STEVENS
INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY®

CS 146: Intro to Web Programming and Project Development

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TCP/IP II

Objectives

Students will be able to:

- Define the layers in TCP/IP
- Understand classes of networks
- Work with IP addresses and subnet masks to determine how many hosts can be connected

Question

- How many hosts can you put on a Class C network? **

Answer

- How many hosts can you put on a Class C network?

2^8

- 1 (for the network itself)

- 1 (broadcast address)

= 256 – 2 = **254**

Subnet Mask Notation

- Subnet masks can be specified with
  – **Binary**

  11111111.00000000.00000000.00000000

  – **Dotted Decimal**

  255.0.0.0

  – **Slash notation**, more properly called **CIDR notation** (short for Classless Inter-Domain Routing)

  /8

Example

- How many subnets and hosts per subnet can you get from the network 192.168.92.0/28? (Steps following)
  - Determine class
  - Convert subnet mask to binary
  - Draw the great divide and subdivide
  - Count by the powers of 2

Problem **

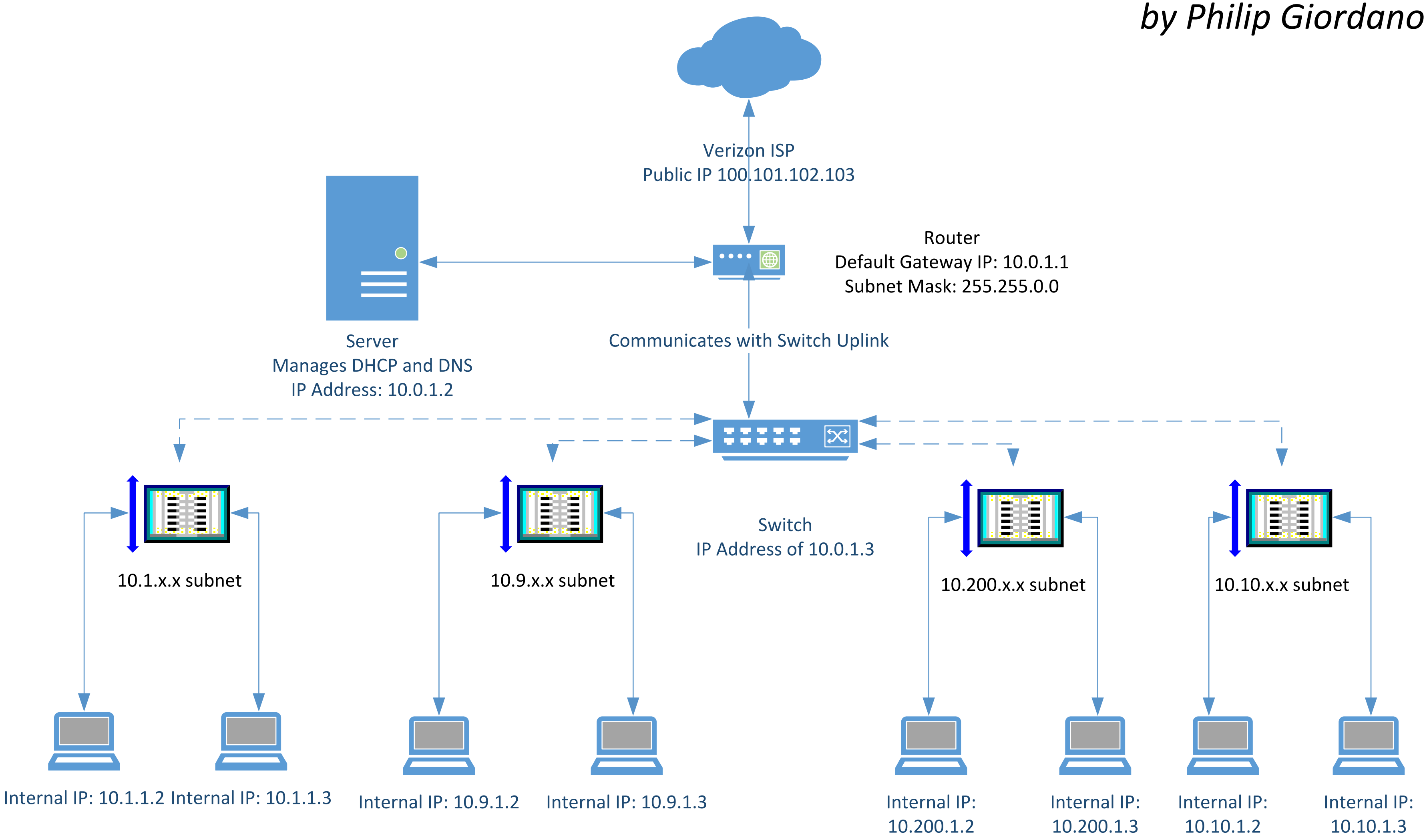
- Network specification is 69.117.198.0/28
  - What is the subnet mask in binary and dotted decimal notations?
  - How valid subnets can there be?
  - How many hosts can there be in each subnet?

