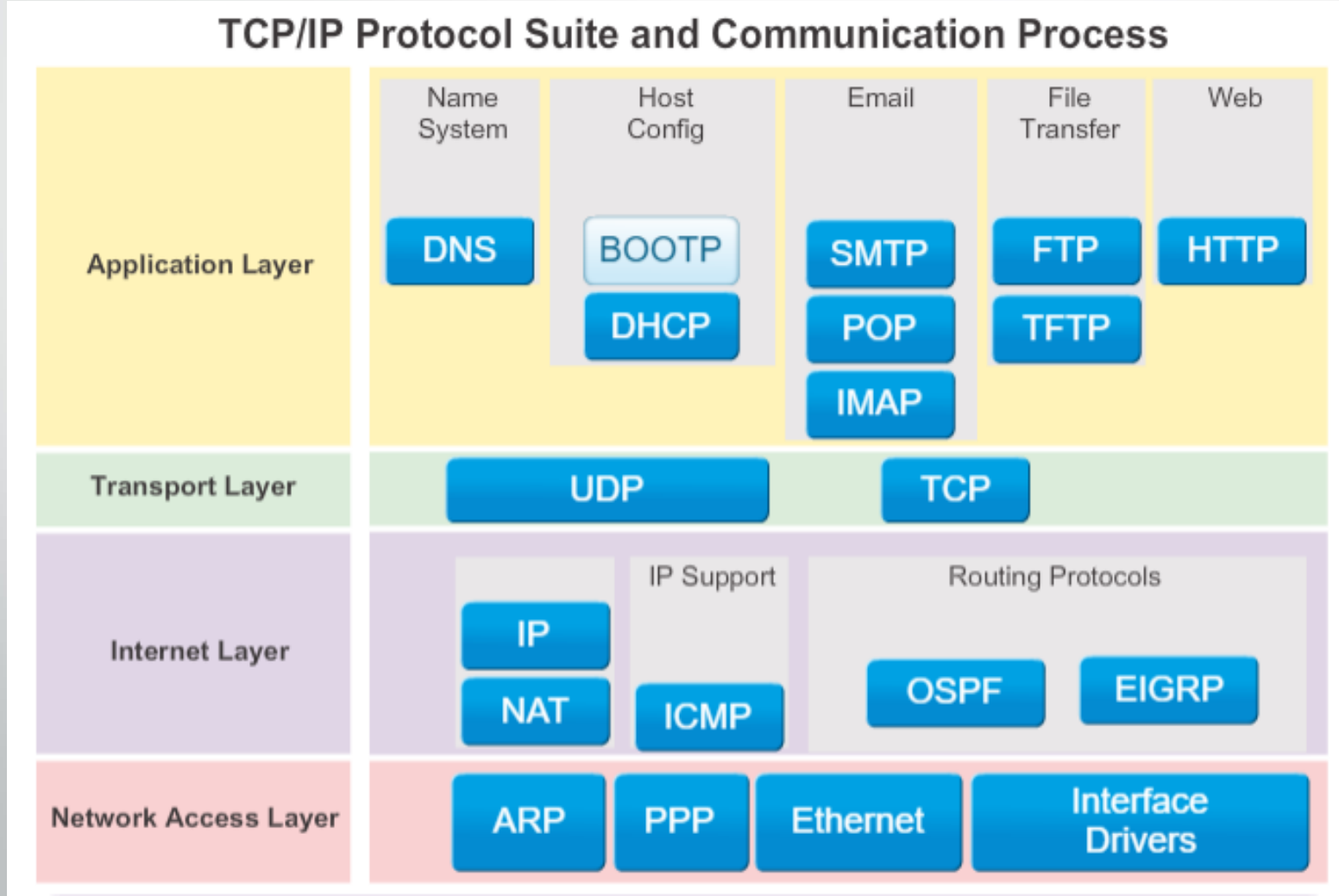
Network Protocol Example



Routing Table Example


```
D       10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05,
        Serial0/0/0
D       10.1.2.0/24 [90/2170112] via 209.165.200.226, 00:00:05,
        Serial0/0/0
     192.168.10.0/24 is variably subnetted, 2 subnets, 3 masks
C       192.168.10.0/24 is directly connected, GigabitEthernet0/0
L       192.168.10.1/32 is directly connected, GigabitEthernet0/0
     192.168.11.0/24 is variably subnetted, 2 subnets, 3 masks
C       192.168.11.0/24 is directly connected, GigabitEthernet0/1
L       192.168.11.1/32 is directly connected, GigabitEthernet0/1
     209.165.200.0/24 is variably subnetted, 2 subnets, 3 masks
C       209.165.200.224/30 is directly connected, Serial0/0/0
L       209.165.200.225/32 is directly connected, Serial0/0/0
```

TCP/IP


TCP/IP Protocol Suite and Communication Process
Application Layer
Name System
Host Config
Email
File Transfer
Web
DNS
BOOTP
DHCP
SMTP
POP
IMAP
FTP
TFTP
HTTP
Transport Layer
UDP
TCP
Internet Layer
IP Support
Routing Protocols
IP
NAT
ICMP
OSPF
EIGRP
Network Access Layer
ARP
PPP
Ethernet
Interface Drivers

