Professor Messer's
CompTIA A+
220 –1001 Core 1
Course Notes

James "Professor" Messer

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A+ Course Notes

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http://www.ProfessorMesser.com

Professor Messer's CompTIA 220-1001 Core 1 A+ Course Notes
Written by James "Professor" Messer
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Trademark Acknowledgments

Warning and Disclaimer

Contents

Introduction

The CompTIA A+ certification requires a broad set of knowledge, and it covers more topics than many industry certifications. It's no surprise that the A+ certification has become one of the most sought-after industry certifications by both aspiring technologists and employers.

I hope this book helps you with your "last mile" of studies before taking your exam. There's a lot to remember, and perhaps some of the information in this book will help jog your memory while you're sitting in the exam room. Best of luck with your studies!

- Professor Messer

The CompTIA A+ Certification

CompTIA's A+ certification is considered to be the starting point for information technology professionals. Earning the A+ certification requires the completion of two exams and covers a broad range of technology topics. After earning the CompTIA A+ certification, an A+ certified professional will have an understanding of computer hardware, mobile devices, networking, operating systems, security techniques, and much more.

The current series of the A+ certification is based on the successful completion of the 220-1001 and the 220-1002 exams. You must pass both exams to earn your CompTIA A+ certification. This book provides a set of notes for the 220-1001 Core 1 exam.

The 220-1001 Core 1 exam
Much of the 220-1001 exam is about hardware, but that's only about a third of the overall exam content. You'll also need to know about networking, mobile devices, and how to troubleshoot all of these technologies.

Here's the breakdown of each domain on the 220-1001 exam:

Domain 1.0 - Mobile Devices - 14%
Domain 2.0 - Networking - 20%
Domain 3.0 - Hardware - 27%
Domain 4.0 - Virtualization and Cloud Computing - 12%
Domain 5.0 - Hardware and Network Troubleshooting - 27%

Study Tips

Exam Preparation
- Download the exam objectives, and use them as a master checklist: http://www.ProfessorMesser.com/objectives
- 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 as much hands-on as possible, especially with network troubleshooting and operating system command prompts.

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.

1.1 - Laptop Hardware

Laptop Storage
- SSD (Solid-state drive)
  - All memory, no moving parts
  - Silent, fast access time, less latency
  - 2.5 inch and 1.8 inch form factors
- Hybrid drive (SSHD)
  - Solid-state hybrid drive
  - Flash memory and hard drive storage
  - SSD caches the hard drive data
- Magnetic disk
  - Traditional spinning drive platters

Replacing Laptop Storage
- Can be very modular
  - Two screws and the drive slides out
- All internal
  - Open a cover on the back
  - Open the entire laptop

Laptop memory
- SO-DIMM
  - Small Outline Dual In-line Memory Module
- Micro-DIMM
  - Micro-Dual In-line Memory Module
- Memory used in laptops and mobile devices

Smart card reader
- Integrated card reader
  - Built into the laptop
- External reader
  - USB connected

Optical drive
- Too large for today's portable devices
  - Becoming difficult to find
- Often removable
  - Replace with other media
- Read and write CD-RW/CD-ROM and DVD-RW/DVD-ROM
  - In a portable device

Video Cards
- Often built into the processor
  - Not upgradable
- Sometimes part of the system board
  - Again, not upgradable
- Some laptops have upgradable video cards
  - Not the slimline models

Screen
- LCD (Liquid Crystal Display)
  - Light and high-resolution
- Very, very fragile - Get a good case!
- Resolutions are fixed
  - Changes to native resolution may look blurry or not as crisp

Laptop power – AC adapters
- Auto-switching or fixed input
  - Converts AC to DC
  - Input voltage - 110 volts / 220 volts
- DC jack on the laptop
  - Specific to the power supply type

Laptop power - batteries
- Lithium Ion (Li-ion)
  - Common in consumer electronics
  - No "memory effect"
  - Charging the battery diminishes capacity

Laptop frame
- Plastic
  - Lightweight, mobile
  - Durable, difficult to break
  - Inexpensive, cost-effective
- Metal
  - More durable than plastic
  - Can be more difficult to repair

Speaker
- Self-contained - Portable audio
- Not the highest quality - Very small
- Often stereo (L/R) - May include a subwoofer!