Answers

- 255.255.255.240
- 2^{20} = 1,048,576 subnets
- 2^{4} – 2 = 14 hosts per subnet

Real-World Network setup (1)

by Philip Giordano



Verizon ISP
Public IP 100.101.102.103

Router
Default Gateway IP: 10.0.1.1
Subnet Mask: 255.255.0.0

Server
Manages DHCP and DNS
IP Address: 10.0.1.2

Communicates with Switch Uplink

Switch
IP Address of 10.0.1.3

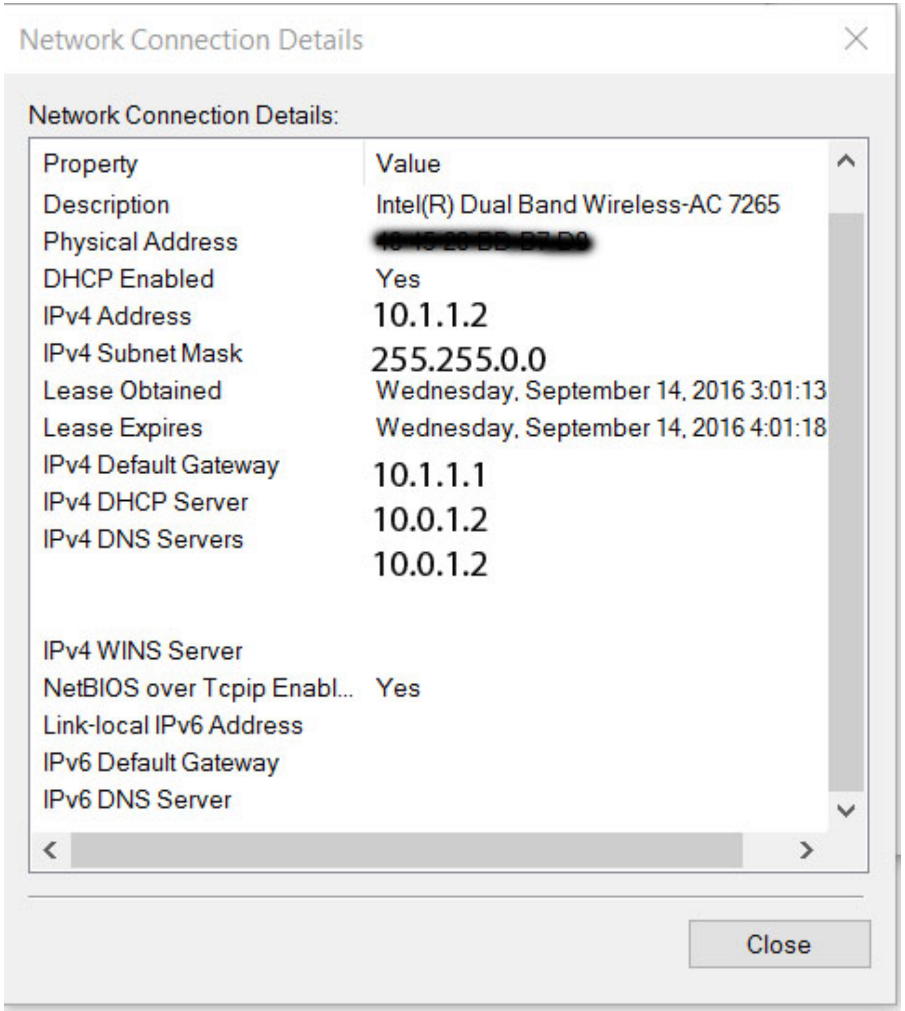
Real-World Network setup (2)

