

# Professor Messer's CompTIA Network+ N10-006 Course Notes

## Network Devices

### Hub

- An OSI layer 1 device
- Multi-port repeater
- Everything is half-duplex
- Becomes less efficient as speeds increase



### Switch

- An OSI layer 2 device
- Hardware bridging ASICs (very fast!)
- Forwards traffic based on MAC address
- The core of an enterprise network
- High bandwidth - Many simultaneous packets



### Router

- An OSI layer 3 device
- Routes traffic between IP subnets
- Routers inside of switches are sometimes called "layer 3 switches"
- Layer 2 = Switch, Layer 3 = Router
- Often connects diverse network types - LAN, WAN, copper, fiber



### Firewall

- OSI layer 4 (TCP/UDP), some firewalls filter through OSI layer 7
- Filters traffic by port number
- Can encrypt traffic into/out of the network and between sites
- Can proxy traffic - A common security technique
- Most firewalls can be layer 3 devices (routers)



### Wireless Access Point

- OSI layer 2 device
- Not a wireless router
- A WAP is a bridge - makes forwarding decisions based on MAC address



### Modem

- Modulator / Demodulator
- Uses standard phone lines
- POTS modems now used for backup and utility functions



### Intrusion detection/prevention system

- Protects against OS and application exploits
- Detection - alerts but does not stop the attack
- Prevention - blocks the attack
- Network-based - high-speed appliances
- Host-based - runs on your operating system

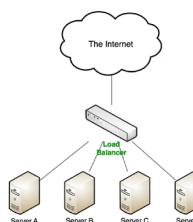


### Content Filters

- Control traffic based on network data
- Filter email - avoid malicious software, phishing, and viruses
- Filter URLs - filter by web site category



### The Internet



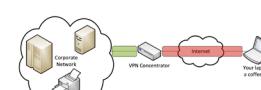
### Load balancer

- Distributes the load over many physical servers
- Adds fault-tolerance
- Can cache and prioritize traffic
- Very common in large environments



### Packet shaper, traffic shaper

- Control by bandwidth usage or data rates
- Set important applications to have higher priorities than other apps
- Manage the Quality of Service (QoS)



### VPN concentrator

- The connection point for remote users
- Traffic is encrypted across the Internet and decrypted on the internal private network

## VPN Protocols

### PPP (Point-to-Point Protocol)

- Authentication, compression, error detection, multilink
- Used in many physical networking environments
- Layer 2 protocol

### PPTP (Point to Point Tunneling Protocol)

- PPTP protocol controls the tunnel
- GRE (Generic Routing Encapsulation) is the tunnel
- Authentication - MS-CHAPv2 (Microsoft Challenge-Handshake Authentication Protocol)
- Encryption - EAP-TLS (Extensible Authentication Protocol – Transport Layer Security)

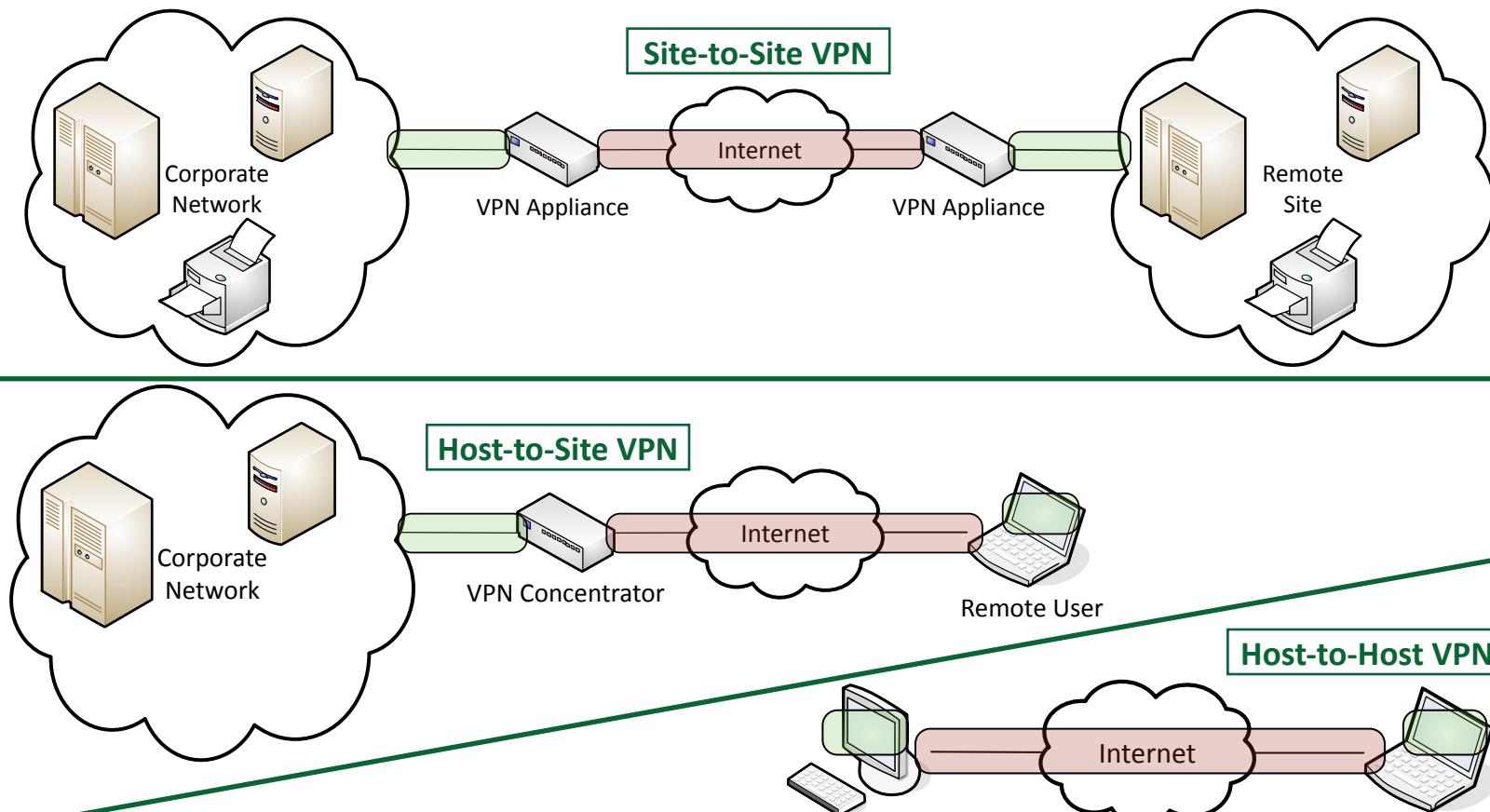
### SSL VPN (Secure Sockets Layer VPN)

- Uses common SSL protocol (tcp/443)
- No big VPN clients

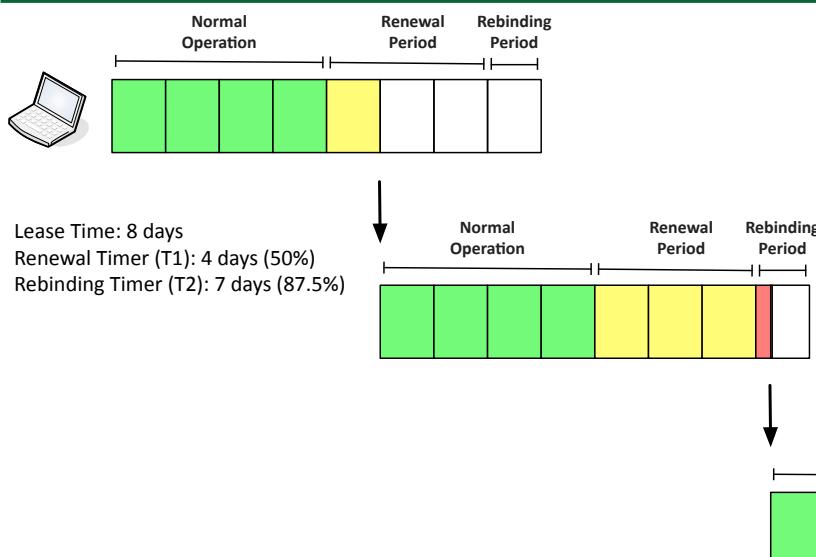
### IPSec (Internet Protocol Security)

- Security for OSI layer 3
- Confidentiality and integrity/anti-replay
- Two core IPsec protocols - Authentication Header (AH) and Encapsulation Security Payload (ESP)

# Virtual Private Networking (VPN)



## DHCP Lease Renewal



## The DHCP Process

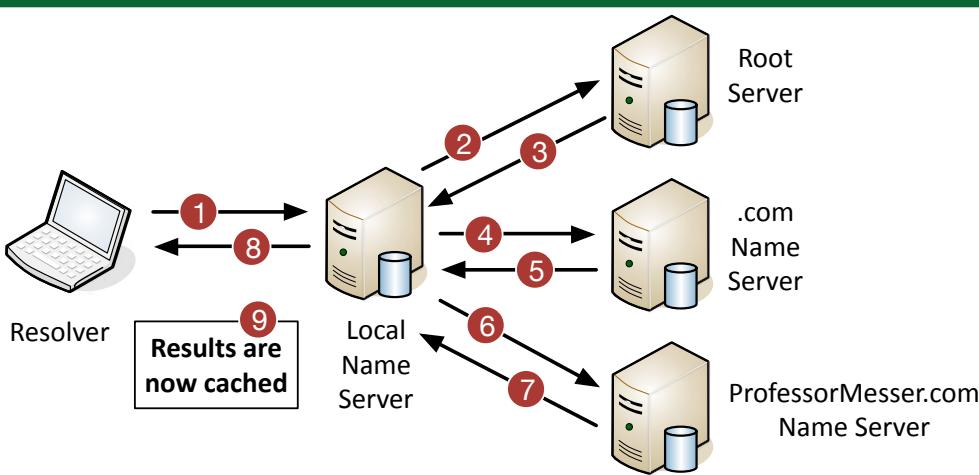
- Step 1: **DHCPDISCOVER** - Client to DHCP Server
  - Find all of the available DHCP Servers
- Step 2: **DHCPOFFER** - DHCP Server to client
  - Send some IP address options to the client
- Step 3: **DHCPREQUEST** - Client to DHCP Server
  - Client chooses an offer and makes a formal request
- Step 4: **DHCPACK** - DHCP Server to client
  - DHCP server sends an acknowledgement to the client

## DNS Resolution Process

- Request sent to local name server
- Name server queries root server
- Root response sent to local name server
- Name server queries .com name server
- .com Response sent to local name server
- Name server queries specific domain server
- Domain server responds to name server
- Name server provides result to local device
- Answer is cached locally

### DNS Records

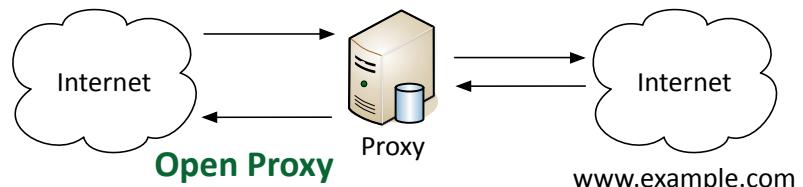
- A and AAAA - Address
- MX - Mail exchanger
- PTR - Pointer
- CNAME - Canonical name
- NS - Name server



# Proxy Servers

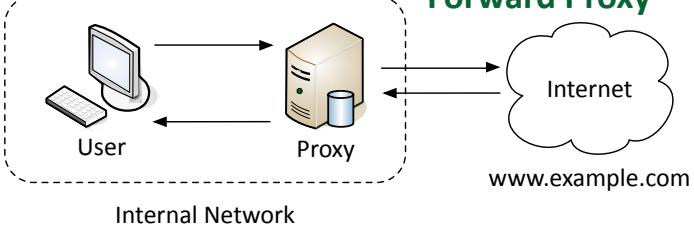
- 1 - Client makes the request to the proxy
- 2 - The proxy performs the actual request
- 3 - The proxy provides results back to the client

Proxies can provide access control, caching, URL filtering, content scanning, etc.