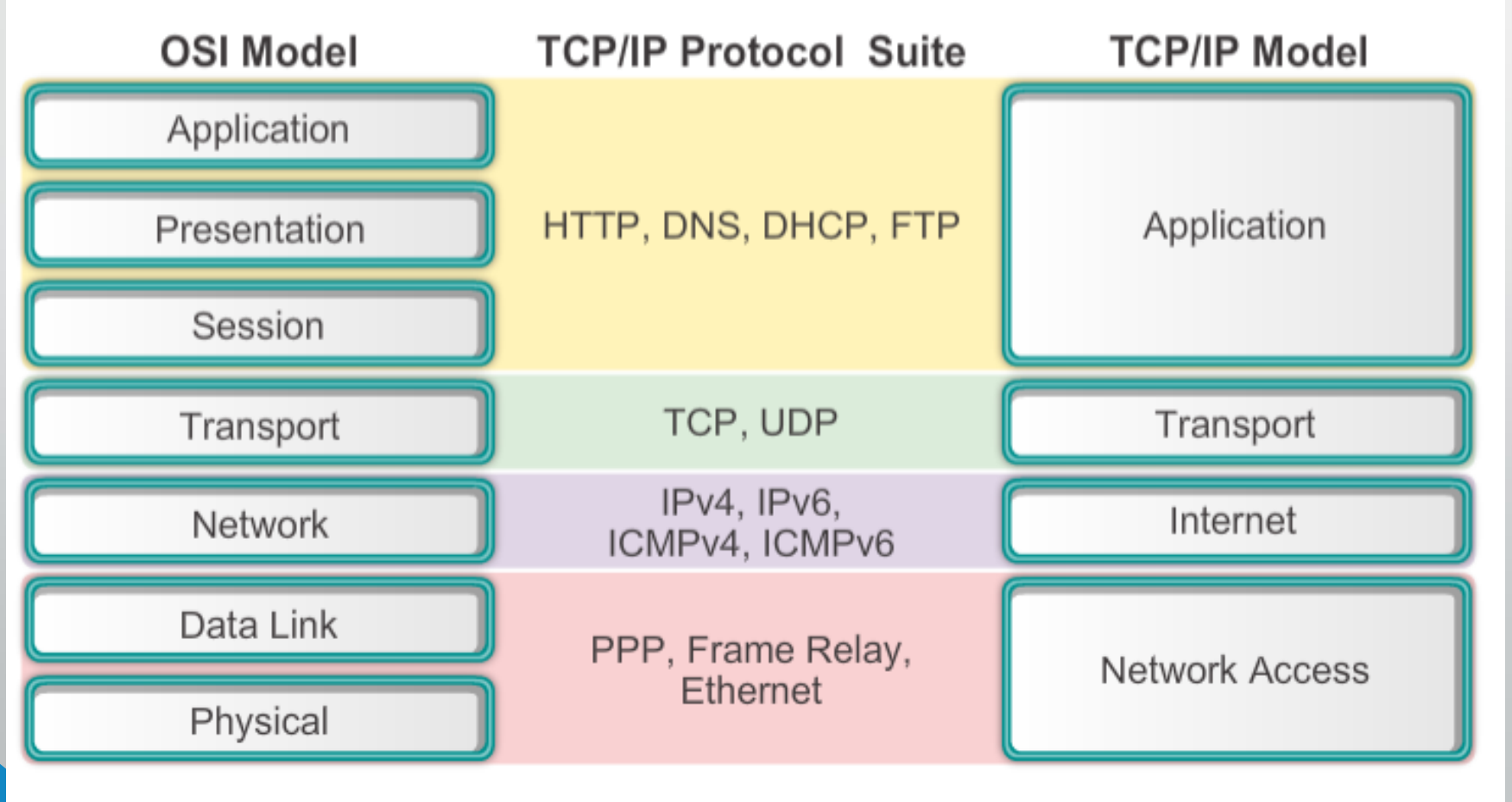
Transport Layer

- TCP
  - Connection oriented
  - Three way handshake (SYN, SYN-ACK, ACK)
  - Reliable
- UDP
  - Not reliable
  - Used for faster transmission, such as streaming

Common Devices

- **Router -** Forwards data packets to and receives data packets from the Internet
- **Switch -** Connects end devices using network cables
- **Wireless access point -** Consists of a radio transmitter capable of connecting end devices wirelessly
- **Firewall appliance -** Secures outgoing traffic and restricts incoming traffic

TCP/IP vs. OSI Model



OSI vs TCP/IP cont

- OSI Model
  - it is used for data network design, operation specifications, and troubleshooting.
- TCP/IP
  - Less advanced model than OSI
  - Internet Model
  - Both Models are the primary models used when discussing network functionality.

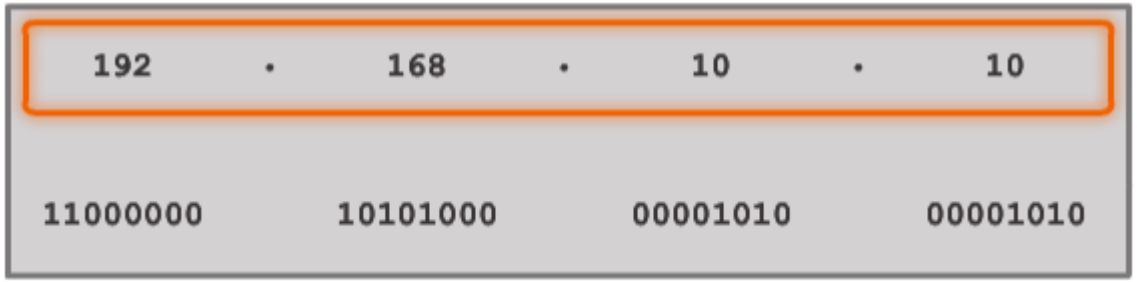
Typically Seen Types of Addresses

- **IP address** - Together with subnet mask, uniquely identifies end device on the inter-network
- **Subnet mask** - Determines which part of a larger network is used by an IP address
- **Default Gateway** – Way out of the network, Think of a gate out of your yard
  - Routers have a GOLR- Gateway of Last resort

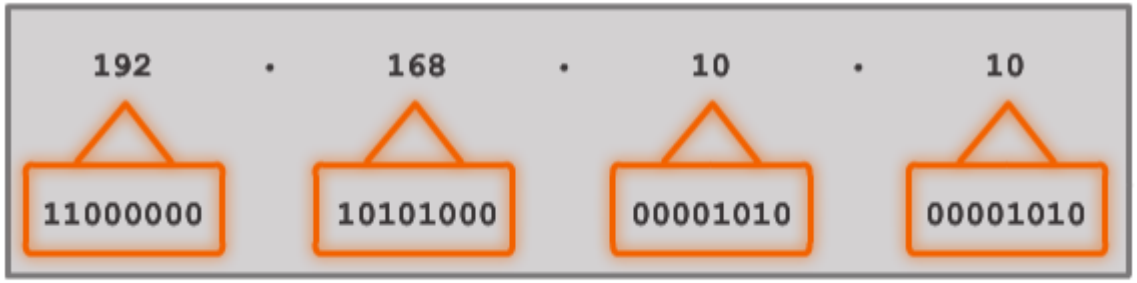
IP Packets

- An IP packet contains two IP addresses:
  - **Source IP address** - The IP address of the sending device.
  - **Destination IP address** - The IP address of the receiving device. The destination IP address is used by routers to forward a packet to its destination.
  - **Source MAC Address**
  - **Destination MAC addresses**- used by switches to forward packets
- Frame Check Sequence(FCS)
  - Checks to see if there are errors in packets, if there is. It's dropped for a new one.