by Philip Giordano

- Computers on one subnet can only see each other; they cannot see computers on other subnets.
- On the switch, each port can be set to a different VLAN*, which DHCP will set the IP address to the correct subnet.
- Otherwise, each computer would have to have a static IP, correlating to its specific subnet, assuming no VLANs were set on the switch.
- DHCP Server can manage everything
  - Lets say we set the subnet mask to 255.255.0.0
    - One subnet: 10.**1**.x.0-254
    - Second subnet: 10.**2**.x.0-254

Real-World Network setup (3)

by Philip Giordano



Network Connection Details:

Property	Value
Description	Intel(R) Dual Band Wireless-AC 7265
Physical Address	[redacted]
DHCP Enabled	Yes
IPv4 Address	10.1.1.2
IPv4 Subnet Mask	255.255.0.0
Lease Obtained	Wednesday, September 14, 2016 3:01:13
Lease Expires	Wednesday, September 14, 2016 4:01:18
IPv4 Default Gateway	10.1.1.1
IPv4 DHCP Server	10.0.1.2
IPv4 DNS Servers	10.0.1.2
IPv4 WINS Server	
NetBIOS over Tcpip Enabl...	Yes
Link-local IPv6 Address	
IPv6 Default Gateway	
IPv6 DNS Server	

Routing Basics

- Router is a device with 2 separate IP addresses: one for LAN one for WAN
- LAN address is your “gateway”
- When a host is not found, the gateway is asked
- Router checks its routing table to know which IP to ask (probably on the WAN port)
- Routers can be connected to other routers
- NAT (Network Address Translation) allows to modify IP headers to provide the WAN address
- Can also use port forwarding / static NAT