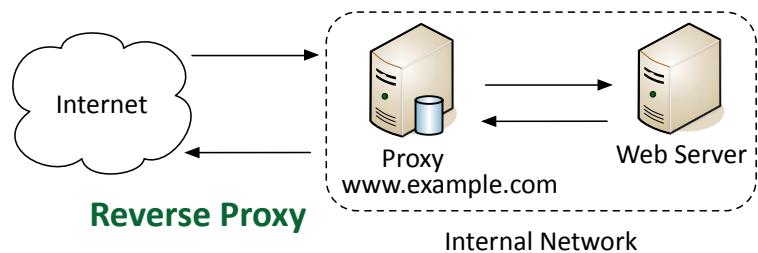


www.example.com

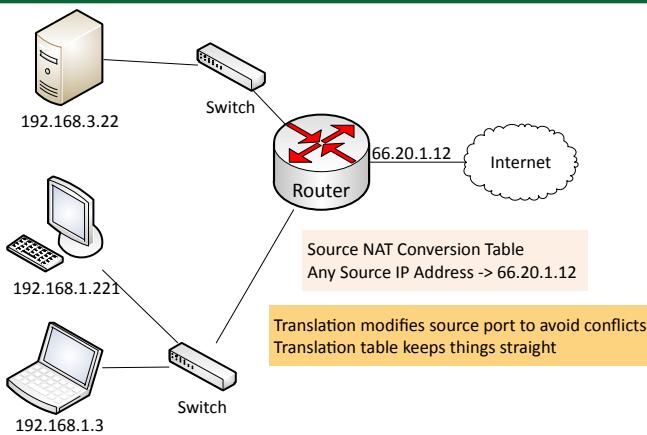
## Forward Proxy



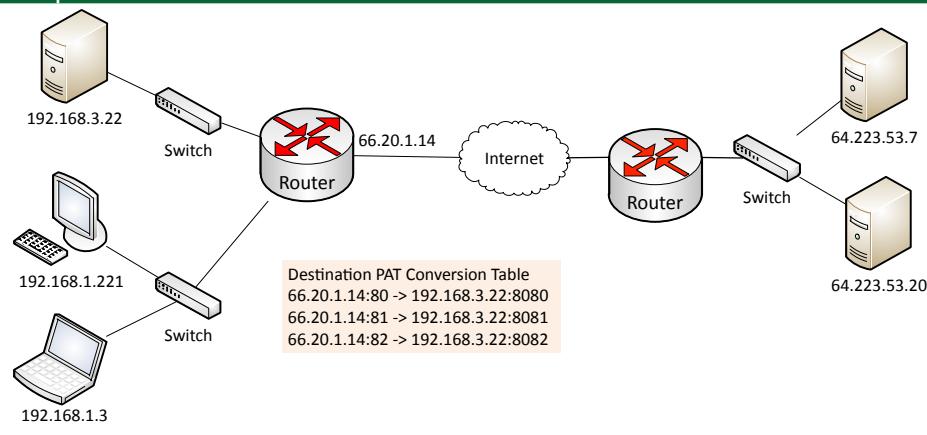
## Reverse Proxy



## PAT (Port Address Translation / Source NAT)



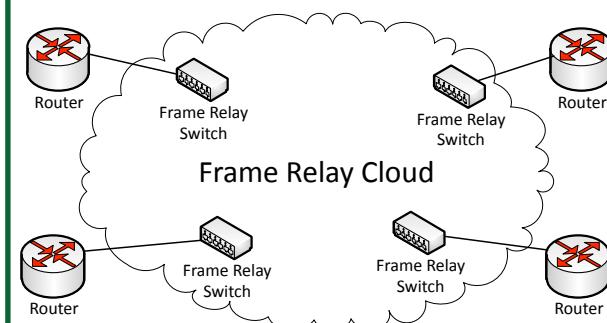
## Static NAT / Destination NAT



## WAN Technologies

SONET	SDH	Bandwidth
<b>STS-1 / OC-1</b>	STM-0	<b>51.84 Mbps</b>
STS-3 / OC-3	<b>STM-1</b>	<b>155.52 Mbps</b>
STS-12 / OC-12	STM-4	622.08 Mbps
STS-48 / OC-48	STM-16	2.488 Gbps
STS-96 / OC-96	STM-32	4.976 Gbps
STS-192 / OC-192	STM-64	9.953 Gbps
STS-768 / OC-768	STM-256	39.813 Gbps

## Frame Relay



### Cellular networks

- Land is separated into "cells"
- 2G networking (GSM, CDMA)

### LTE (Long Term Evolution)

- Based on GSM/EDGE
- 300 Mbit/s down, 75 Mbit/s up

### HSPA+ (Evolved High Speed Packet Access)

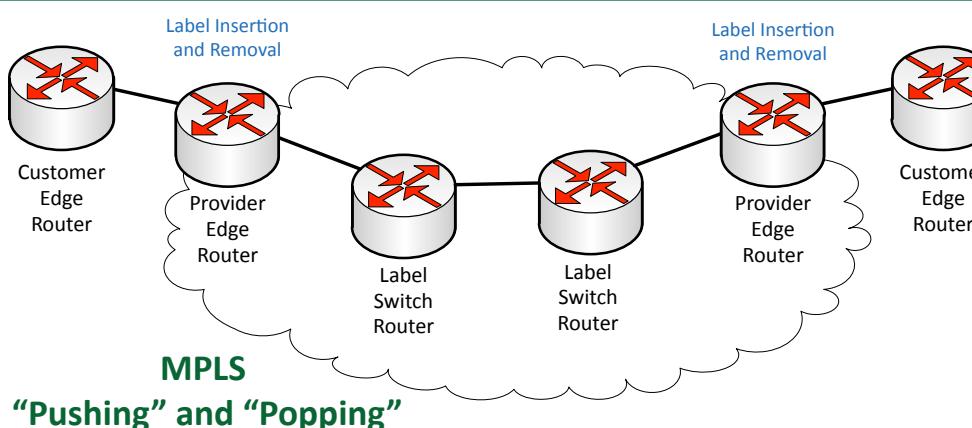
- Based on CDMA
- 84 Mbit/s down, 22 Mbit/s up

### WiMAX

- Worldwide Interoperability for Microwave Access
- Fixed WiMax (IEEE 802.16)
  - 37 Mbit/s down, 17 Mbit/s up

### Mobile WiMAX (IEEE802.16e-2005)

- 1 Gbit/s for fixed stations
- 100 Mbit/s for mobile stations



# WAN Technologies



## Satellite Networking

- 15 Mbit/s down, 2 Mbit/s up
- High latency (250 ms up, 250 ms down)
- High frequencies (line of sight, rain fade)

## ISDN (Integrated Services Digital Network)

- BRI - Basic Rate Interface (2B+D)
  - Two 64 kbit/s bearer (B) channels
  - One 16 kbit/s signaling (D) channel
- PRI - Primary Rate Interface (23B+D)
  - T1 – 23B + D
  - E1 – 30B + D + alarm channel

## DSL (Digital Subscriber Line)

- ADSL (Asymmetric DSL)
  - 24 Mbit/s down, 3.5 Mbit/s up
- SDSL (Symmetric DSL)
  - Never standardized
- VDSL (Very high bitrate DSL)
  - 4 Mbit/s through 100 Mbit/s

## PPPoE

- Encapsulate point-to-point protocol over Ethernet
- Common on DSL networks
- Many similarities to dial-up networking

## Cable modem

- DOCSIS (Data Over Cable Service Interface Specification)
- 4 Mbit/s through 100 Mbit/s

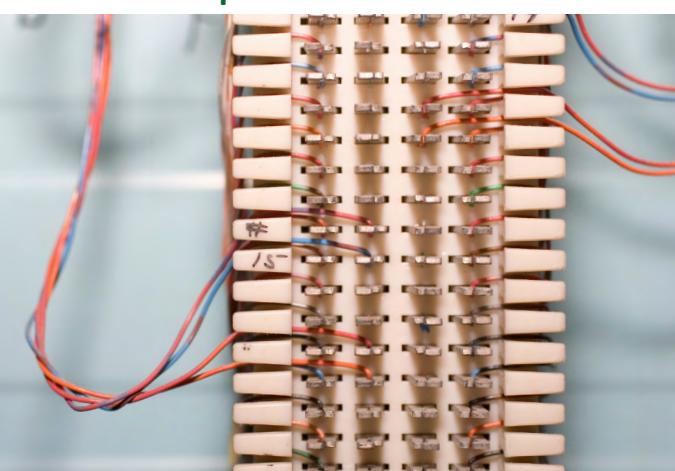
## Dial-up

- Legacy systems
- 56 kbit/s, compression up to 320 kbit/s



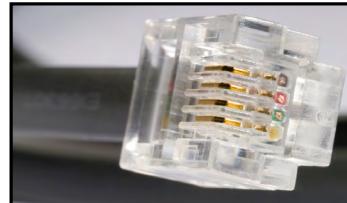
RJ-45 Coupler

RG-6 Cable

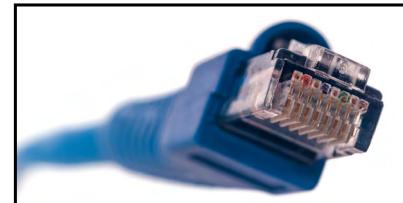


66 block

Network	Channels	Line Rate
T1	24 at 64 kbit/s	1.544 Mbit/s
E1	32 at 64 kbit/s	2.048 Mbit/s
T3	28 T1 circuits 672 T1 channels	44.736 Mbit/s
E3	16 E1 circuits 512 E1 channels	33.368 Mbit/s