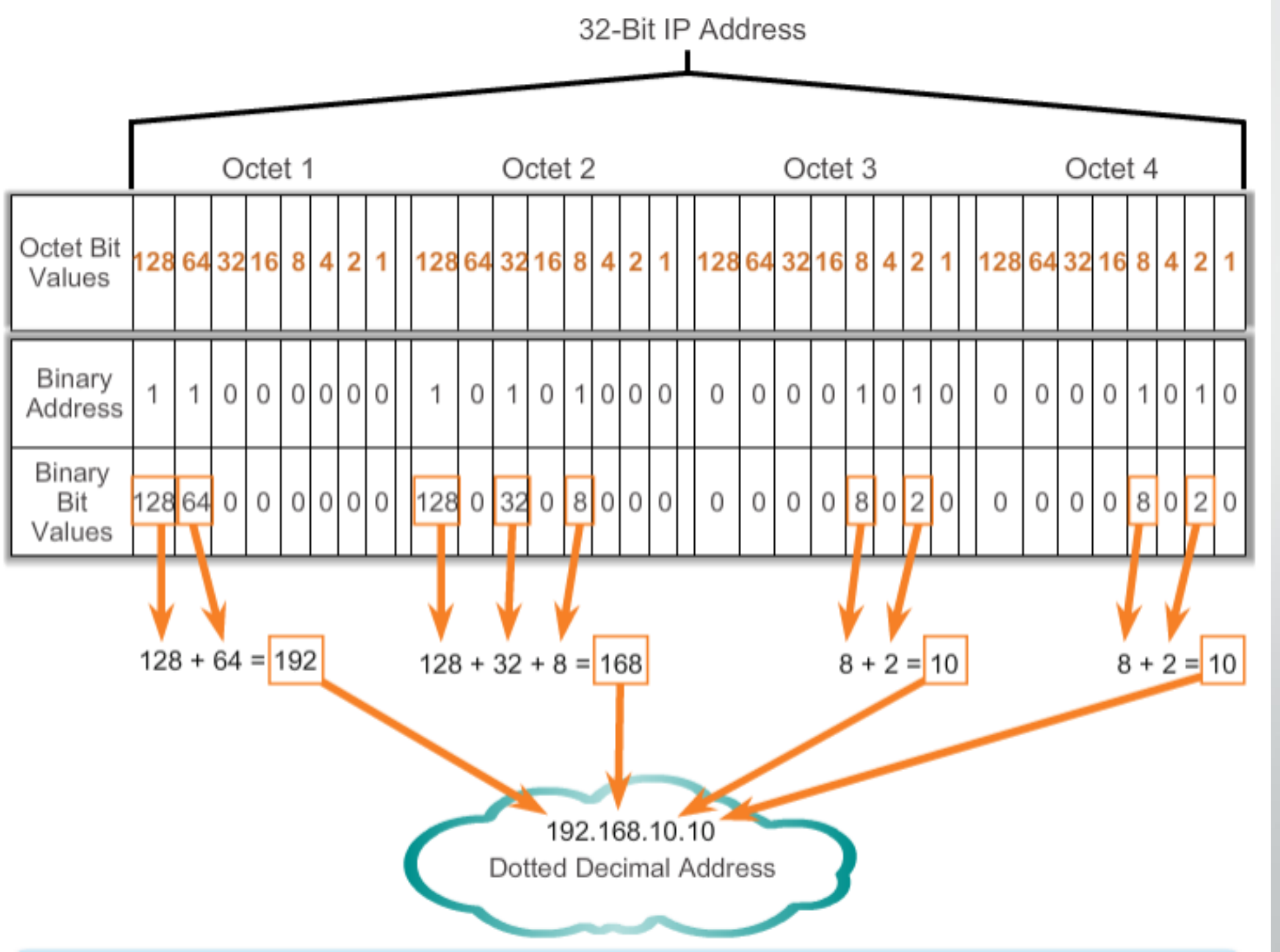
IP Addresses



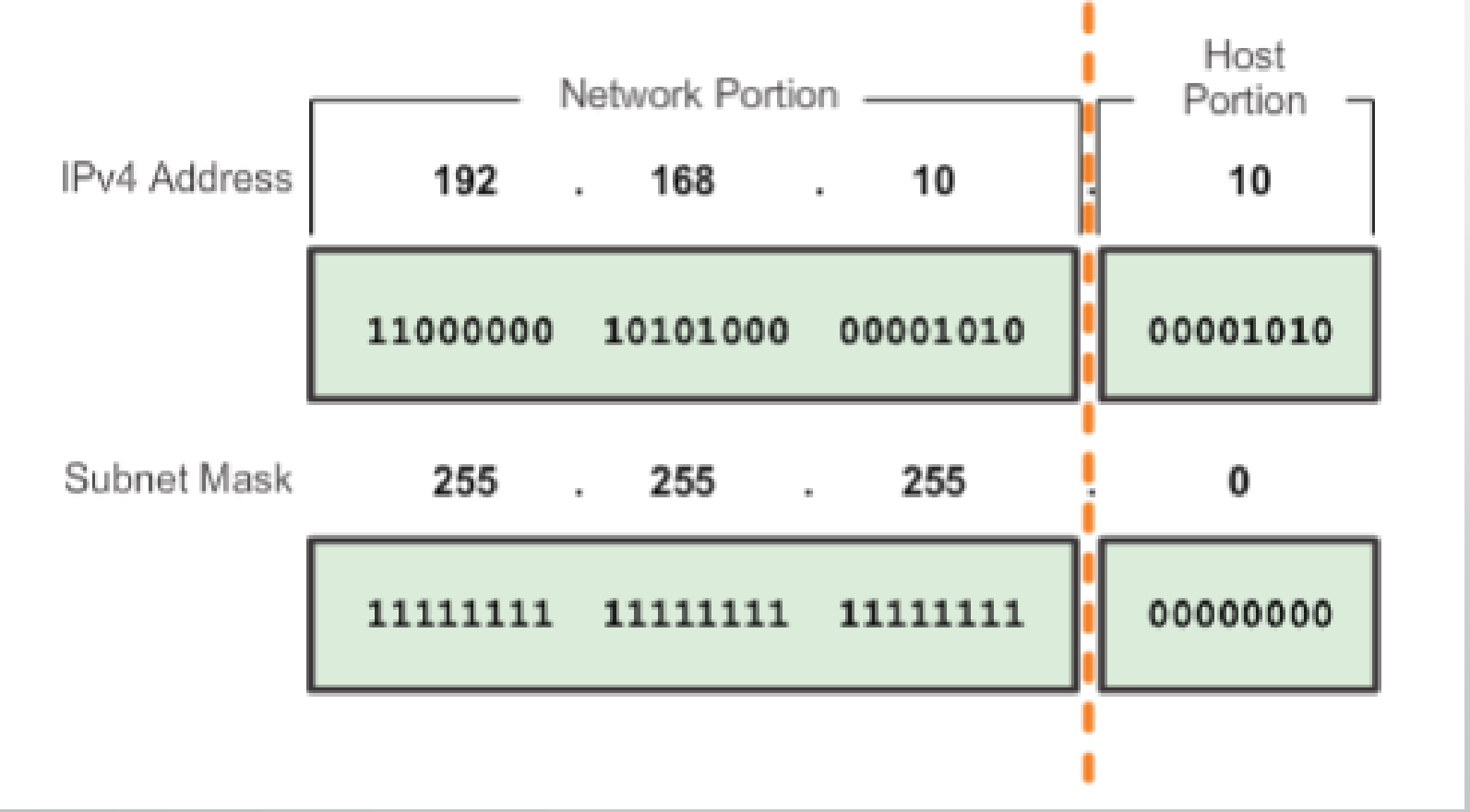
192.168.10.10 is an IP address that is assigned to a computer.



This address is made up of four different octets.


32-Bit IP Address
Octet 1
Octet 2
Octet 3
Octet 4
Octet Bit Values
128 64 32 16 8 4 2 1 128 64 32 16 8 4 2 1 128 64 32 16 8 4 2 1 128 64 32 16 8 4 2 1
Binary Address
1 1 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0
Binary Bit Values
128 64 0 0 0 0 0 0 128 0 32 0 8 0 0 0 0 0 0 0 8 0 2 0 0 0 0 0 8 0 2 0
128 + 64 = 192
128 + 32 + 8 = 168
8 + 2 = 10
8 + 2 = 10
192.168.10.10
Dotted Decimal Address