System board
- Proprietary
  - Built to fit
- Replacement isn't easy
  - Swap the entire board
  - Most components are on the system board

CPU
- Designed for mobility
  - Power management
- Integrated features
  - Memory controller, video controller
- Not very upgradable
  - Replaceable, but not upgradeable
- Often slower than desktops
  - Size and heat are disadvantages

Version 0x04

1.2 - Laptop Displays

Portable LCD
• Liquid crystal display - Light shines through liquid crystals
• Advantages
  • Lightweight
  • Relatively low power and relatively inexpensive
• Disadvantages
  • Black levels are a challenge
  • Requires separate backlight
    • Florescent, LED, etc. / Difficult to replace

OLED on laptops
• Organic Light Emitting Diode
  • Organic compound emits light when receiving an electric current
• Thinner and lighter
  • Flexible and mobile - no glass needed
• No backlight - The organic compound provides the light
• Not quite ready for laptops
  • Organic materials degrade over time
  • Decayed images can remain on the screen
  • More costly and power hungry than LCD

Wi-Fi antennas
• Multiple antennas - WiFi main and aux and Bluetooth
• Antenna wires wrap around the laptop screen

Laptop webcam
• Video capture - Built-in camera and microphone
• Usually includes both audio and video
  • Specialized drivers and software

Microphone
• Built-in to the laptop
  • Useful for video calls
• Not good for non-casual use
  • Analog or USB microphones can help

Backlight and inverter
• LCD displays need a backlight
  • Florescent lamp to LCD display to your eyes
• Some laptops have inverters
  • Convert DC into AC
• Verify backlight
  • Look closely
• May need to replace the LCD inverter or display
  • Choose carefully

Digitizer
• Use a pen-like device as input
  • Useful for graphical input
• Becoming more common on laptop / tablets
  • Or hybrid devices

Touchscreen
• Merge laptop and tablet input
  • No keyboard required
  • But often still available
• Many options for input
  • Use the best one for the job

1.3 - Laptop Features

Dual displays
• Toggle Fn keys
  • Secondary functions
  • Toggle between LCD / external monitor / both
• LCD switch
  • The "refrigerator door" effect
  • Physical switch on older systems
  • Internal magnetic switch on newer portable systems
  • Set functionality in the BIOS or utility

Wireless control
• Control your wireless signal
  • Airplane mode, secure areas
  • Look for a status light
• Physical switch
• Function key
• May include 802.11, Bluetooth, and cellular
  • Look for the symbol or status light

Volume settings
• Another function key
  • May be a standalone key
  • Often includes a mute option
• Physical dial or button
  • May see visual feedback

Screen brightness
• Control the backlight
  • Secondary function keys
• More light, more power
  • Conserve your battery

Keyboard backlight
• An option on many laptops
  • See in the dark
• Secondary function control
  • Intensity
  • Duration
  • Disable

Touch pad
• Enable and disable
  • Avoid inadvertent mouse clicks and movements

Screen orientation
• Rotate the screen
  • Useful on rotating tablet / laptops
  • Landscape to portrait
• Fn key or hotkey
  • Different across manufacturers

1.3 - Laptop Features (continued)

Media options
- Control audio and video from your keyboard
  - No mouse clicking
- Play, stop, rewind, fast forward
  - Mute, volume

GPS
- Listen for GPS signals
- May also be associated with airplane mode or other wireless settings

Docking station
- Docking station
  - Use external keyboard and mouse
  - Extend existing laptop interfaces
  - Add additional functionality
  - Desktop adapter cards
  - Avoid cable issues
- Port replicator
  - Similar to a docking station
  - Does not have an expansion card option

Physical laptop locks
- Keep your laptop from walking away
  - The bad guys are good at this
- Connect to a solid object
  - Nothing moves
- Laptops include metal-reinforced locking slots
  - Connect to the lock

Rotating / removable screens
- Combine a laptop keyboard with a tablet screen
- Presentation display
- May include a stylus for input

1.4 - Mobile Devices

Tablets
- Single-screen touch computers
  - iOS, Android, etc.
  - Larger than ~7 inches diagonal
- Designed for touch input
  - Virtual keyboards, drawing interfaces
- Application support
  - Productivity, games, utility, etc.
  - Specialized applications
- Media - Take pictures, watch movies

Smart Phones
- Mobile communication
  - Voice, email, text, instant message, pictures, video
  - ~ 3.5 inches to 5.5 inches diagonal
- Media viewer - Music, movies, videos
- Mobile applications
  - Maps, travel information
- Other apps
  - Productivity, games, specialized apps, etc.