RJ-11 Cable



RJ-45 Cable



DB-25

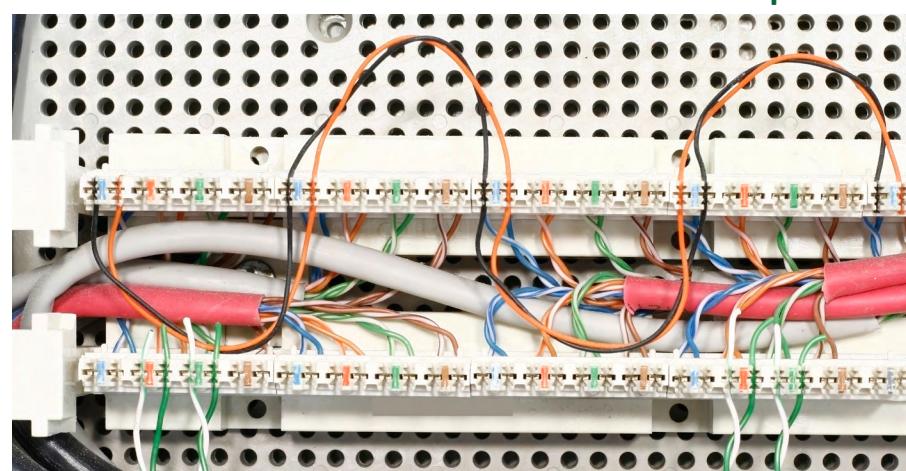
DB-9



BNC Cable



BNC Coupler

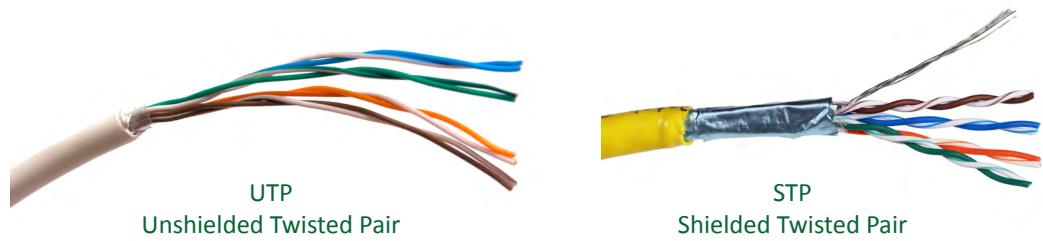


110 block

# Copper Cabling

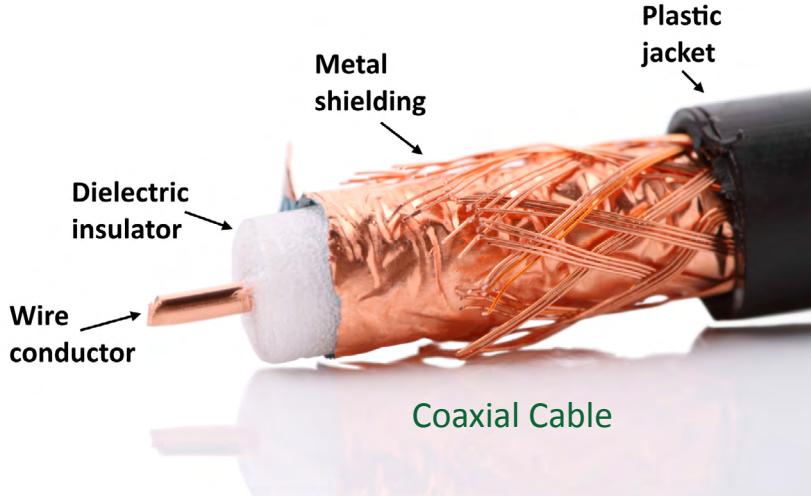
## Twisted Pair Cabling

- STP (Shielded Twisted Pair)
- UTP (Unshielded Twisted Pair)
- Plenum-rated cable
  - Fire-resistant cable jacket



## Coaxial Cabling

- RG-59 - Short-distance video
- RG-6 - Television, digital cable Internet



Cable Category	Ethernet Standard	Maximum Distance
Category 3	10BASE-T	100 meters
Category 5	100BASE-TX, 1000BASE-T	100 meters
Category 5e (enhanced)	100BASE-TX 1000BASE-T	100 meters
Category 6	10GBASE-T	37 to 55 meters
Category 6A (augmented)	10GBASE-T	100 meters

## EIA/TIA-568 Standard Pin Assignments

TIA/EIA 568A

1	Green	White and Green
2	Green	Green
3	White and Orange	White and Orange
4	Blue	Blue
5	White and Blue	White and Blue
6	Orange	Orange
7	White and Brown	White and Brown
8	Brown	Brown

1 2 3 4 5 6 7 8



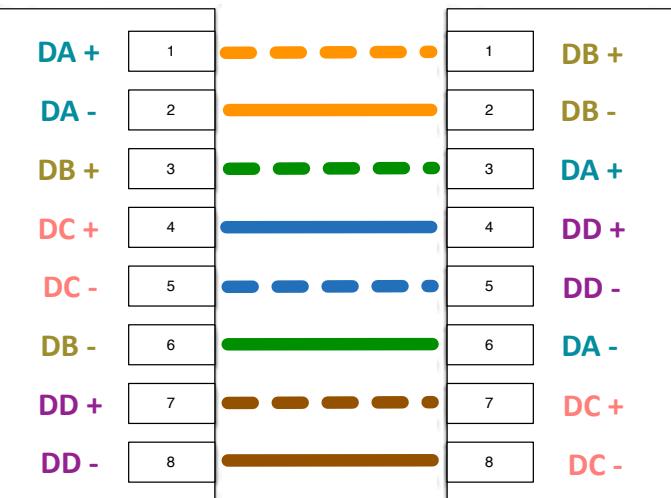
TIA/EIA 568B

1	White and Orange	White and Orange
2	Orange	Orange
3	White and Green	White and Green
4	Blue	Blue
5	White and Blue	White and Blue
6	Green	Green
7	White and Brown	White and Brown
8	Brown	Brown

TIA/EIA 568B Straight Through Cable



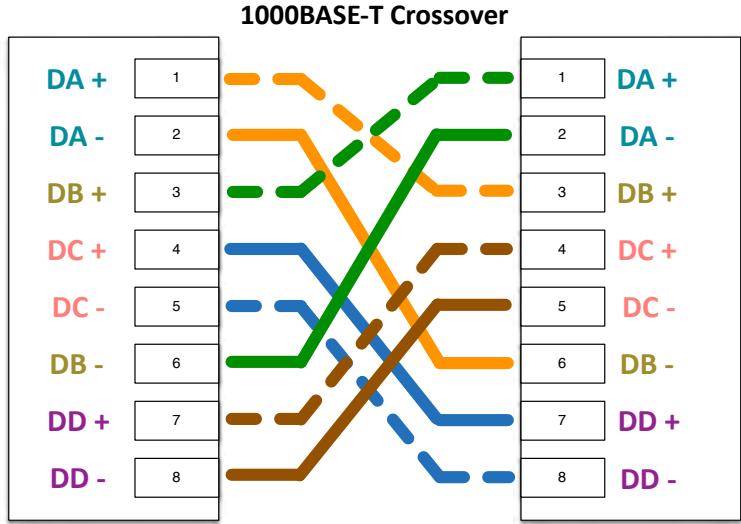
1000BASE-T Straight-through



Media Dependent Interface (MDI)  
Network Interface Card

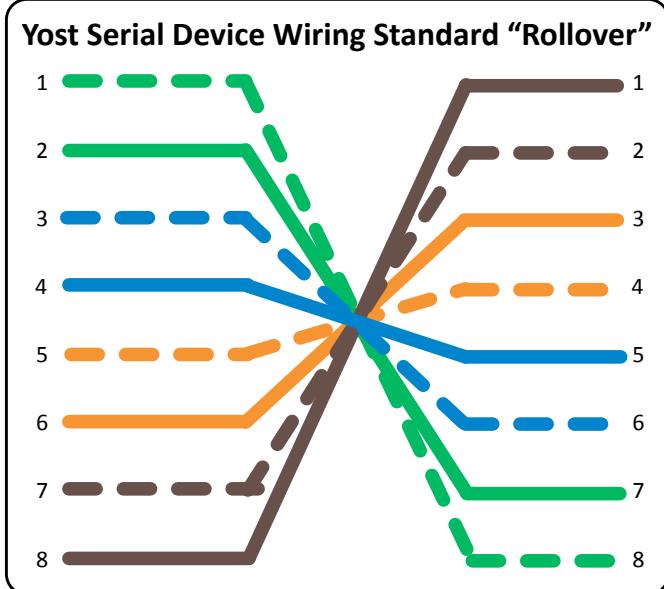
Media Dependent  
Interface Crossover (MDI-X)  
Network Switch

# Copper Cabling



Media Dependent Interface (MDI)  
Network Interface Card

Media Dependent Interface (MDI)  
Network Interface Card



## Optical Fiber



ST - Straight Tip



FC - Field Assembly Connector



SC - Subscriber Connector



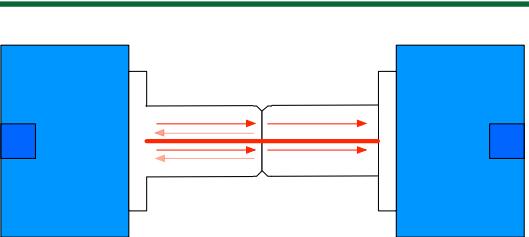
LC - Lucent Connector



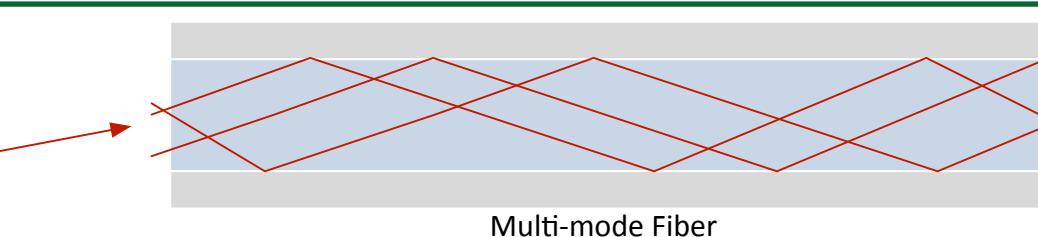
MT-RJ - Mechanical Transfer Registered Jack