Subnet Masks

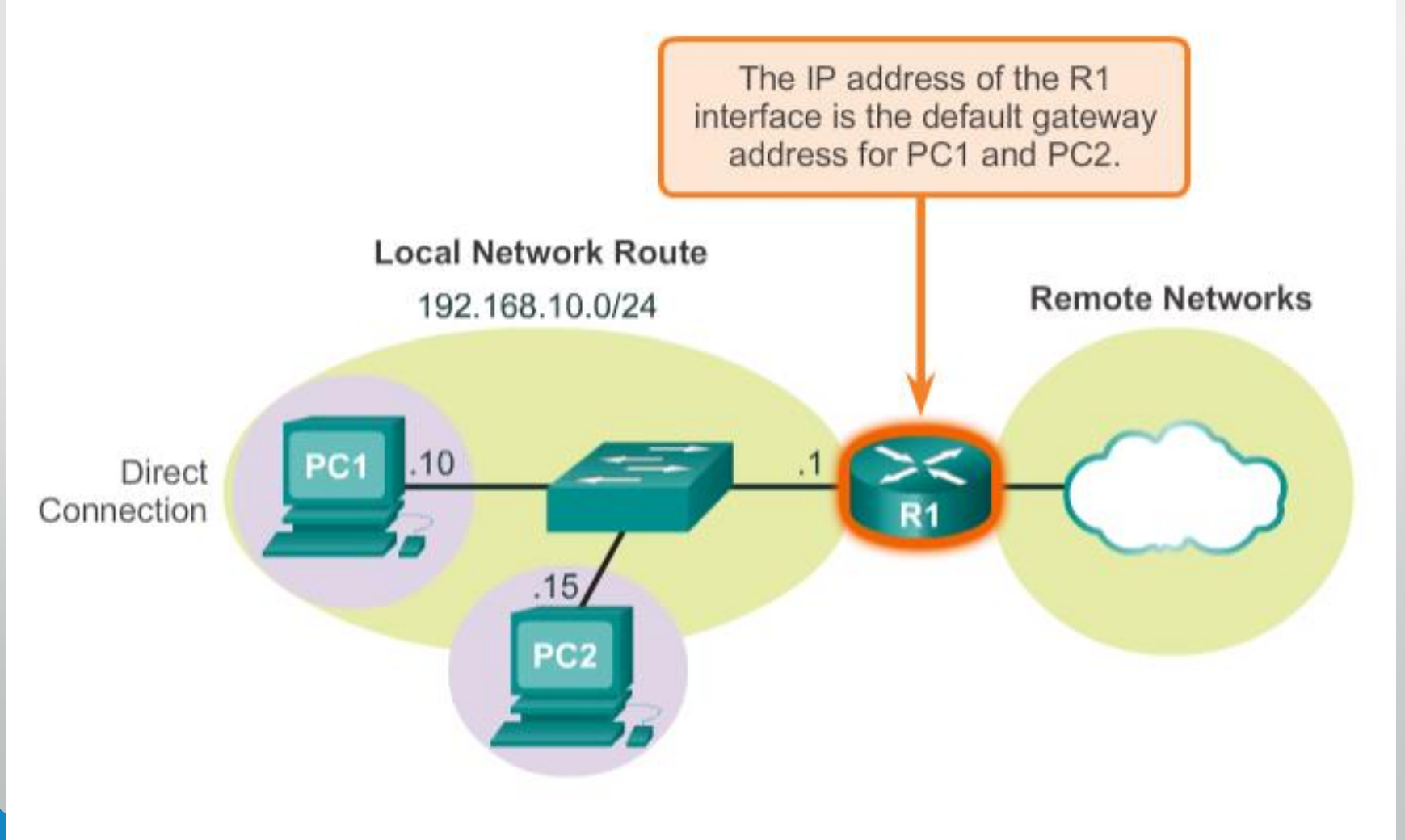


	Dotted Decimal	Significant bits shown in binary
Network Address	**10.1.1.0/24**	**10.1.1.00000000**
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.254	10.1.1.11111110
Broadcast Address	10.1.1.255	10.1.1.11111111
Number of hosts: 2^8 – 2 = 254 hosts		

Network Address	**10.1.1.0/25**	**10.1.1.00000000**
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.126	10.1.1.01111110
Broadcast Address	10.1.1.127	10.1.1.01111111
Number of hosts: 2^7 – 2 = 126 hosts		

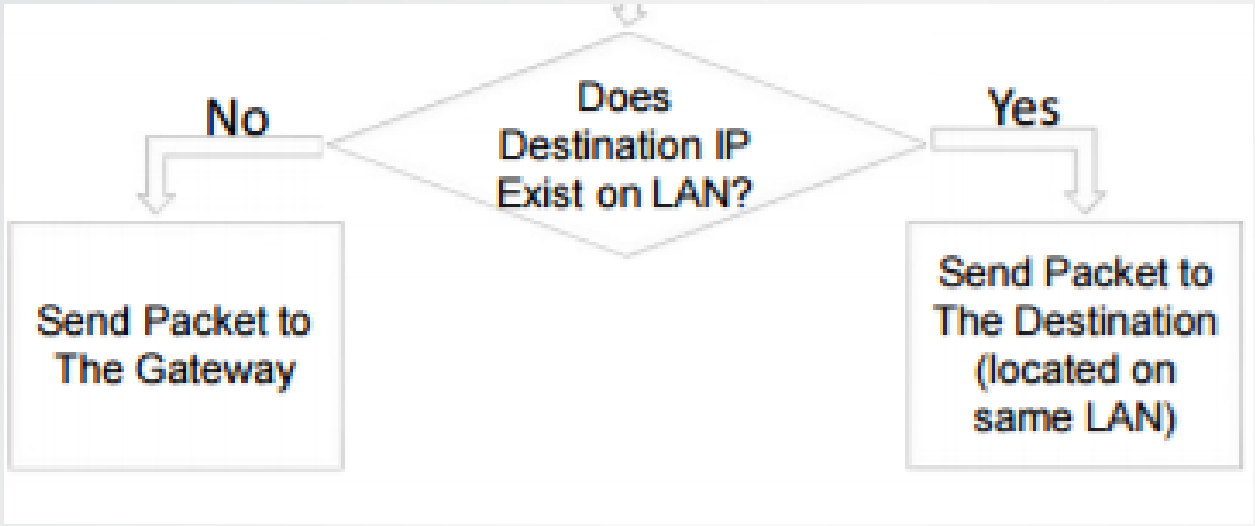
Network Address	**10.1.1.0/26**	**10.1.1.00000000**
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.62	10.1.1.00111110
Broadcast Address	10.1.1.63	10.1.1.00111111
Number of hosts: 2^6 – 2 = 62 hosts		

Default Gateway



Flow of Data and Packets

- The IP layer determines if the client your sending a packet to resided on you LAN by looking at:
  - Your client's IP address
  - Your client's subnet mask
  - Your destination's IP address



- Switches handle LAN traffic (Layer 2 devices)
  - LAN traffic is handled through MAC Addresses
  - Address Resolution Protocol (ARP) request
    - What IP goes to what MAC Address?
    - Is it in the Arp table?
    - If not forward to router or default gateway
- Router looks at routing table and forwards to the correct router or connected network
    - Remember that Routers are connected to each other via Routing Tables

MAC Addresses

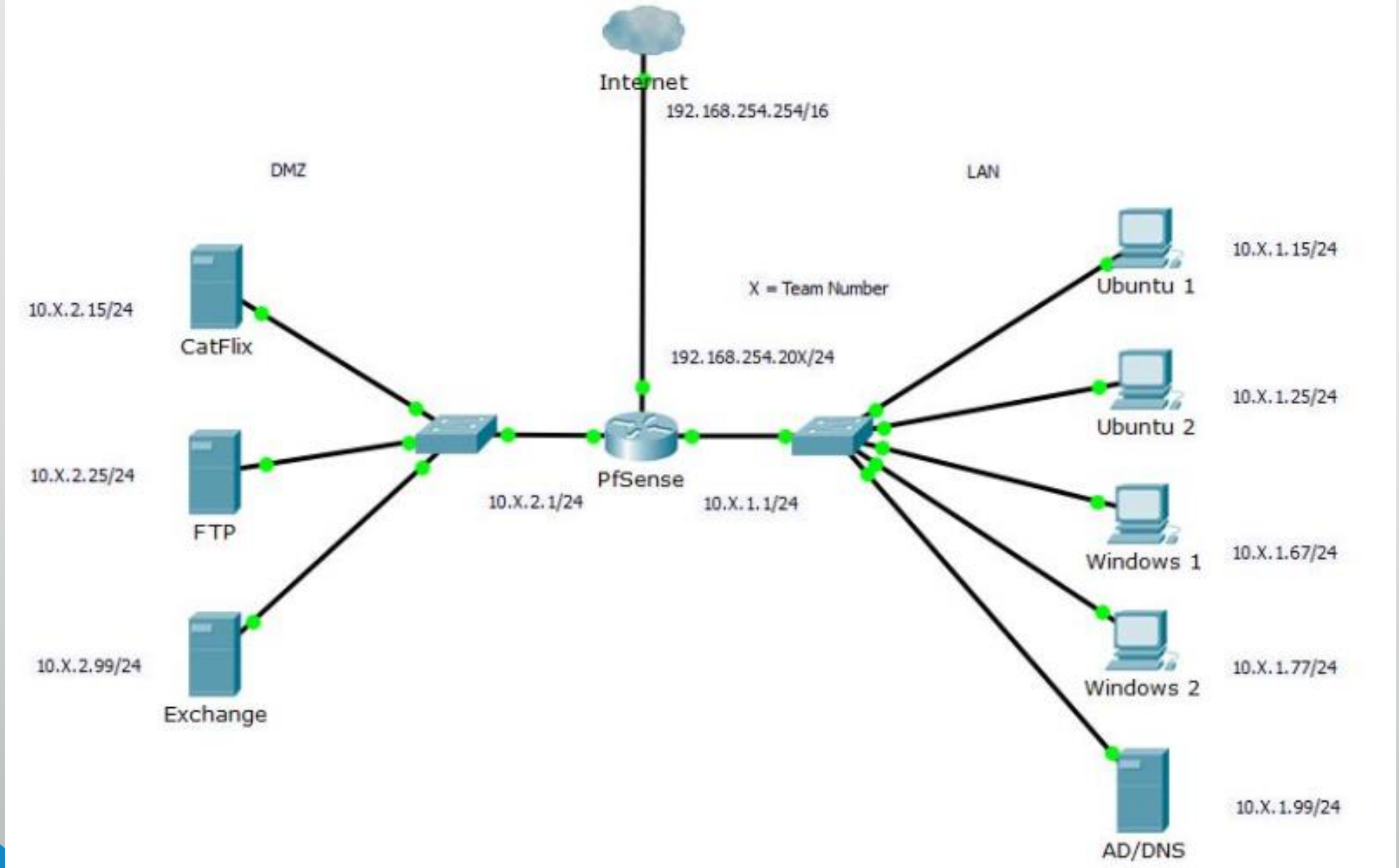
- Hardcoded addresses into a computer's NIC
  - Network Interface Controller/Card
- 48- bit Address
  - Made up of a Organsationally Unique Idenitifier (OUI) and NIC Addresses
  - Layer 2 address used by switches