Wearable technology
- Smart watches
  - An extension of your phone and body
- Fitness monitors
  - Track heart rate, steps, sleep patterns, and more

Virtual reality
- Replace reality with a computer-generated version
  - Input from the real world interacts with the virtual world
- Many different application
  - Gaming, industrial design, art
  - Enhanced video and image viewing

Augmented reality
- Overlay a virtual augmentation with the physical world
  - The computer provides additional detail
- Used in medical, travel, gaming

e-Readers
- Specialized device
  - Book reading - Some music, some apps
- Electronic paper
  - Black and white screen
  - Performs well in direct light
  - Exceptionally long battery life
- Network access - WiFi, cellular

GPS
- In-car navigation (and non-car)
- Requires a view of the sky - Need to receive GPS signal
- Periodic updates required
  - Over the air and memory card

1.5 - Mobile Device Connections

Micro-USB and mini-USB
- EU standardized on Micro-USB
  - Common now worldwide
- Older devices may use Mini-USB
  - Slightly larger

USB-C
- 24-pin double-sided USB connector
  - Used for both hosts and devices
- Acts as a USB 3.1 / USB 2.0 connection
  - Only the interface is different
- Includes an analog audio option
  - Headset support through a 3.5 mm jack

Mini-B Plug   **Micro-B Plug**   **Micro-B Plug**   **USB-C Plug**

Lightning plug

Lightning
- Apple proprietary
  - 8-pin digital signals
  - iPhone, iPad, iPod devices
- Some advantages over Micro-USB
  - Higher power output for phones and tablets
  - Can be inserted either way
  - Simpler design, more durable

Tethering
- Physically connect a device to your mobile phone
  - Use the Internet/data connection
- Enable Internet access from almost anywhere
  - May require service or configuration by wireless carrier

Proprietary mobile interfaces
- Early mobile technology was all about cables
  - One cable for power
  - A completely different cable for data
- Every manufacturer was different - Intentionally
- The EU changed things
  - Common external power supply for all data-enabled mobile phones sold in the European Union

NFC (Near Field Communication)
- Send small amounts of data wirelessly over a limited area
  - Built into your phone
  - Payment systems, transportation, in-person information exchange
- Access token, identity "card"
  - Short range with encryption support

Bluetooth
- High speed communication over short distances
  - PAN (Personal Area Network)
- Connects our mobile devices
  - Smartphones
  - Tethering
  - Headsets and headphones
  - Health monitors
  - Automobile and phone integration
  - Smartwatches
  - External speakers

Hotspot
- Turn your phone into a WiFi hotspot
  - Your own personal wireless router
  - Extend the cellular data network to all of your devices
- Dependent on phone type and provider
  - May require additional charges and data costs

IR (Infrared)
- Included on many smartphones, tablets, and smartwatches
  - Not really used for file transfers and printing
- Control your entertainment center
  - Almost exclusively IR

1.5 - Mobile Device Accessories

Headsets
- Hands-free audio - Earphones and microphone
- Wired
  - Connects to TRRS connector (Tip-Ring-Ring-Sleeve)
- Wireless - Bluetooth headsets

Speakers
- Mobile audio - Battery powered
- Wireless connection - Bluetooth link
- Stereo sound - Small package

Game Pads
- Gaming console feel - Mobile phone or tablet
- Connect with Bluetooth - Wireless connectivity

Extra battery packs / battery chargers
- Power is key - And in short supply
- Swappable battery pack
  - Carry an extra or two
- External USB chargers
  - Phones and tablets
  - And any other USB devices

Protective covers
- Screen protector
  - Avoid scratches
  - May be difficult to install
- Device protector
  - Wrap the entire device
  - Waterproofing options are available
  - Can create problems for docking stations

Credit card readers
- Phone or tablet becomes a point of sale terminal
  - Connections to audio/mic TRRS jack
  - Great for small and mobile businesses
- Uses the Internet link for approvals
  - Immediate feedback
- Additional features
  - Email receipts
  - Sign with your finger

Memory / microSD
- Increase storage capacity of smartphone or tablet
  - Common on Android devices
  - Not available on iOS devices
- MicroSD cards
  - Small form factor, with increasing capacities

SD memory card   **microSD memory card**

1.6 - Mobile Device Connectivity

Wireless / cellular data network
- Your phone has an Internet connection
  - Use your mobile provider network
  - Take advantage of this connectivity
- Hotspot
  - Turn your phone into a WiFi Router
  - You may have to pay extra phone charges
  - Other devices connect to your phone via WiFi