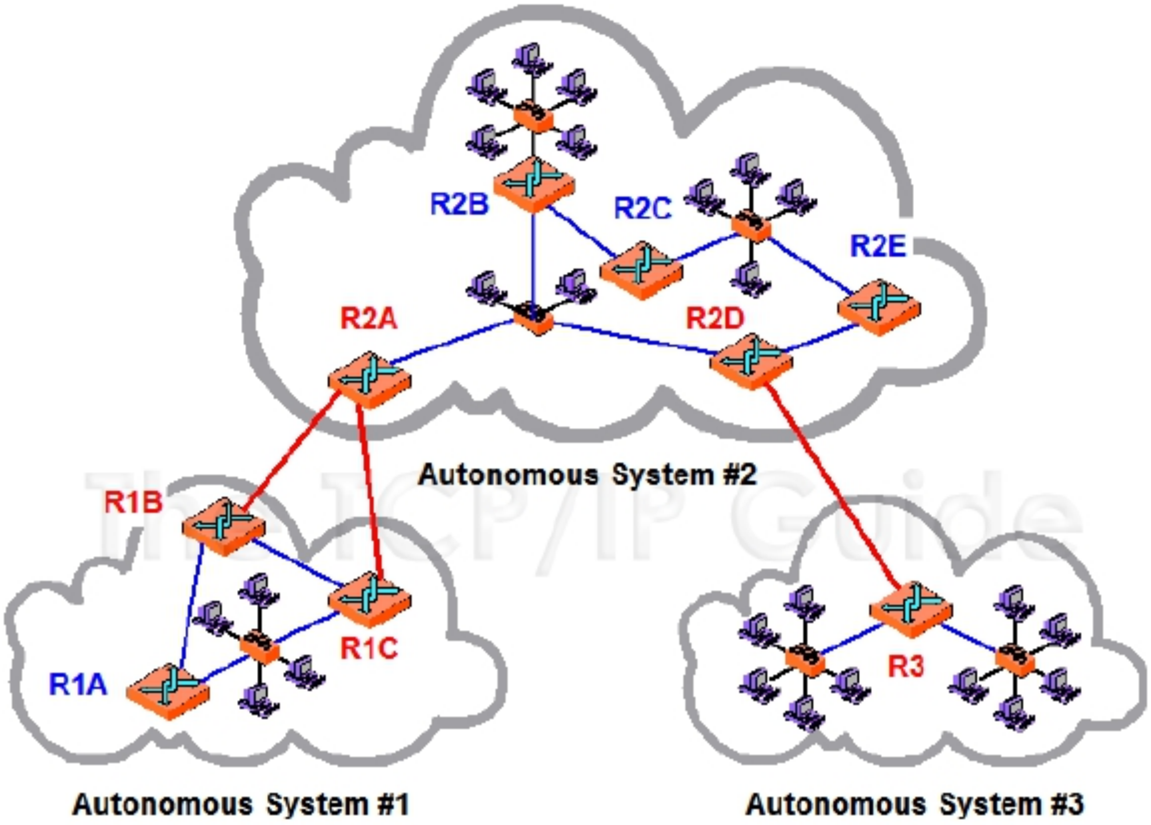
Core Architecture

- Early architecture of the Internet consisted of a small number of core routers
  - They contained comprehensive information about the inter-network
  - Adding more routers expanded the core
  - Core became too large
- Two-level hierarchy was formed with noncore routers on the periphery of the core
  - Still didn't scale well

Autonomous System (AS) Architecture

- Decentralized architecture
- Treats internetwork as a set of independent groups
- Each group (AS) consists of a set of routers and networks controlled by a particular organization or administrative entity
  - Internal routers – connect only to other routers in the same AS
  - Border routers – connect to other routers within the AS and to routers in one or more other ASes

AS Routing Architecture



IPv6

- Becoming increasing popular due to the large number of hosts on the Internet
- Uses 128-bit addresses
- About 3.4 x 10^{38} addresses
  - That's enough for many trillions to be assigned to every person on the planet!
- No need for NAT!
- Subnet mask fixed to 64 bits
- Stateless Address Autoconfiguration (SLAAC)
  - When first connected to a network, a host sends a link-local router solicitation multicast request for its configuration parameters; routers respond to such a request with a router advertisement packet that contains Internet Layer configuration parameters.
- Mandatory support of Internet Protocol Security (IPsec)

IPv6 Supported Address Types

- Unicast – Standard unicast addresses as in IPv4.
- Multicast – A message sent to a multicast address goes to all devices in the group.
- Anycast – When a message must be sent to any member of the group, but does not need to be sent to all of them.
  - A packet sent to an anycast address is delivered to the closest member of a group, according to the routing protocol's measure of distance

IPv6 Addresses and Zero Compression

- Addresses written as 8 groups of 4 hex digits, separated by colons
  - 2011:0BCD:0000:0000:0000:A3BD:0192:BA89
- To simplify, leading 0s in each word can be omitted and strings of 0s are replaced with two colons.
- For example the previous address can be written as
  - 2011:BCD::A3BD:192:BA89
- IPv4-mapped IPv6 addresses
  - 80 bits set to 0, 16 set to 1, and 32 bits of IPv4 address (::FFFF:192.168.1.12), or more properly.. **
- Tunneling encapsulates IPv6 headers in an IPv4 packet.