Ipconfig /all Output

```
Description . . . . . . . . . . . : Intel(R) Dual Band Wireless-AC 3160
Physical Address. . . . . . . . . : F4-06-69-70-74-0C
DHCP Enabled. . . . . . . . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
IPv6 Address. . . . . . . . . . . : 2620:cc:8000:484:4d53:2c1f:64e0:c0c6(Preferred)
Temporary IPv6 Address. . . . . . : 2620:cc:8000:484:c00d:530a:1ff1:dd38(Preferred)
Link-local IPv6 Address . . . . . : fe80::4d53:2c1f:64e0:c0c6%17(Preferred)
IPv4 Address. . . . . . . . . . . : 10.84.110.225(Preferred)
Subnet Mask . . . . . . . . . . . : 255.255.248.0
Lease Obtained. . . . . . . . . . : Thursday, February 9, 2017 9:38:51 AM
Lease Expires . . . . . . . . . . : Thursday, February 9, 2017 1:30:06 PM
Default Gateway . . . . . . . . . : fe80::208:e3ff:feff:fd94%17
                                    10.84.111.254
DHCP Server . . . . . . . . . . . : 128.205.1.203
DHCPv6 IAID . . . . . . . . . . . : 552863337
DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-1C-BE-E5-28-F0-76-1C-A9-BF-59
DNS Servers . . . . . . . . . . . : 128.205.1.200
```

DHCP vs Static Addressing

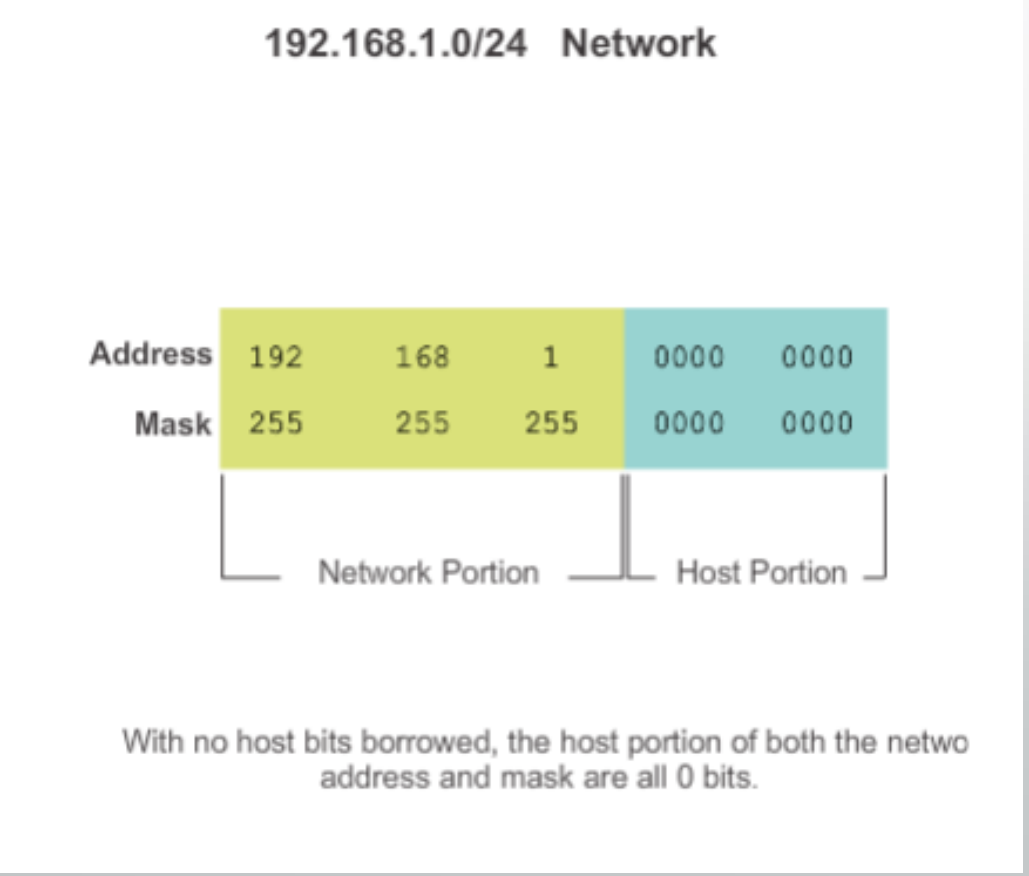
- Static addressing means manually assigning each address manually,
  - IP Addresses won't change
  - Good for devices like printers and IP phones
- DHCP is generally the preferred method of assigning IPv4 addresses to hosts on large networks because it reduces the burden on network support staff and virtually eliminates entry errors.
  - Dynamically assigns addresses throughout the network
  - Usually needs a DHCP server and DHCP Client