Wireless / cellular data network
- Tethering
  - Anchored to your mobile device
  - Connect your laptop via USB or Bluetooth
  - Single connection
  - May require additional services from phone provider

Wireless / cellular data network
- Airplane mode - One button turns off all radios
  - Cellular, WiFi, Bluetooth, NFC, etc.
- You can re-enable individual features without enabling cellular features
  - Useful when the airplane has WiFi

Wireless networks
- Enable and disable cellular, WiFi, and Bluetooth independently
  - Airplanes, conserve battery
- iOS - Settings / Cellular
- Android - Settings / Wireless & network settings

Bluetooth
- Short-range personal area network (PAN)
  - About 10 meters
- Connect different devices
  - Mouse, keyboard, headset, computer, automobile, speakers
- Once paired, devices work together
  - Connect and disconnect automatically

Bluetooth pairing process
- Enable Bluetooth on both devices
  - Android and iOS: Settings / Bluetooth
- Set devices to discoverable mode
  - May require key sequence on Bluetooth device
- Select discovered device
  - Many devices may appear!
- Enter or confirm PIN
  - Should be the same on both devices
- Test connectivity
  - Devices should now communicate

Your phone is a radio
- Baseband radio processor
  - A network interface for your radio
  - This isn't WiFi or Bluetooth
- Has its own firmware and memory
  - Quite proprietary
- Real-time operating system
  - Everything happens very quickly as needed
- The firmware can be updated
  - Over the air (OTA)
  - Invisible to the end user

Phone updates
- PRL updates
  - Preferred Roaming List
  - CDMA networks (i.e., Verizon, Sprint)
  - Allows your phone to connect to the right tower
  - Can be updated over the air (OTA)
- PRI updates
  - Product Release Instructions
  - Radio settings - ID numbers, network codes, country codes, etc.
  - Also updated over the air

IMEI

• International Mobile Station Equipment Identity

• Identifies a physical mobile device

• Every phone has a different IMEI

• Can be used to allow or disallow access

IMSI

• International Mobile Subscriber Identity

• Identifies the user of a mobile network

• Can be provisioned in the SIM card
  • Swap the SIM to move between phones

VPN

• Turn your phone into a VPN endpoint
  • Important for secure communication

• Integrated into the phone OS
  • No additional software required

• May require some additional setup
  • Detailed configuration settings

• May support multifactor authentication
  • RSA SecureID

1.6 - Configuring Email on Mobile Devices

Email configurations

• Retrieving mail - POP3, IMAP

• Sending mail - SMTP

• Corporate email - Microsoft Exchange

• Integrated providers
  • iCloud, Google, Exchange Online, Yahoo

Retrieving mail messages

• Post Office Protocol 3 (POP3)
  • Used for downloading mail to local mail client
  • Downloads and (optionally) deletes from server

• Configuration information
  • Name of POP3 server
  • Username and password

• Network ports
  • Defined by your mail provider
  • POP3: tcp/110
  • SSL (Secure Socket Layer) settings - POP3S: tcp/995

• Internet Message Access Protocol (IMAP4)
  • Access mail on a central server,
  • Mail is usually stored on the server
  • Supports folders and server-side searching

• Configuration information
  • Name of IMAP server
  • Username and password

• Network ports
  • Defined by your mail provider
  • IMAP: tcp/143
  • SSL (Secure Socket Layer) settings - IMAPS: tcp/993

Sending email

• SMTP - Simple Mail Transfer Protocol

• Send mail from a device to a mail server
  • Or between mail servers
  • You usually must send from a local or trusted device

• Authentication usually required
  • May be different credentials than the incoming mail

• Port numbers
  • SMTP (no authentication, relatively unused): tcp/25
  • SMTP with authentication: tcp/587

Microsoft Exchange

• Enterprise email
  • Not a service for the home

• More than just email
  • Contacts, Calendars, Reminders

• Integrates with mobile device database
  • Integrated contacts, calendars, etc.