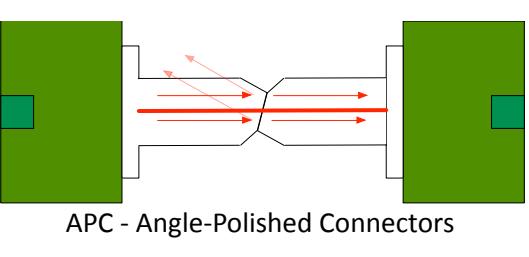
Fiber Couplers



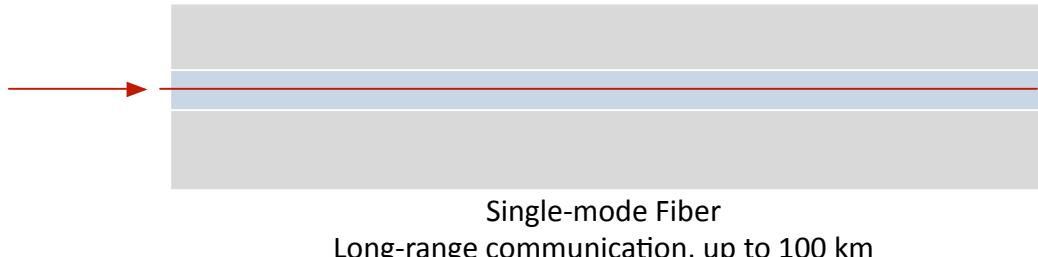
UPC - Ultra-Polished Connectors



Multi-mode Fiber  
Short-range communication, up to 2 km



APC - Angle-Polished Connectors



Single-mode Fiber  
Long-range communication, up to 100 km

# Network Cabling Tools



## Cable Crimper

- "Pinch" the connector onto the wire
- The final step of a cable installation



## Snips / Electrician's scissors

- Precise cutting
- Wire stripping and cutting notches



## Punch-down Tool

- Forces wire into a wiring block
- Trims the wires and breaks the insulation



## TDR / OTDR

- (Optical) Time Domain Reflectometer
- Estimate fiber lengths, measure signal loss, determine light reflection, create wire maps



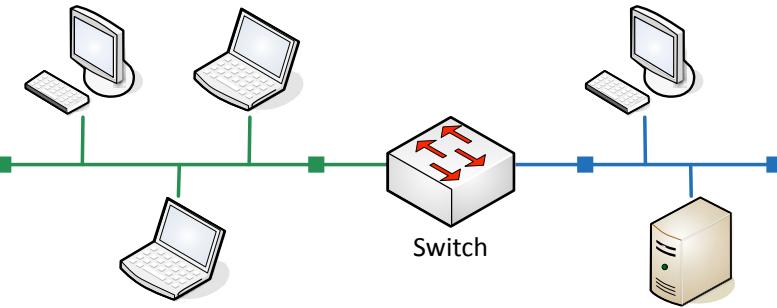
## Wire stripper

- Easily remove insulation from copper wire

## Collision Domains and Broadcast Domains

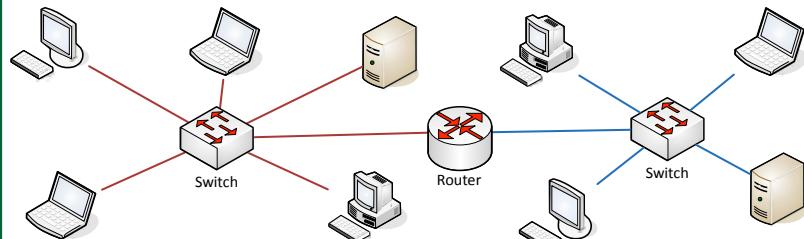
### Collision Domains

Separated by switch/bridge interfaces

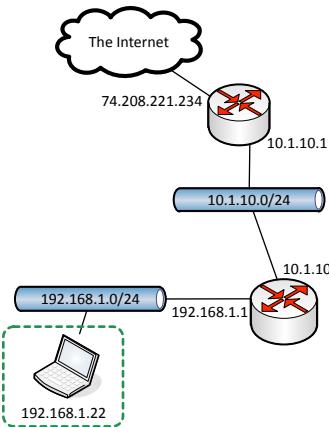


### Broadcast Domains

Separated by router interfaces



## Routing



### Common Routing Metrics

- Hop count
- Load
- Packet loss
- MTU
- Latency
- Throughput
- Network speed
- Path reliability
- Link utilization

Destination	Gateway	Interface	Metric
0.0.0.0/0	192.168.1.1	192.168.1.22	10
127.0.0.1/8	127.0.0.1	127.0.0.1	1
192.168.1.0/24	192.168.1.22	192.168.1.22	10
192.168.1.22/32	127.0.0.1	127.0.0.1	10
192.168.1.255/32	192.168.1.22	192.168.1.22	10

### Link State Routing Protocol

- Routes are based on availability, speed, and other criteria
- Very scalable, used by large networks
- OSPF, IS-IS

### Distance-Vector Routing Protocol

- Determine routes based on number of hops
- The deciding vector is the distance
- RIP, RIPv2, BGP

### Hybrid Routing Protocol

- A little link state, a little distance-vector
- EIGRP

## High availability

- Design a system for smallest chance of downtime
- Higher availability almost always means higher costs

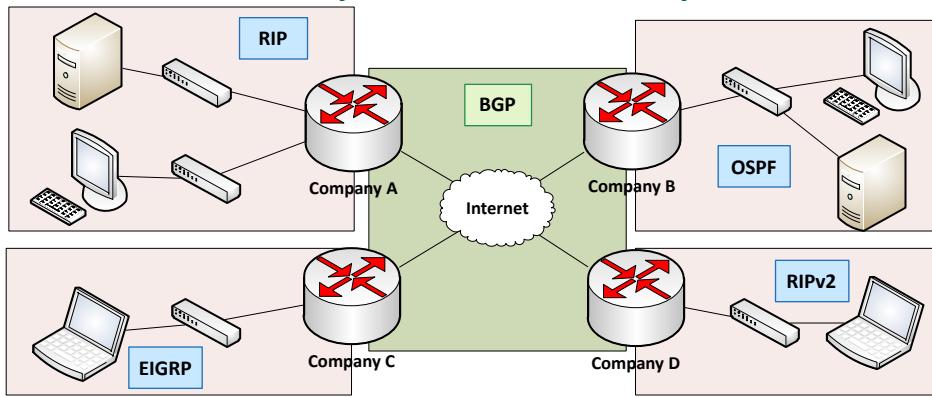
## VRP

- Virtual Router Redundancy Protocol
- The default router isn't real
- Devices use a virtual IP for the default gateway
- If a router disappears, another one takes its place

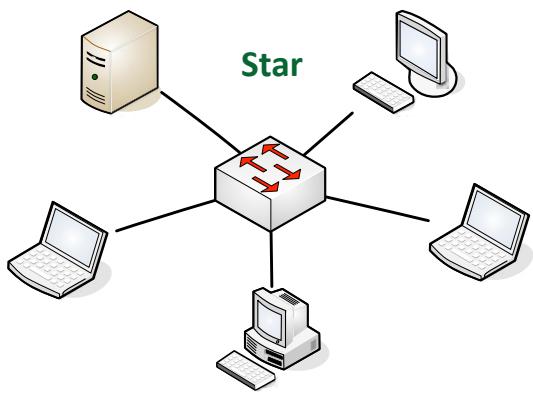
## HSRP

- Hot Standby Router Protocol
- Cisco proprietary version of VRRP
- Default gateway is assigned to a virtual router