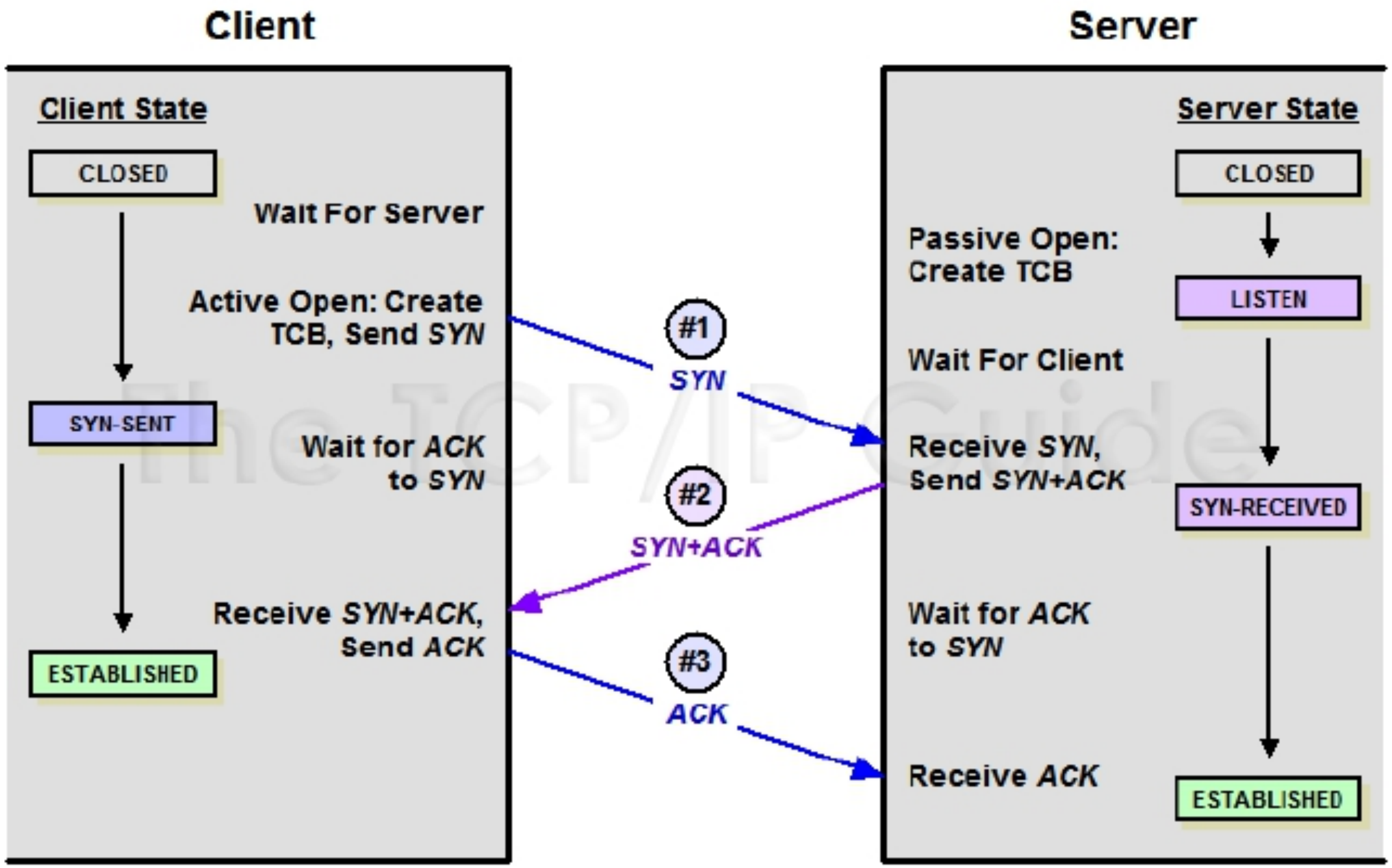
What Happened to IPv5?

- In the late 1970's, a protocol named ST - The Internet Stream Protocol - was created for the experimental transmission of voice, video, and distributed simulation
- Two decades later, this protocol was revised to become ST2 and started to get implemented into commercial projects by groups like IBM, NeXT, Apple, and Sun
- ST2 distinguishes its own packets with an Internet Protocol version number 5, although it was never known as IPv5