• Configuration options
  • Email, server, domain, username, password

• Integrated message encryption with S/MIME
  • Secure/Multipurpose Internet Mail Extensions
  • Encrypt and digitally sign

Commercial email providers

• Gmail
  • Google email, splits inbox into tabs, IMAP4, POP3

• Exchange Online (hosted email)
  • IMAP4 and POP3 support

• iCloud Mail - Apple Mail, IMAP4 support only

• Yahoo Mail - IMAP4 and POP3 support

IMAP and POP incoming mail server configuration settings

SMTP outgoing mail server configuration settings

 http://www.ProfessorMesser.com

Synchronizing your data
- No single desktop
  - Many different devices
- Complete mobility
  - Access anything from anywhere
- Many different types of data
  - Email, calendar, apps, etc.
- All devices must stay synchronized
  - Most of it is invisible to us
- Mutual authentication
  - The client and server must authenticate with each other

Data Types
- Contacts
- Applications
- Email
- Pictures, music, video
- Calendar
- Bookmarks
- Documents
- Location data
- Social media data
- eBooks
- Passwords

Synchronize to the cloud
- Completely hands-off
  - No physical cables, no local files
  - May be integrated into your
  - Exchange or Gmail
  - Choose provider network and/or Wi-Fi
- Apple iOS
  - Sync all data types to iCloud
  - Complete backup and recovery
- Android
  - Configure your Google account

Synchronize to the desktop
- Application requirements - OS and disk space
- Operating System
  - Mac, Windows
  - Synchronize to the desktop
  - Relatively modern versions
- Memory - Relatively minimal
- Storage space
  - Enough to store backups, video, pictures
  - You'll need quite a bit
- iOS
  - Apple iTunes - syncs everything in the phone
  - Creates full backups on the computer
- Android
  - Syncs online with Google
  - Use third-party apps like doubleTwist to transfer movies and music

Synchronize to the automobile
- Connect to your automobile over Bluetooth or wired cable
  - Extends the phone functionality into the vehicle
- Display maps, control phone calls, play music
  - Big display screen, keep hands on the wheel
- iOS CarPlay, Android Auto
  - Synchronizes contact information, music, and other details
  - Shares phone information in real-time
  - This could be a security issue in a rental car

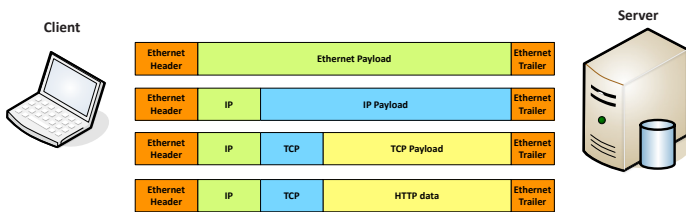**Synchronization connections**
- iOS
  - USB - Proprietary (30-pin or 8-pin Lightning)
  - USB-C
  - 802.11 wireless
  - Mobile network
- Android
  - USB Micro-B
  - USB-C
  - 802.11 wireless
  - Mobile network

USB Micro-B

Apple 8-pin Lightning

USB-C

Apple 30-pin

USB Standard Type-A

A series of moving vans

- Efficiently move large amounts of data
  - Use a shipping truck
- The network topology is the road
  - Ethernet, DSL, cable system
- The truck is the Internet Protocol (IP)
  - We've designed the roads for this truck
- The boxes hold your data
  - Boxes of TCP and UDP
- Inside the boxes are more things
  - Application information

Client **Server**

| Ethernet Header | Ethernet Payload | | | Ethernet Trailer |
Ethernet Header	IP	IP Payload		Ethernet Trailer
Ethernet Header	IP	TCP	TCP Payload	Ethernet Trailer
Ethernet Header	IP	TCP	HTTP data	Ethernet Trailer

TCP and UDP

- Transported inside of IP
  - Encapsulated by the IP protocol
- Two ways to move data from place to place
  - Different features for different applications
- OSI Layer 4
  - The transport layer
- Multiplexing
  - Use many different applications at the same time
 - TCP and UDP

TCP – Transmission Control Protocol

- Connection-oriented
  - A formal connection setup and close
- "Reliable" delivery
  - Recovery from errors
  - Can manage out-of-order messages or retransmissions
- Flow control
  - The receiver can manage how much data is sent

TCP - Transmission Control Protocol Communication

TCP Data →

← TCP ACK
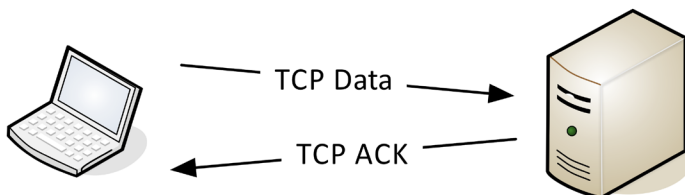
UDP - User Datagram Protocol Communication