## Interior Gateway and Exterior Gateway Protocols



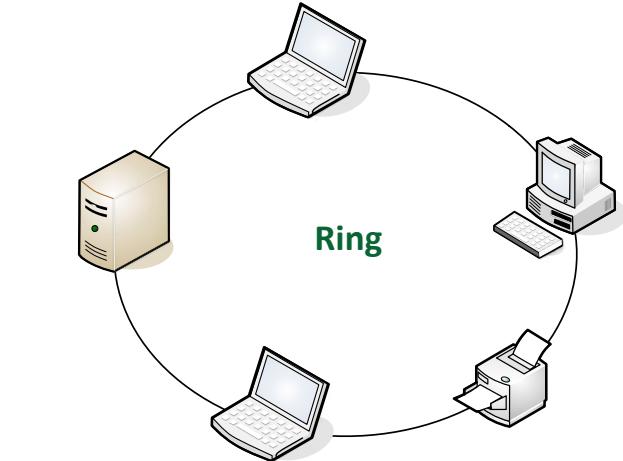
# Network Topologies



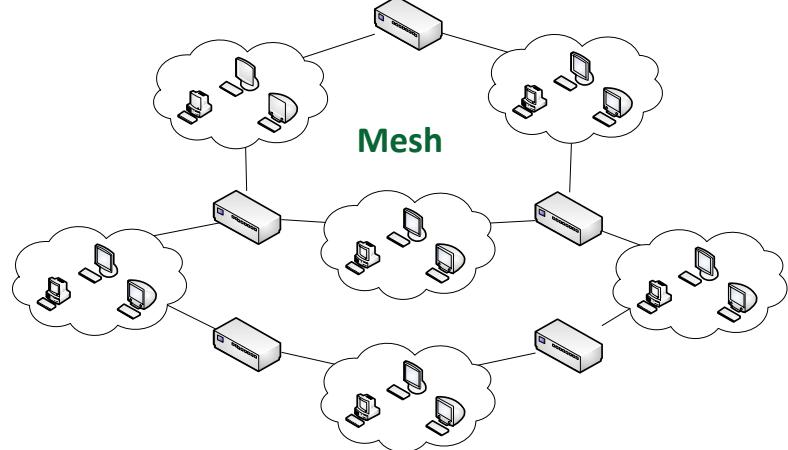
**Point-to-Point**



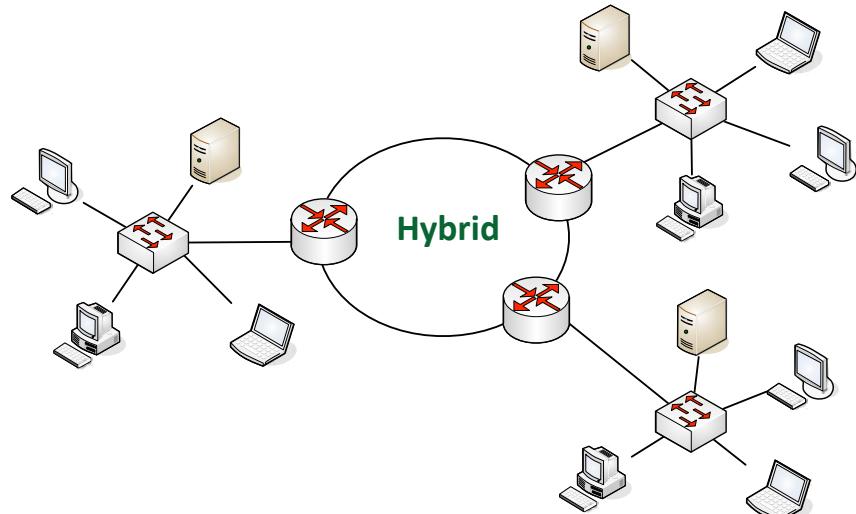
**Point-to-Multipoint**



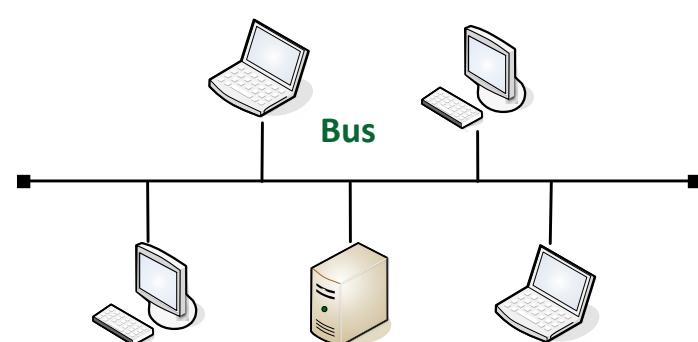
**Mesh**



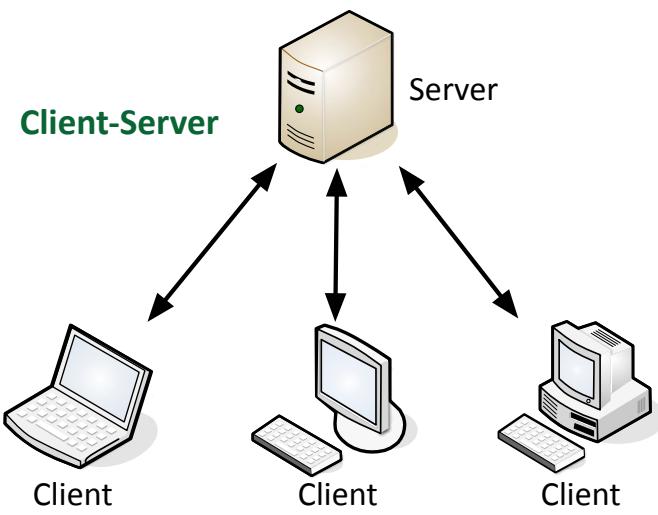
**Hybrid**



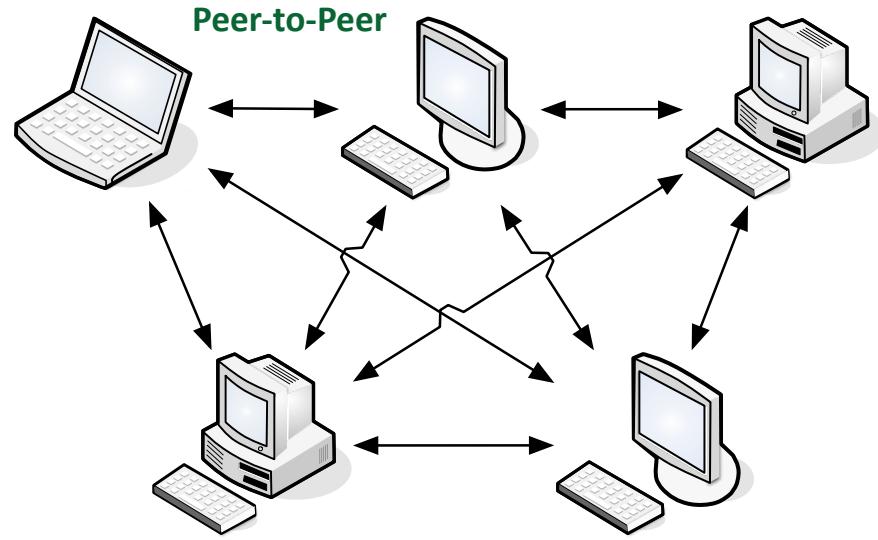
**Bus**



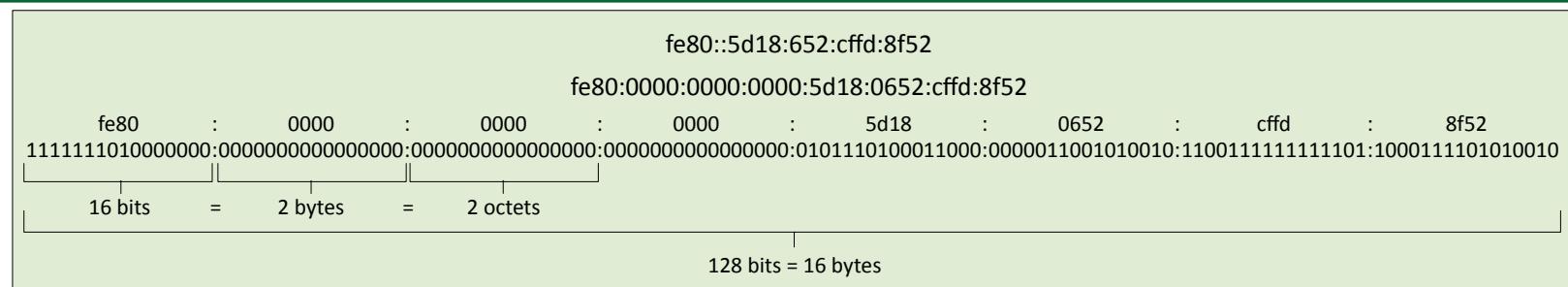
**Client-Server**



**Peer-to-Peer**

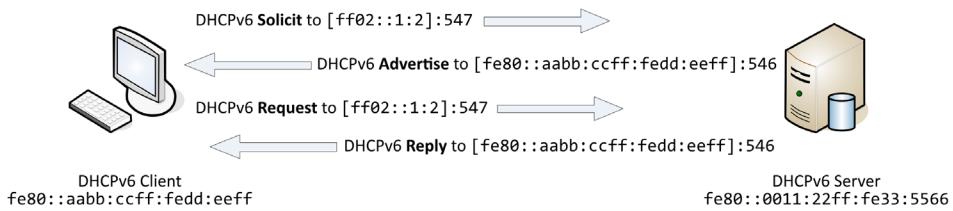


# IPv6 Addressing



## DHCPv6

Very similar process to DHCPv4 - udp/546 (client) and udp/547 (server)



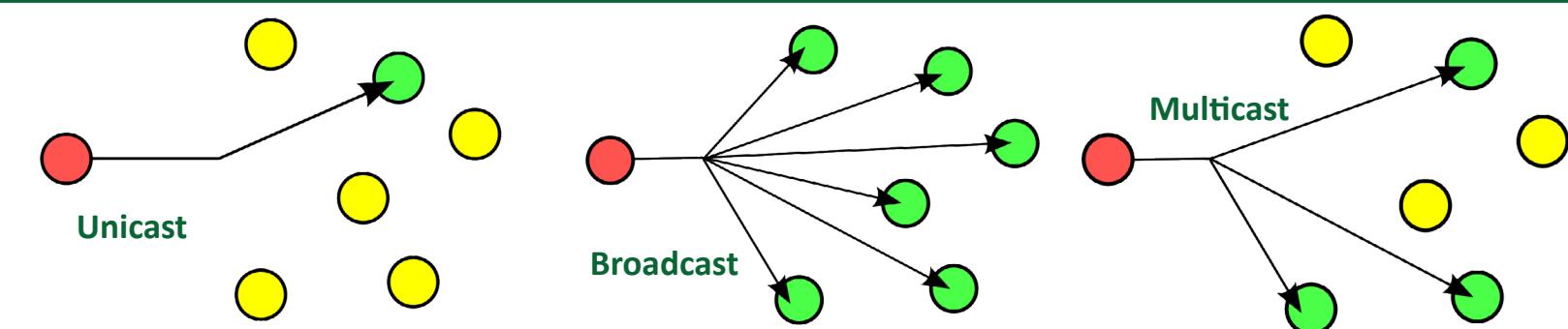
## Subnet Classes

Class	Leading Bits	Network Bits	Remaining Bits	Number of Networks	Hosts per Network	Default Subnet Mask
Class A	0xxx (1-126)	8	24	128	16,777,214	255.0.0.0
Class B	10xx (128-191)	16	16	16,384	65,534	255.255.0.0
Class C	110x (192-223)	24	8	2,097,152	254	255.255.255.0
Class D (multicast)	1110 (224-239)	Not defined	Not defined	Not defined	Not defined	Not defined
Class E (reserved)	1111 (240-254)	Not defined	Not defined	Not defined	Not defined	Not defined

## RFC 1918 Private Addresses

IP address range	Number of addresses	Classful description	Largest CIDR block (subnet mask)	Host ID size
10.0.0.0 – 10.255.255.255	16,777,216	single class A	10.0.0.0/8 (255.0.0.0)	24 bits
172.16.0.0 – 172.31.255.255	1,048,576	16 contiguous class Bs	172.16.0.0/12 (255.240.0.0)	20 bits
192.168.0.0 – 192.168.255.255	65,536	256 contiguous class Cs	192.168.0.0/16 (255.255.0.0)	16 bits

## Network Communication



# Software Defined Networking

- Networking devices have two functional planes of operation
  - Control plane, data plane
- Directly programmable - Configuration is different than forwarding
- Agile - Changes can be made dynamically
- Centrally managed - Global view, single pane of glass
- Programmatically configured - No human intervention
- Open standards / vendor neutral - A standard interface to the network

# Quality of Service (QoS)

## QoS

- Prioritize traffic performance
- Many different methods

## CoS (Class of Service)

- Ethernet frame header in an 802.1q trunk
- Usually applied in the intranet (not from an ISP)

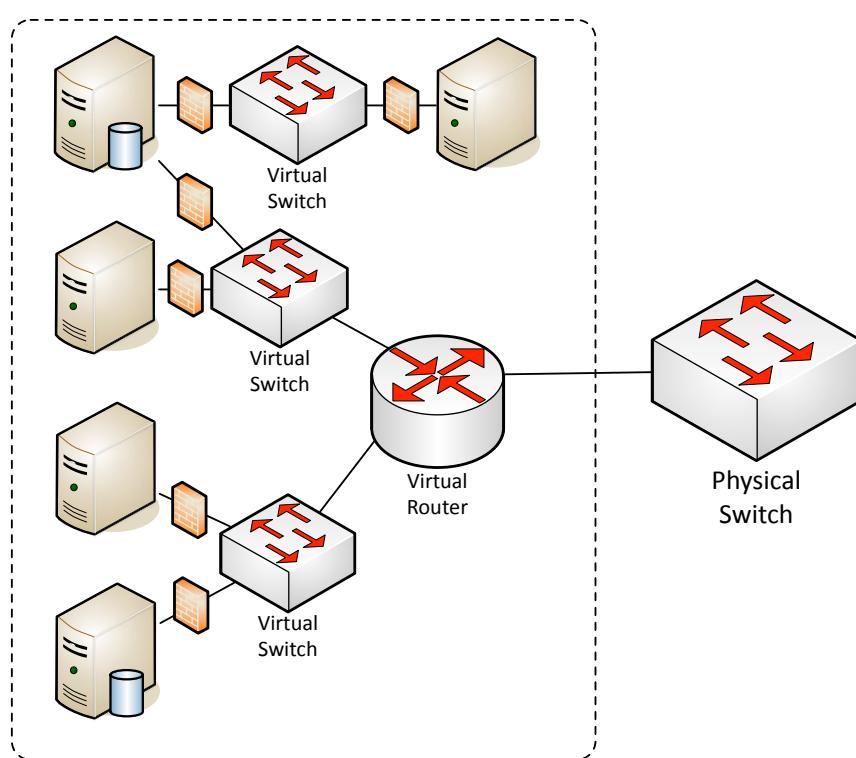
## Differentiated Services (DiffServ)