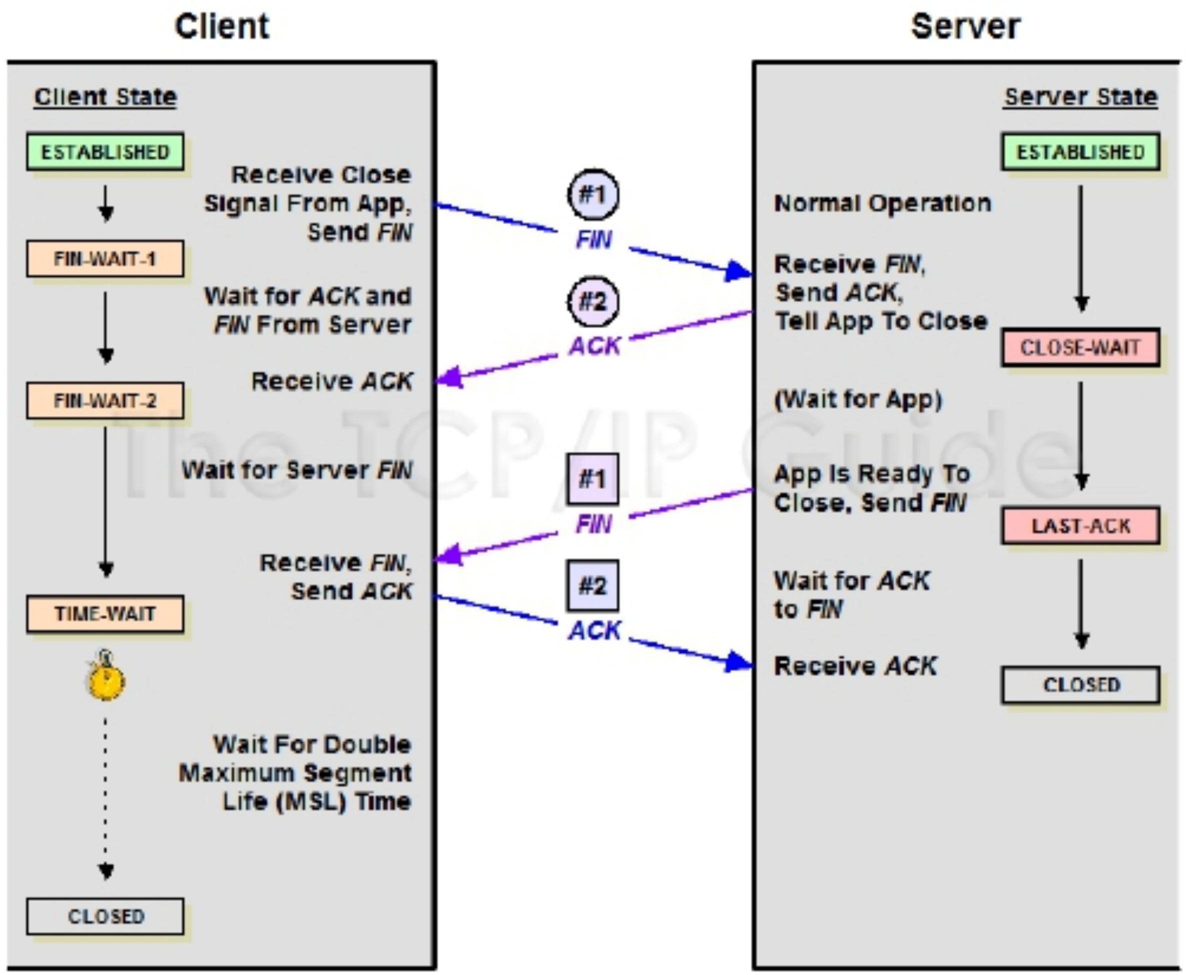
TCP

- One of the core protocols in the TCP/IP suite
- TCP provides reliable, ordered and error-checked delivery of a stream of octets between programs running on computers connected to a local area network, intranet, or the public Internet
- It resides at the transport layer
- Accepts data from a data stream, segments it into chunks, and adds a TCP header, creating a TCP segment
- TCP segment is encapsulated into an IP datagram
- **Windowing**!?

Three-way Handshake



Connection Termination Procedure



Client

Client State

ESTABLISHED

Receive Close Signal From App, Send *FIN*

FIN-WAIT-1

Wait for *ACK* and *FIN* From Server

Receive *ACK*

FIN-WAIT-2

Wait for Server *FIN*

Receive *FIN*, Send *ACK*

TIME-WAIT

Wait For Double Maximum Segment Life (MSL) Time

CLOSED

#1 *FIN*

#2 *ACK*

#1 *FIN*

#2 *ACK*

Server

Server State

ESTABLISHED

Normal Operation

Receive *FIN*, Send *ACK*, Tell App To Close

CLOSE-WAIT

(Wait for App)