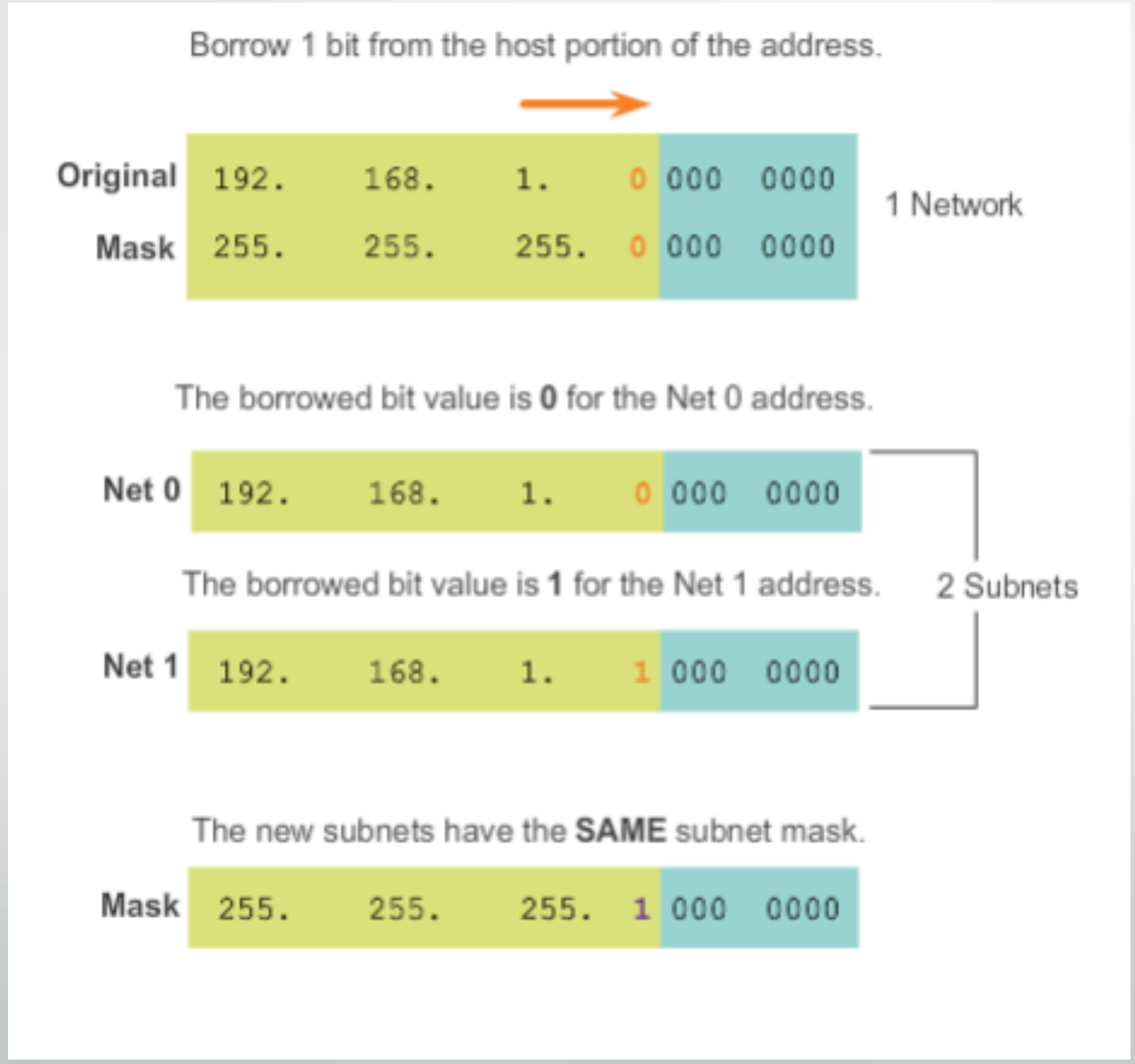

Internet
192.168.254.254/16
DMZ
LAN
X = Team Number
10.X.2.15/24
CatFlix
10.X.2.25/24
FTP
10.X.2.99/24
Exchange
192.168.254.20X/24
PfSense
10.X.2.1/24
10.X.1.1/24
Ubuntu 1
10.X.1.15/24
Ubuntu 2
10.X.1.25/24
Windows 1
10.X.1.67/24
Windows 2
10.X.1.77/24
AD/DNS
10.X.1.99/24

Domain Name System (DNS)

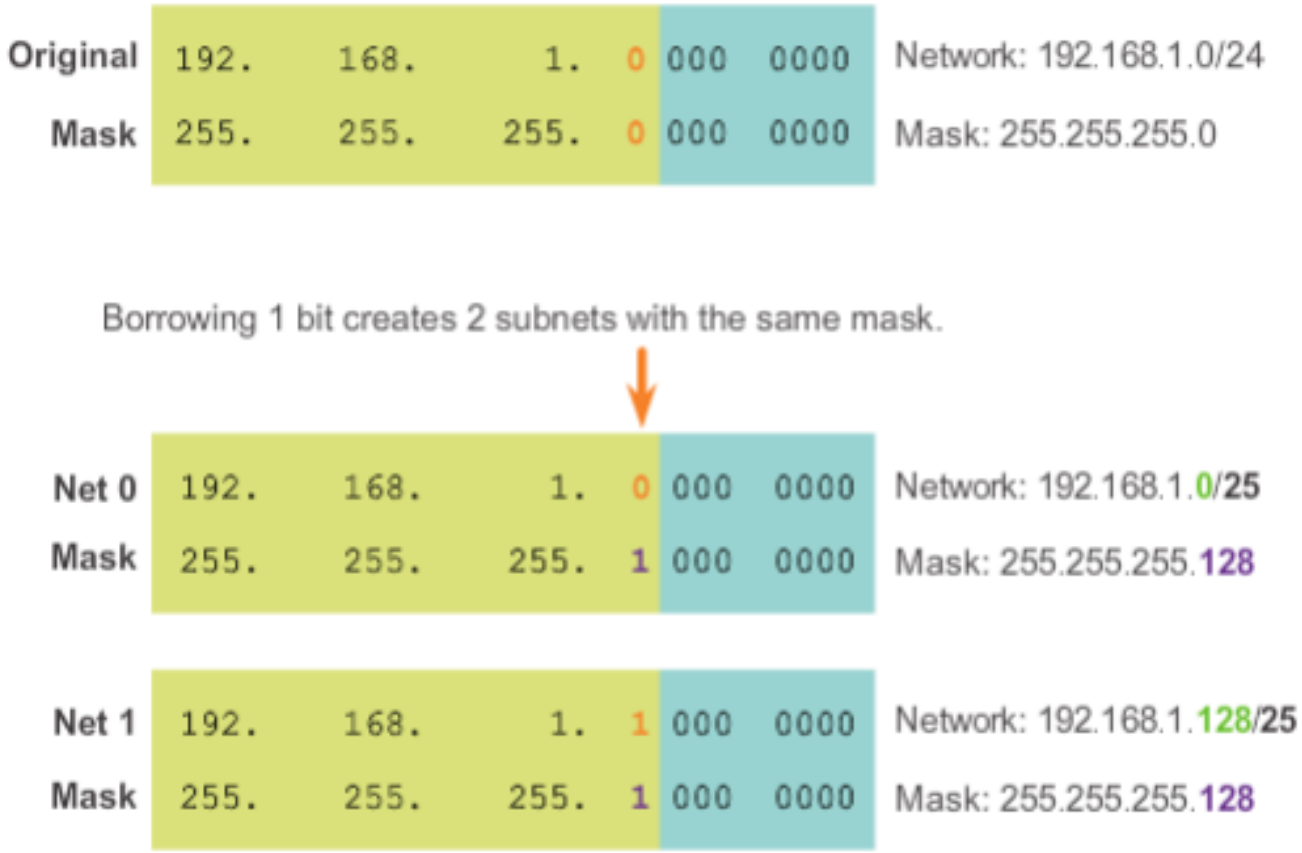
- Translates an IP address to a name
- Humans are bad at remember numbers that's why DNS was created
- Example 128.205.201.57 is mapped to www.buffalo.edu
- So when you type www.buffalo.edu in the web browser
  - DNS translates that domain name to an IP address to connect to the website

Intro to Subnetting



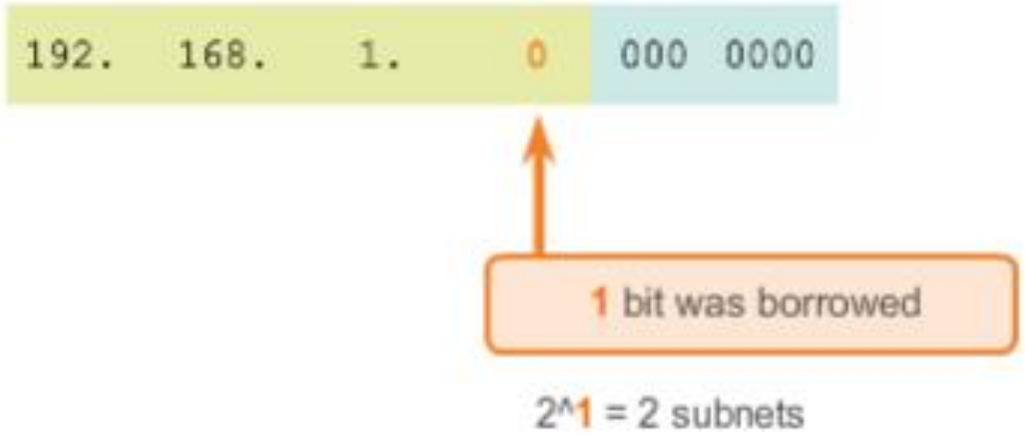

Borrow 1 bit from the host portion of the address.
Original
192. 168. 1. 0 000 0000
Mask
255. 255. 255. 0 000 0000
1 Network
The borrowed bit value is 0 for the Net 0 address.
Net 0
192. 168. 1. 0 000 0000
The borrowed bit value is 1 for the Net 1 address.
Net 1
192. 168. 1. 1 000 0000
2 Subnets
The new subnets have the SAME subnet mask.
Mask
255. 255. 255. 1 000 0000