- QoS bits are enabled in the IPv4 header
- Bits are set external to the application
- Routers and switches have to play along

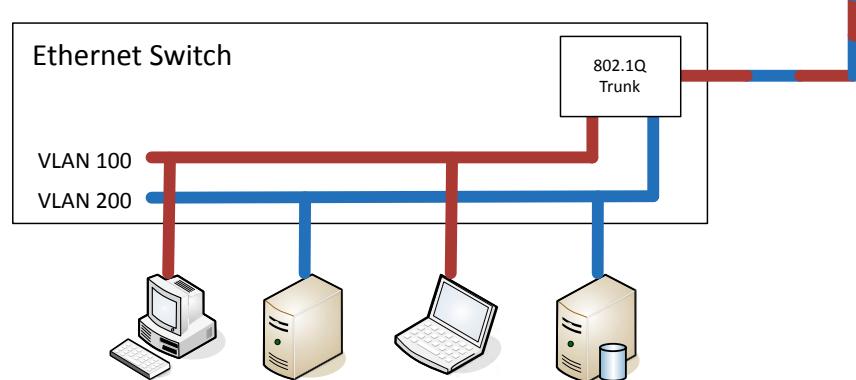
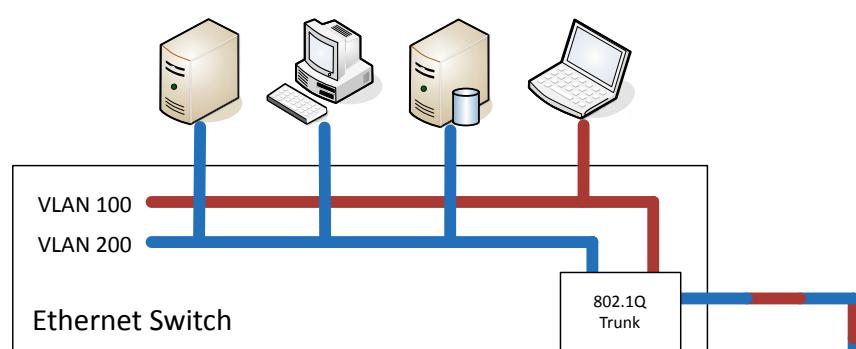
## DSCP (Differentiated Services Code Point)

- DS (Differentiated Services) field in the IP header

# Virtual Networks and Firewalls



# 802.1Q Trunking



# Storage Area Networks

## Network Attached Storage (NAS)

- Connect to a shared storage device across the network
- File-level access

## Storage Area Network (SAN)

- Looks and feels like a local storage device
- Block-level access
- Very efficient reading and writing

## Jumbo Frames

- Ethernet frames with more than 1,500 bytes of payload
- Increases transfer efficiency
- Ethernet devices must support jumbo frames

## iSCSI

- Internet Small Computer Systems Interface
- Send SCSI commands over an IP network

## Fibre Channel (FC)

- A specialized high-speed topology
- Connect servers to storage
- 2-, 4-, 8- and 16-gigabit per second rates
- Supported over both fiber and copper

## Fibre Channel over Ethernet (FCoE)

- Use Fibre Channel over an Ethernet network
- Non-routable

## Fibre Channel over IP (FCIP)

- Encapsulate Fibre Channel data into IP packets
- Geographically separate the servers from the storage

# Cloud Technologies

## Platform as a Service (PaaS)

- No servers, no software, no maintenance team, no HVAC
- Someone else handles the platform, you handle the product
- Salesforce.com

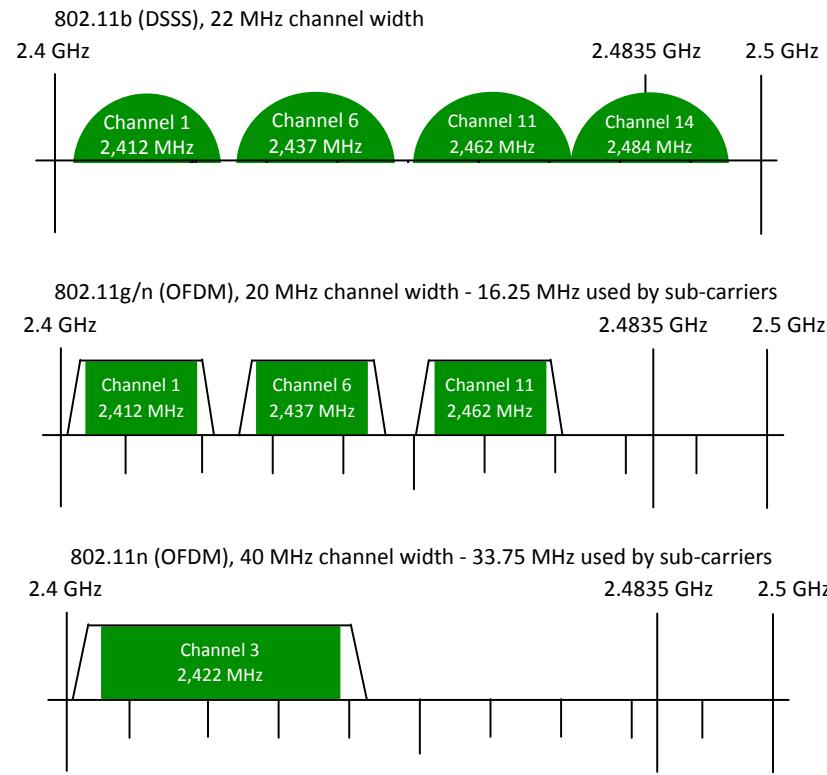
## Software as a Service (SaaS)

- On-demand software
- No local installation
- Google Mail

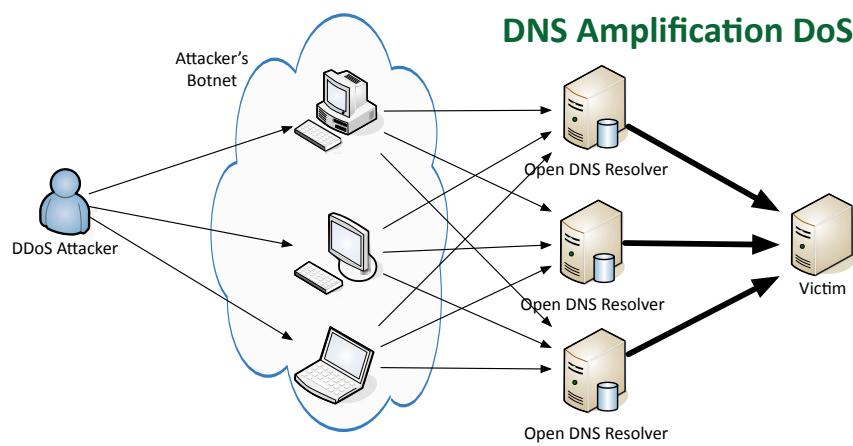
## Infrastructure as a service (IaaS)

- Sometimes called Hardware as a Service (HaaS)
- Outsource your equipment
- Web server and email server providers

# Non-Overlapping Channels for 2.4 GHz WLAN



## Denial of Service



## Wireless Security

### WEP

- 64-bit or 128-bit key size
- Cryptographic vulnerabilities found in 2001
- WEP can no longer be used

### WPA

- Short-term workaround after WEP
- Used RC4 cipher as a TKIP (Temporal Key Integrity Protocol)
- TKIP has its own vulnerabilities

### WPA2

- Replaced TKIP with CCMP (Counter Mode with Cipher Block Chaining Message Authentication Code Protocol)
- Replaced RC4 with AES (Advanced Encryption Standard)
- WPA2 is the latest and most secure wireless encryption method

### WPA2-Enterprise

- WPA2-Enterprise adds 802.1x
- RADIUS server authentication

## Power over Ethernet

### POE: IEEE 802.3af

- The original PoE specification
- Included in 802.3at, now part of 802.3-2012
- 15.4 watts DC power, maximum current of 350 mA

### POE+: IEEE 802.3at-2009

- The updated PoE specification
- Now also part of 802.3-2012
- 25.5 watts DC power, maximum current of 600 mA

## Insecure and Secure Protocols

### Communication protocols

- Insecure: SLIP (Serial Line Interface Protocol)
- Secure: IPsec - Internet Protocol Security

### Terminal communication

- Insecure: TELNET
- Secure: SSH - Secure Shell

### Browsers

- Insecure: HTTP - Hypertext Transport Protocol
- Secure: TLS/SSL - Transport Layer Security / Secure Sockets Layer

### File transfers

- Insecure: FTP, TFTP
- Secure: SFTP - Secure (SSH) File Transfer Protocol

### Network management

- Insecure: SNMPv1 and SNMPv2
- Secure: SNMPv3

## Switch Port Security

### DHCP Snooping

- IP tracking on a layer 2 device (switch)
- Switch watches for DHCP conversations
- Filters invalid IP and DHCP information

### Dynamic ARP inspection (DAI)

- Stops ARP poisoning at the switch level
- Relies on DHCP snooping for intel
- Intercept all ARP requests and responses
- Invalid IP-to-MAC address bindings are dropped

### MAC limiting and filtering

- Media Access Control - the physical Ethernet address
- Collect the MAC address of all devices
- MAC addresses are easily spoofed

### VLAN assignments

- Network segmentation
- The type of separation depends on the application
- Separate by VLAN

## Cryptographic Hash Functions

### MD5 (Message Digest Algorithm)

- 128-bit hash value
- 1996: Vulnerabilities found - not collision resistant

### SHA (Secure Hash Algorithm)

- A US Federal Information Processing Standard
- SHA-1
  - Widely used, 160-bit digest, 2005: Collision attacks published
- SHA-2
  - The preferred SHA variant, Up to 512-bit digests
  - SHA-1 is now retired for most US Government use

# User Authentication

## PAP (Password Authentication Protocol)

- Unsophisticated, insecure, clear text password exchange

## CHAP / MS-CHAP

- Challenge-Handshake Authentication Protocol
- Encrypted challenge sent over the network