App Is Ready To Close, Send *FIN*

LAST-ACK

Wait for *ACK* to *FIN*

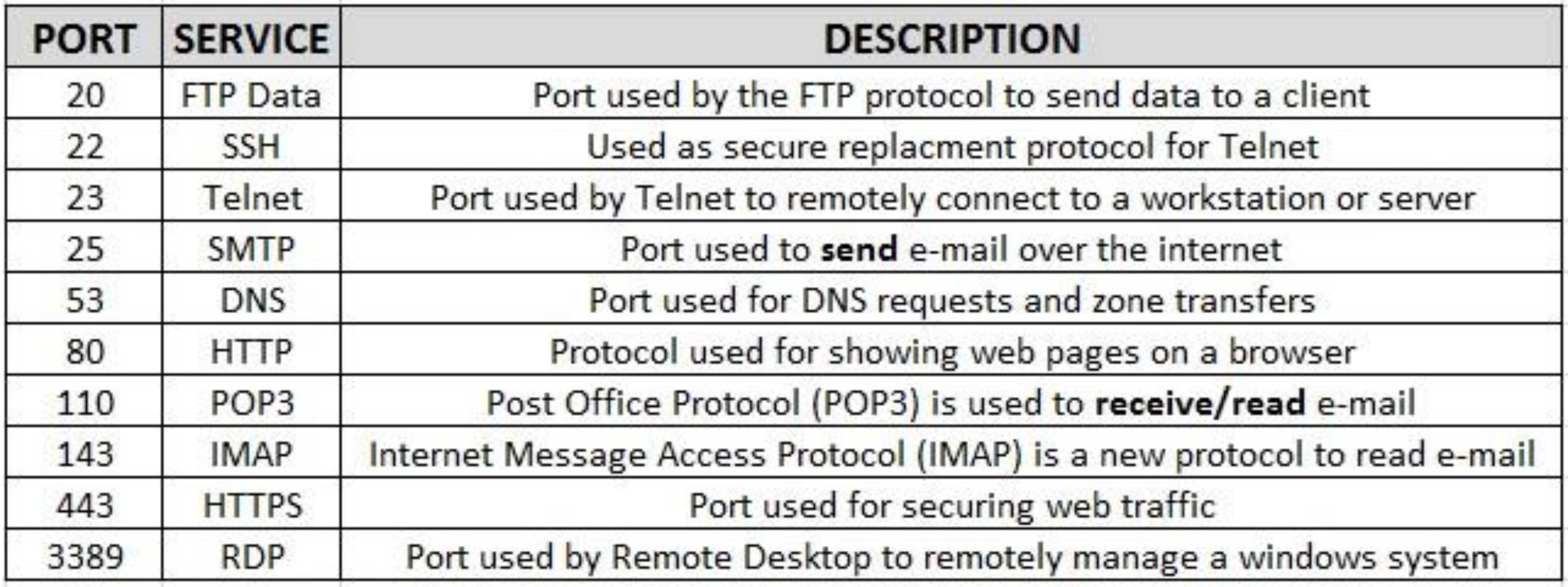
Receive *ACK*

CLOSED

Sockets

- A socket is a combination of an IP address and a port number
- Ports are like "doors" on your computer, they can be open or closed
- On a standard client/server setup
  - Server has a local socket to receive incoming connections
  - Client opens a socket to connect to the server
  - Server receives the connection, accepting a new socket (the client's)
- Port range is 0-65535

Ports



PORT	SERVICE	DESCRIPTION
20	FTP Data	Port used by the FTP protocol to send data to a client
22	SSH	Used as secure replacment protocol for Telnet
23	Telnet	Port used by Telnet to remotely connect to a workstation or server
25	SMTP	Port used to **send** e-mail over the internet
53	DNS	Port used for DNS requests and zone transfers
80	HTTP	Protocol used for showing web pages on a browser
110	POP3	Post Office Protocol (POP3) is used to **receive/read** e-mail
143	IMAP	Internet Message Access Protocol (IMAP) is a new protocol to read e-mail
443	HTTPS	Port used for securing web traffic
3389	RDP	Port used by Remote Desktop to remotely manage a windows system