Decimal Representation



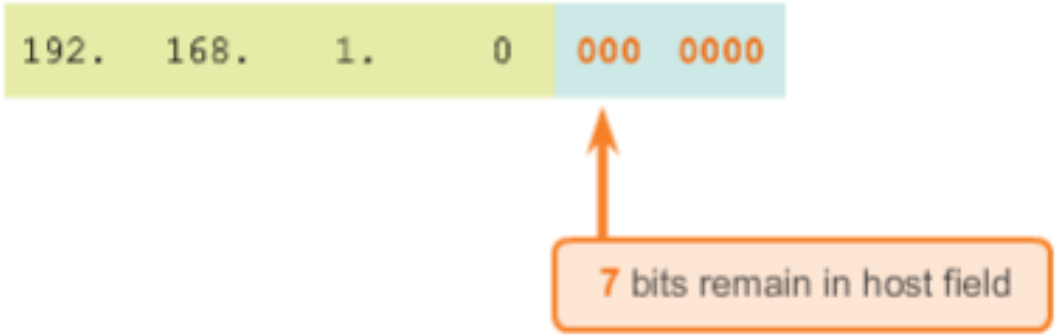
Calculate Number of Subnets

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



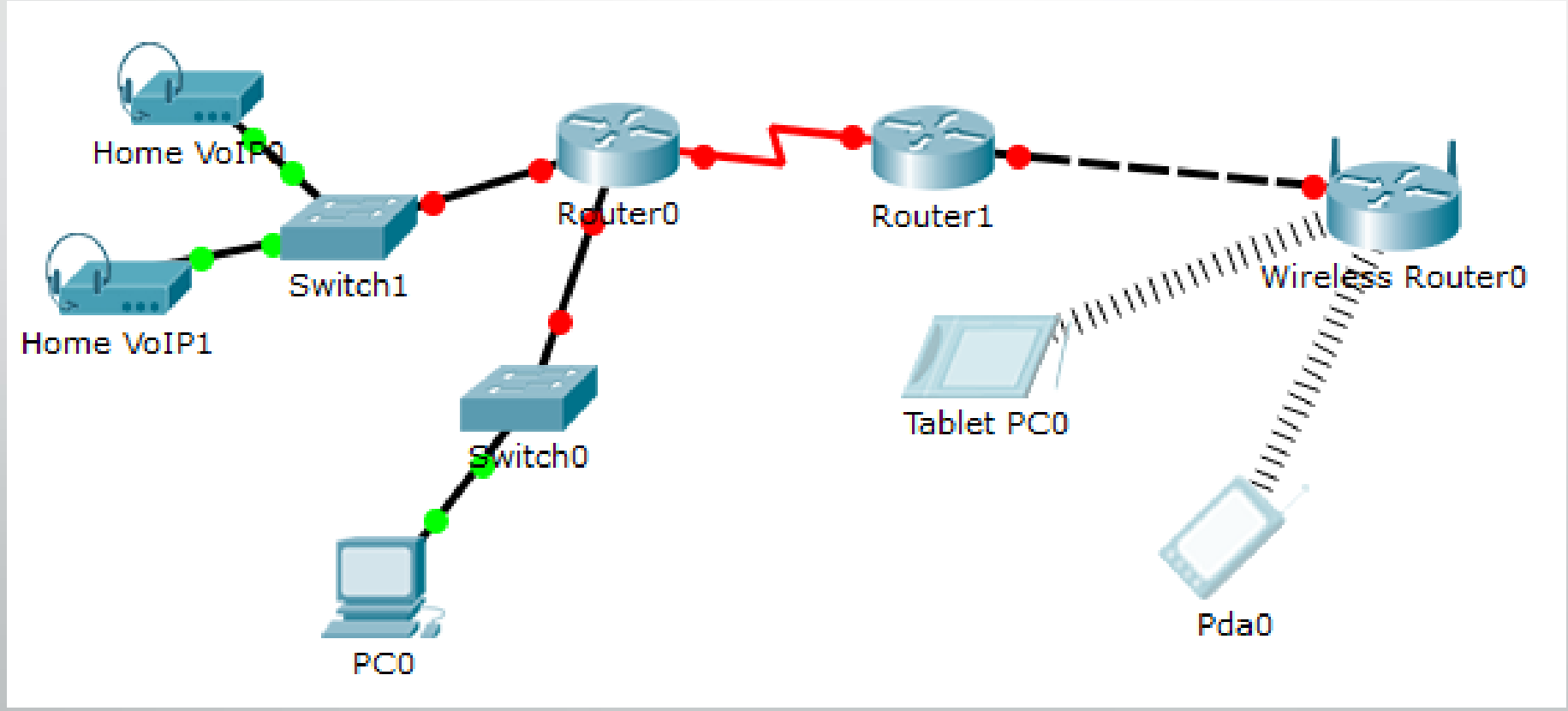
Calculate Number of Hosts

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



2^7 = 128 hosts per subnet
2^7 - 2 = 126 valid hosts per subnet

Subnetting Example



Subnetting Example

- The business Unbelieve-bowl contracting you to develop a networking scheme and has given you the address **192.168.1.0/24**.
- They have a large number of sales reps on the floor answering IP phones, there is **60 phones**.
- They also have a crew of loaders at the truck dock which require only about **34 computers** throughout the loading department and administrative staff on the other side of the building with about **55 computers**.
- The link between the routing devices also needs addresses.

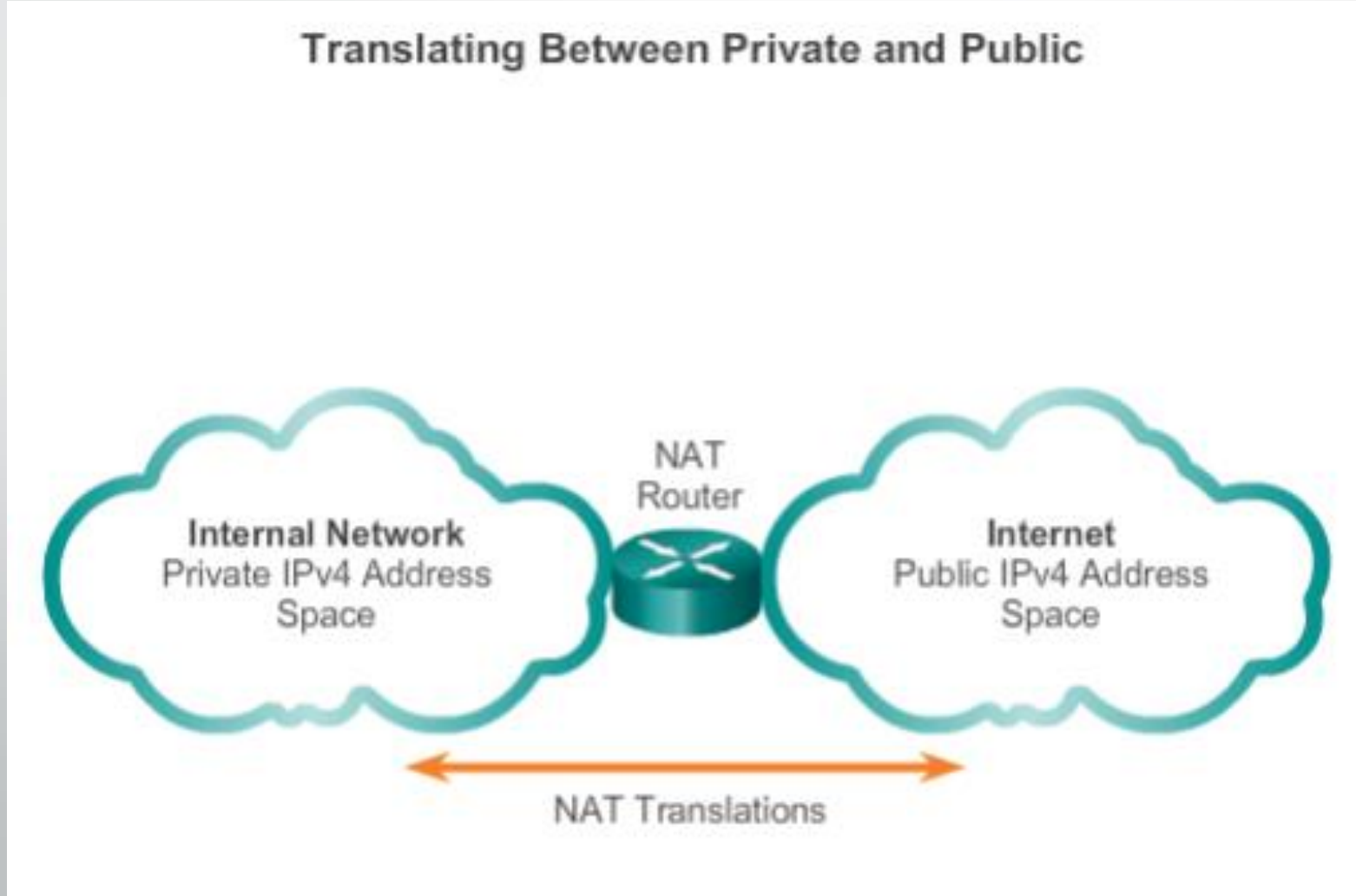
Subnetting Example Answers

- Subnet 0: 192.168.1.0/26
- Subnet 1: 192.168.1.64/26
- Subnet 2: 192.168.1.128/26
- Subnet 3: 192.168.1.192/26
- Any one of these subnets can be assigned to any departments (60 hosts, 35 hosts, 34 hosts and the 2 links) since they will each support 62 hosts.