## EAP

- Extensible Authentication Protocol
- Many different ways to authenticate based on RFC standards
- WPA and WPA2 use five EAP types as authentication mechanisms

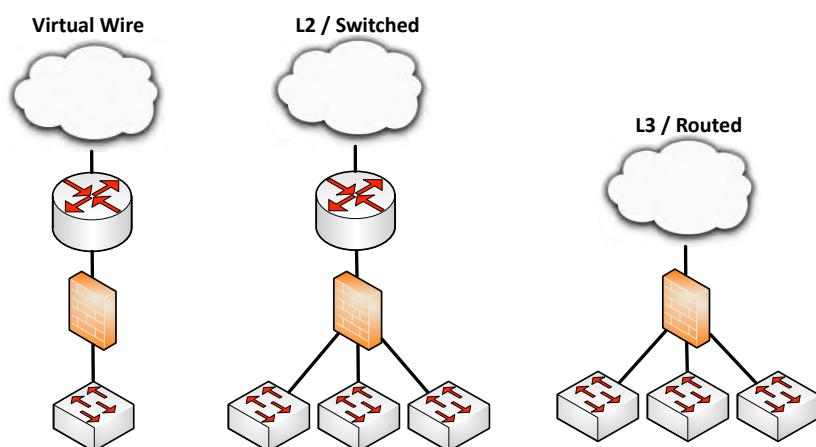
## PEAP

- Protected Extensible Authentication Protocol
- Created by Cisco, Microsoft, and RSA Security
- Encapsulates EAP in a TLS tunnel, one certificate on the server

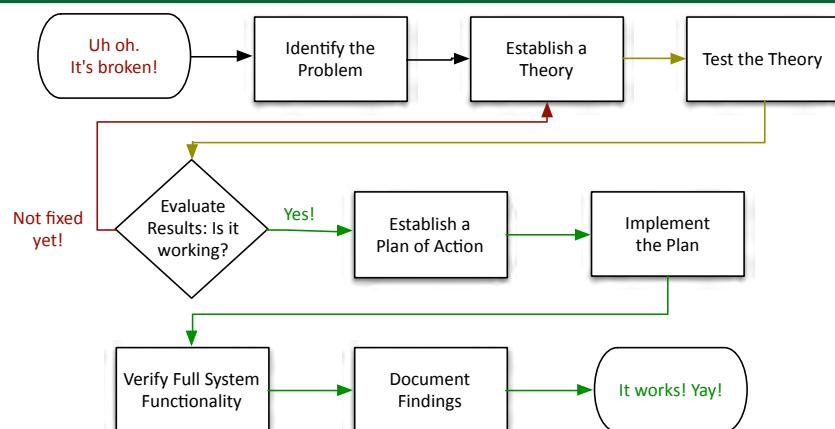
## Kerberos

- Authenticate once, trusted by the system
- No need to re-authenticate to everything
- Standard since the 1980s
- Microsoft starting using Kerberos in Windows 2000

## Firewall Connectivity



## The Network Troubleshooting Process



## Command Line Tools

### ipconfig and ifconfig - View and manage IP configuration

- `ipconfig` - Windows TCP/IP config
- `ipconfig /all` - Display all IP configuration details
- `ipconfig /release` - Release the DHCP lease
- `ipconfig /renew` - Renew the DHCP lease
- `ipconfig /flushdns` - Flush the DNS resolver cache
- `ifconfig` - Linux interface configuration

### netstat - Display network statistics

- `netstat -a` - Show all active connections
- `netstat -b` - Show binaries
- `netstat -n` - Do not resolve names

### ping - Test reachability

- `ping <ip address>` - Test reachability to a TCP/IP address
- `ping -t <ip address>` - Ping until stopped with Ctrl-c
- `ping -a <ip address>` - Resolve address to a hostname
- `ping -n <count> <ip address>` - Send # of echo requests
- `ping -f <ip address>` - Send with Don't Fragment flag set

### traceroute - Determine the route a packet takes to a destination

- Takes advantage of ICMP Time to Live Exceeded error message
- Not all devices will reply with ICMP Time Exceeded messages
- `traceroute <ip address>`

### nbtstat - Query NetBIOS over TCP/IP information

- `nbtstat -n` - List local NetBIOS names
- `nbtstat -A <ip address>` - List remote NetBIOS names
- `nbtstat -a <device name>` - List remote NetBIOS names

### nslookup and dig - Lookup information from DNS servers

- `nslookup <ip address>`
- `dig <ip address>`

### arp - Address resolution protocol information

- `arp -a` - View the local ARP table

### pathping - Combination of ping and traceroute

- `pathping <ip address>`

- Identify the problem
  - Information gathering, identify symptoms, question users
- Establish a theory of probable cause
- Test the theory to determine cause
- Establish a plan of action to resolve the problem and identify potential effects
- Implement the solution or escalate as necessary
- Verify full system functionality and, if applicable, implement preventative measures
- Document findings, actions and outcomes

## Physical Testing Tools



### Cable Tester

- Can identify missing pins or crossed wires
- Not generally used for frequency testing



### Multimeter

- AC/DC voltages
- Continuity, wire mapping



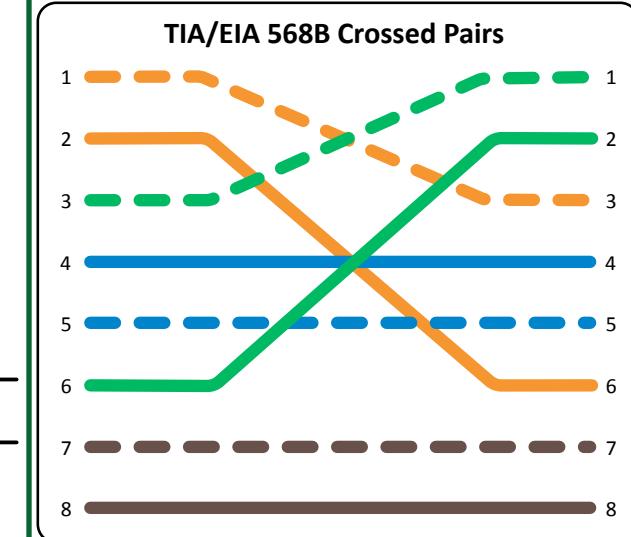
### Toner Probe

- Puts an analog sound on the wire
- Inductive probe doesn't need to touch the copper

### Protocol analyzer

- Capture and display network traffic
- Use a physical tap or redirect on the switch

# Troubleshooting Network Cabling



## The OSI Model

Layer 7 - Application	The layer we see - Google Mail, Twitter, Facebook
Layer 6 - Presentation	Encoding and encryption (SSL/TLS)
Layer 5 - Session	Communication between devices (Control protocols, tunneling protocols)
Layer 4 - Transport	The "post office" layer (TCP segment, UDP datagram)
Layer 3 - Network	The routing layer (IP address, router, packet)
Layer 2 - Data Link	The switching layer (Frame, MAC address, EUI-48, EUI-64, Switch)
Layer 1 - Physical	Signaling, cabling, connectors (Cable, NIC, Hub)

## The TCP/IP Model

Application	FTP, BOOTP, TFTP, DNS, HTTP(S), TLS/SSL, VoIP, SSH, POP3, IMAP4, NTP, Telnet, SMTP, SNMP
Transport	TCP, UDP
Internet	IPv4, IPv6, ICMP, IGMP
Link	ARP

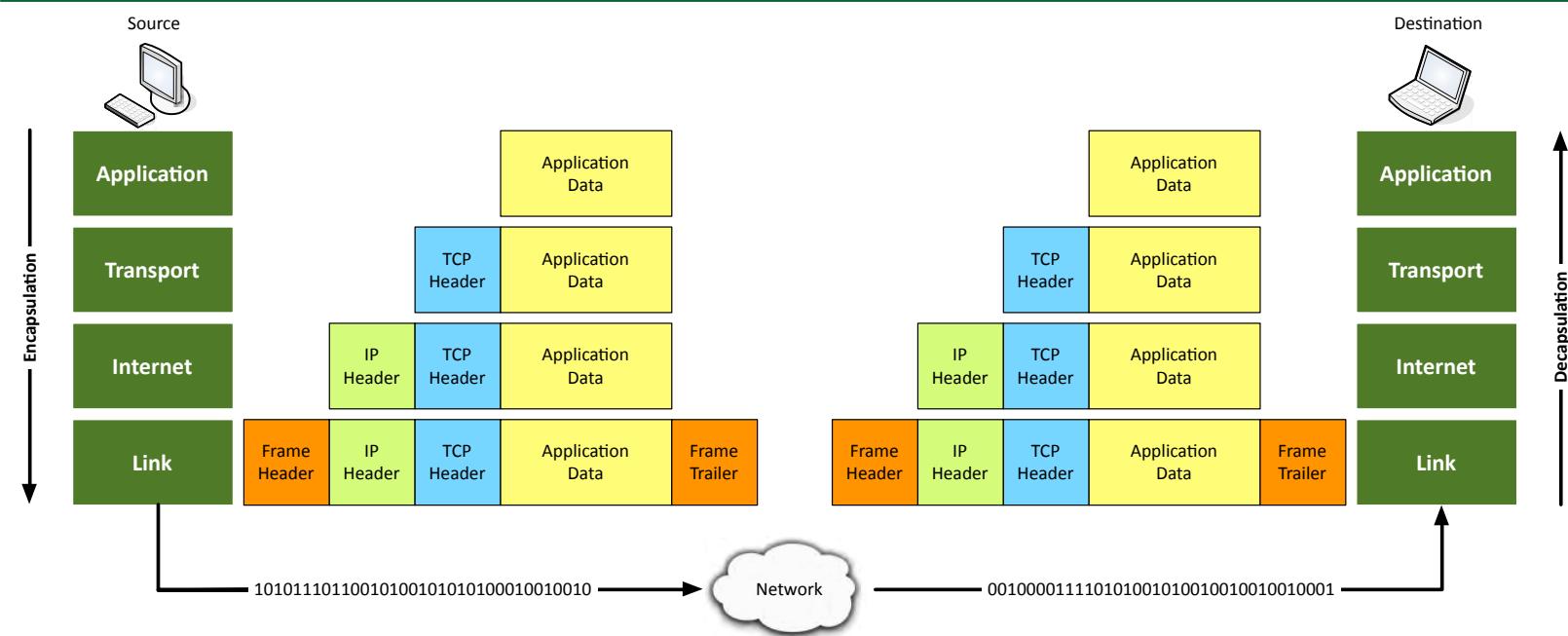
## OSI Mnemonics

- Please Do Not Trust Sales Person's Answers
- All People Seem To Need Data Processing
- Please Do Not Throw Sausage Pizza Away!

## Octal Conversion

4,096	512	64	8	1
$8^4$	$8^3$	$8^2$	$8^1$	$8^0$

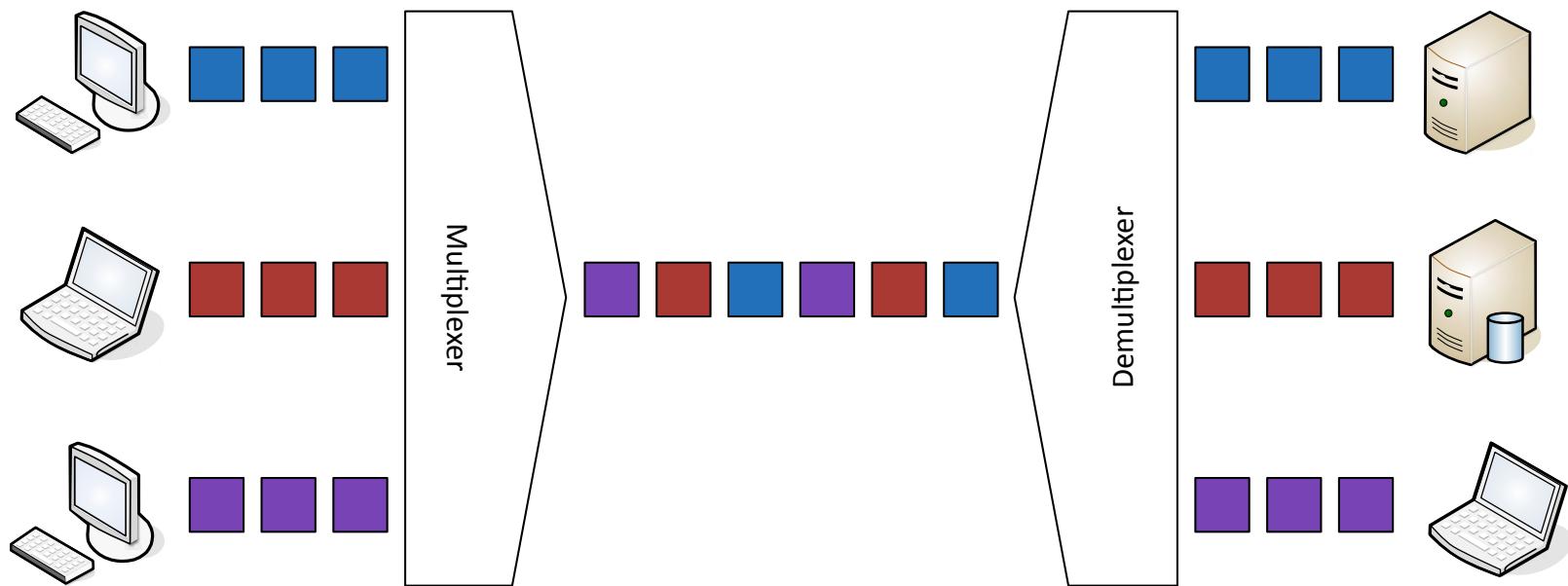
## Encapsulation and Decapsulation



## Binary Conversion

$2^{12}$	$2^{11}$	$2^{10}$	$2^9$	$2^8$	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
4,096	2,048	1,024	512	256	128	64	32	16	8	4	2	1

# Time-division Multiplexing (TDM)



## Hexadecimal Conversion

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	4,096	256	16	1
0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	$16^3$	$16^2$	$16^1$	$16^0$

## Wireless Standards

	Frequencies	Maximum allowable streams	Maximum theoretical throughput (per stream)	Maximum theoretical throughput (total)
802.11a	5 GHz	1	54 Mbit/s	54 Mbit/s
802.11b	2.4 GHz	1	11 Mbit/s	11 Mbit/s
802.11g	2.4 GHz	1	54 Mbit/s	54 Mbit/s
802.11n	5 GHz / 2.4 GHz	4	150 Mbit/s	600 Mbit/s
802.11ac	5 GHz	8	866.7 Mbit/s	6,934 Mbit/s

## Ethernet Standards

### 10 Mbit/s Ethernet

- 10BASE-2 - Coax / "Thinnet" over RG-58A/U, 185 meters
- 10BASE-T - Twisted pair copper, 100 meters

### 100 Mbit/s Ethernet

- 100BASE-TX - Category 5 twisted pair, 100 meters
- 100BASE-FX - Multimode fiber (2 km), Single-mode fiber (over 2 km)

### 1000 Mbit/s (1 Gbit/s) Ethernet

- 1000BASE-T - Category 5/5e, uses all pairs, 100 meters
- 1000BASE-TX - Category 5/5e, uses two pair, 100 meters - rarely seen
- 1000BASE-LX - Long wavelength fiber, over 5 kilometers
- 1000BASE-SX - Short wavelength fiber, 550 meter distance

### 10 Gbit/s Ethernet

- 10GBASE-T - Cat 6 (55 meters), Cat 6a (100 meters)
- 10GBASE-SR (Short Range) - Multimode fiber, 300 meters
- 10GBASE-ER (Extended Range) - Single-mode fiber, 40 km
- 10GBASE-SW - 10 gigabit Ethernet over SONET and SDH

### IEEE 1905.1 - Networking ubiquity for the home

- 802.11 wireless, power-line networks, Ethernet, and MoCA
- Power-line communication (PLC) - IEEE 1901 - 500 Mbit/s

### Ethernet over HDMI

- HEC - HDMI Ethernet Channel, 100 Mbit/s Ethernet
- Part of the HDMI specification

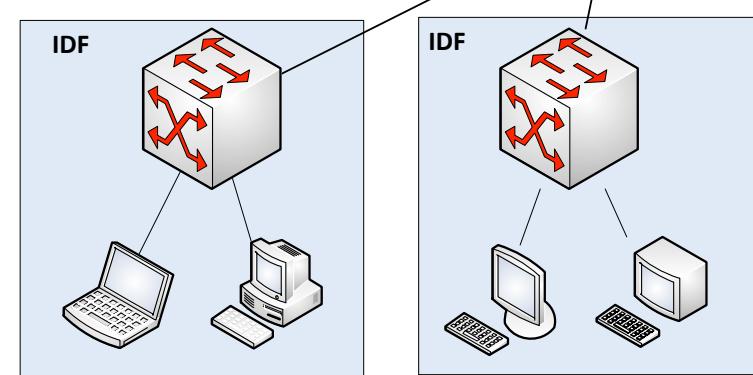
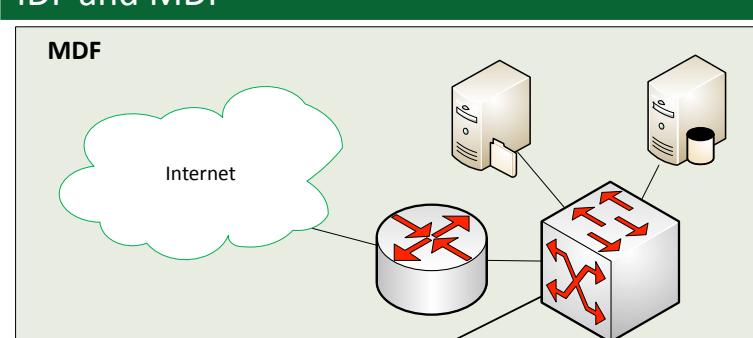
## CSMA/CD and CSMA/CA

### CSMA/CD

- CS - Carrier Sense - Is anyone communicating across the media
- MA - Multiple Access - More than one device on the network
- CD - Collision Detect - Determine if two stations talk at once
- Commonly seen on half-duplex Ethernet

### CSMA/CA

- CA - Collision Avoidance - Common on wireless networks
- Common to see Ready To Send (RTS) / Clear To Send (CTS)



# Ports and Protocols

Protocol	Port	Name	Description
<b>Common Network Protocols</b>			
ARP	-	Address Resolution Protocol	Resolve IP address to MAC
TCP	-	Transmission Control Protocol	Connection-oriented network communication
UDP	-	User Datagram Protocol	Connectionless network communication
<b>Common Network Management Protocols</b>			
DHCP	udp/67, udp/68	Dynamic Host Configuration Protocol	Update to BOOTP
DNS	udp/53, tcp/53	Domain Name System	Convert domain names to IP addresses
ICMP	-	Internet Control Message Protocol	Send management messages between devices
SNMP	udp/161	Simple Network Management Protocol	Gather statistics and manage network devices
Telnet	tcp/23	Telecommunication Network	Remote console login to network devices
SSH	tcp/22	Secure Shell	Encrypted console login
RDP	tcp/3389	Remote Desktop Protocol	Graphical display of remote device
<b>Common Application Protocols</b>			
FTP	tcp/20, tcp/21	File Transfer Protocol	Sends and receives files between systems
TFTP	udp/69	Trivial File Transfer Protocol	A very simple file transfer application
SMB	tcp/445	Server Message Block	Windows file transfers and printer sharing
SMTP	tcp/25	Simple Mail Transfer Protocol	Transfer email between mail servers
POP3	tcp/110	Post Office Protocol version 3	Receive mail into a mail client
IMAP4	tcp/143	Internet Message Access Protocol v4	A newer mail client protocol
HTTP	tcp/80	Hypertext Transfer Protocol	Web server communication
HTTPS	tcp/443	Hypertext Transfer Protocol Secure	Web server communication with encryption
TLS/SSL	tcp/443	Transport Layer Security and Secure Sockets Layer	Secure protocols for web browsing
NetBIOS	udp/137	NetBIOS name service	Register, remove, and find services by name
NetBIOS	udp/138	NetBIOS datagram service	Connectionless data transfer
NetBIOS	tcp/139	NetBIOS session service	Connection-oriented data transfer
<b>Voice over IP Protocols</b>			
SIP	tcp/5060-5061	Session Initiation Protocol	Voice over IP signaling protocol
RTP	dynamic	Real-time Transport Protocol	Voice over IP media stream
MGCP	udp/2427	Media Gateway Control Protocol - Gateway	Call Agent to Gateway
MGCP	udp/2727	Media Gateway Control Protocol - Call Agent	Gateway to Call Agent
H.323	tcp/1720	ITU Telecommunication H.32x protocol series	Voice over IP signaling

## Study Tips

### Exam Preparation

- Download the exam objectives, and use them as a master checklist
- Use as many training materials as possible. Books, videos, and Q&A guides can all provide a different perspective of the same information.
- It's useful to have some hands-on, especially with network troubleshooting commands.

### Taking the Exam

- Use your time wisely. You've got 90 minutes to get through everything.
- Choose your exam location carefully. Some sites are better than others.
- Get there early. Don't stress the journey.
- Manage your time wisely. You've got 90 minutes to get through everything.
- Wrong answers aren't counted against you. Don't leave any blanks!
- Mark difficult questions and come back later. You can answer the questions in any order.