IPv6

- Created to replace IPv4
  - No more IPv4 addresses to give out
- 8 x 16 bit (128 bit) alphanumeric addresses in decimal notation separated by '.'s. For example 2001:0000:3238:DFE1:63:0000:0000:FEFB – IPV6
- Tends to be ignored

Network Address Translation (NAT)



Public Addresses Vs. Private addresses

- Public is used for intranet communication
- Private is used mainly in home networks or companies
- UB is public addressed
- Think, if you go to anyone's house an run an ipconfig, you'll get an IP of 192.168.1.x or something similar

My Home Network:

```
Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . : local
   Link-local IPv6 Address . . . . . : fe80::1cc0:ba50:364:1c7e%17
   IPv4 Address. . . . . . . . . . . : 192.168.0.233
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.0.1
```

Testing Connection

- Ping – checks for network connection
- Tracert - shows hops to a destination
- Nslookup (windows) – shows the dns server information
- Ipconfig (Windows) – displays generic IP addressing info
- Ipconfig /all (Windows) – shows detailed information for all network adapters
- Ifconfig (linux) – displays generic IP addressing info
- Netstat- Shows active connections

Nslookup : DNS set to a raspberrypi (PiHole installed) to block Advertisements

```
C:\Users\Alex>Nslookup
Default Server:  raspberrypi
Address:  192.168.0.116
```

Clients

- Clients access servers for information and resources
- Connected to a network (LAN/ WAN.. MAN)
  - Local Area, Wide Are, Metropolitan Area
  - DMZ vs Regular connection
    - DMZ- network is segmented so people on the outside can’t get in
  - Most likely segmented on a VLAN(Virtual Local Area Network)
- Could be devices such as smartphones, tablets, PCs
- Programs could be considered to be clients also

Servers

- Servers store information and contain resources that clients can access
- Provides a service to users or specific programs
- Can be used to run a variety of applications
- Types of Servers:
  - File, SQL, Websites, Active directory, Virtualization
- Does not necessarily have to look like a server to be a server
- Could be compromised through a client

IP Classes

- Class A – 16,777,216 hosts
- Class B – 1,048,576 hosts
- Class C- 65,536 hosts

Class	Private Networks	Subnet Mask	Address Range
A	10.0.0.0	255.0.0.0	10.0.0.0 - 10.255.255.255
B	172.16.0.0 - 172.31.0.0	255.240.0.0	172.16.0.0 - 172.31.255.255
C	192.168.0.0	255.255.0.0	192.168.0.0 - 192.168.255.255

Cloud Computing

- Iaas - Infrastructure as a Service
- Paas - Platform as a Service
- Saas - Software as a Service

SsaS – Software as a Service

- On Demand Software, Usually accessible Via Webclient
- Ex: Office 365 , Salesforce.com, Google Suite (Doc, Sheets, Slides) etc.

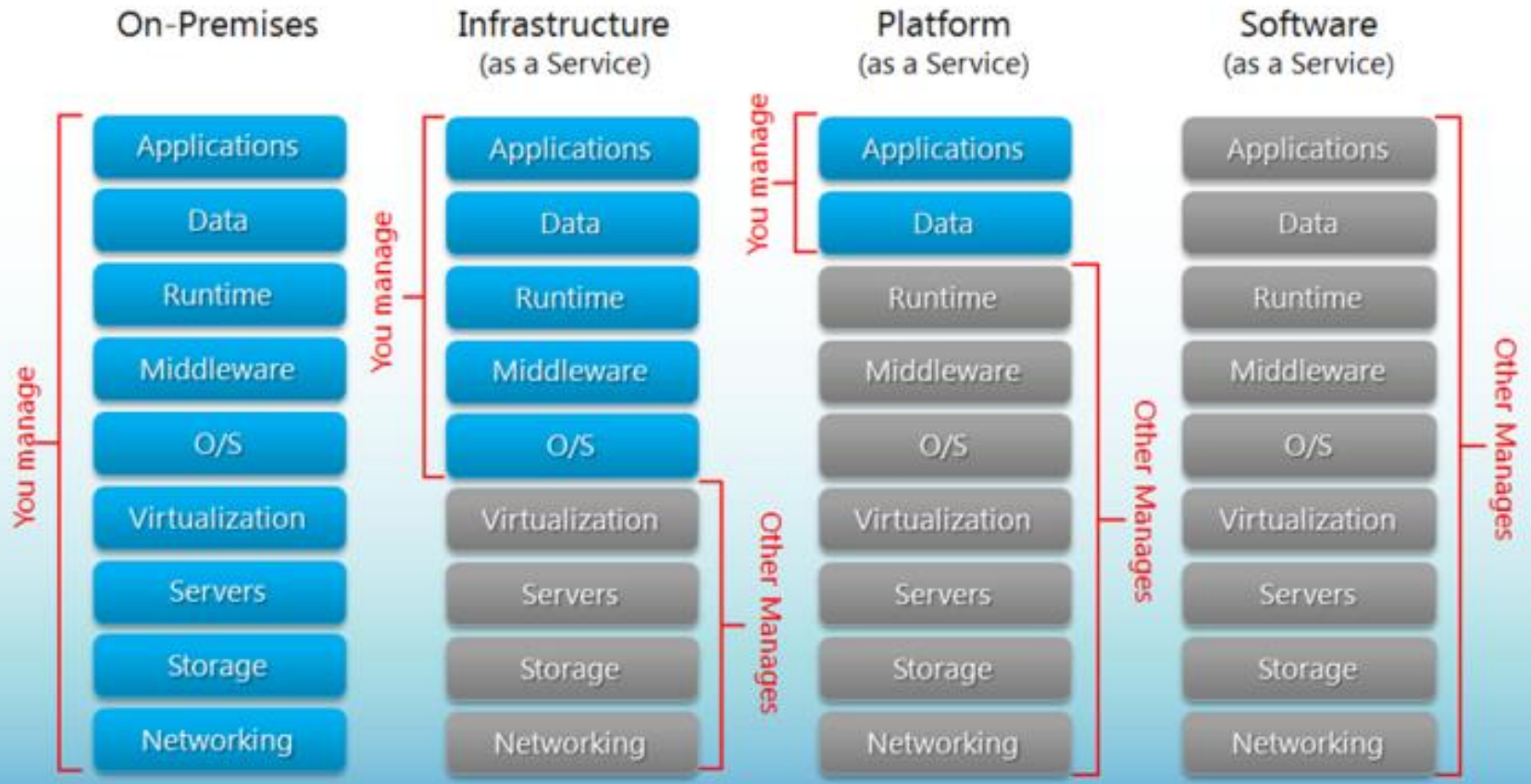
IaaS – Infrastructure as a Service

- The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.

PaaS - Platform as a Service

- The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.

Separation of Responsibilities



Video: Virtualization Explained

- https://www.youtube.com/watch?v=o8JXiCYNuDo

END