UDP Data →
UDP Data →
UDP Data →
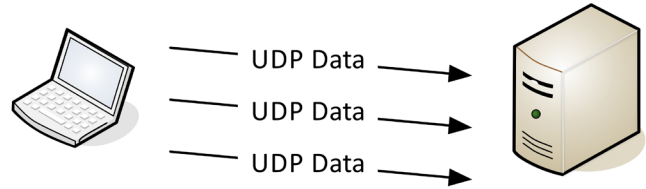
UDP – User Datagram Protocol

- Connectionless
  - No formal open or close to the connection
- "Unreliable" delivery
  - No error recovery
  - No reordering of data or retransmissions
- No flow control
  - Sender determines the amount of data transmitted

Speedy delivery

- The IP delivery truck delivers from one (IP) address to another (IP) address
  - Every house has an address, every computer has an IP address
- Boxes arrive at the house / IP address
  - Where do the boxes go?
  - Each box has a room name
- Port is written on the outside of the box
  - Drop the box into the right room

Lots of ports

- IPv4 sockets - Server IP address, protocol, server application port number
  - Client IP address, protocol, client port number
- Non-ephemeral ports – permanent port numbers
  - Ports 0 through 1,023
  - Usually on a server or service
- Ephemeral ports – temporary port numbers
  - Ports 1,024 through 65,535
  - Determined in real-time by the client

Port numbers

- TCP and UDP ports can be any number between 0 and 65,535
- Most servers (services) use non-ephemeral (not-temporary) port numbers
  - This isn't always the case
  - It's just a number.
- Port numbers are for communication, not security
- Service port numbers need to be "well known"
- TCP port numbers aren't the same as UDP port numbers

FTP – File Transfer Protocol
- tcp/20 (active mode data), tcp/21 (control)
  - Transfers files between systems
- Authenticates with a username and password
  - Some systems use a generic/anonymous login
- Full-featured functionality
  - List, add, delete, etc.

SSH - Secure Shell
- Encrypted communication link - tcp/22
  - Looks and acts the same as Telnet

Telnet
- Telnet – Telecommunication Network - tcp/23
- Login to devices remotely
- Console access
- In-the-clear communication
- Not the best choice for production systems

SMTP - Simple Mail Transfer Protocol
- Server to server email transfer - tcp/25
- Also used to send mail from a device to a mail server
  - Commonly configured on mobile devices and email clients
- Other protocols are used for clients to receive email
  - IMAP, POP3

DNS - Domain Name System
- Converts names to IP addresses - udp/53
  - www.professormesser.com = 162.159.246.164
- These are very critical resources
  - Usually multiple DNS servers are in production

HTTP and HTTPS
- Hypertext Transfer Protocol - tcp/80
  - Communication in the browser
  - And by other applications
- In the clear or encrypted - HTTPS - tcp/443
  - Supported by nearly all web servers and clients

POP / IMAP
- Receive emails from an email server
  - Authenticate and transfer
- POP3 - Post office Protocol version 3 - tcp/110
  - Basic mail transfer functionality
- IMAP4
  - Internet Message Access Protocol v4 - tcp/143
  - Includes management of email inbox from multiple clients

RDP - Remote Desktop Protocol
- Share a desktop from a remote location over tcp/3389
- Remote Desktop Services on many Windows versions
- Can connect to an entire desktop or just an application
- Clients for Windows, macOS, Linux, Unix, iPhone, Android, and others

SMB - Server Message Block
- Protocol used by Microsoft Windows
  - File sharing, printer sharing
  - Also called CIFS (Common Internet File System)
- Using NetBIOS over TCP/IP
  - udp/137 - NetBIOS name services (nbname)
  - udp/138 - NetBIOS datagram service (nbdatagram)
  - tcp/139 - NetBIOS session service (nbsession)
- Direct over tcp/445 (NetBIOS-less)
  - Direct SMB communication over TCP without the NetBIOS transport

AFP (Apple Filing Protocol)
- File services in macOS
  - tcp/548
- Works with SLP (Service Location Protocol)
  - tcp/427 and udp/427
  - Populates the list of available devices
- File management
  - Copy, move, delete files

DHCP - Dynamic Host Configuration Protocol
- Automated configuration of IP address, subnet mask and other options
  - udp/67, udp/68
  - Requires a DHCP server
  - Server, appliance, integrated into a SOHO router, etc.
- Dynamic / pooled
  - IP addresses are assigned in real-time from a pool
  - Each system is given a lease and must renew at set intervals
- DHCP reservation
  - Addresses are assigned by MAC address in the DHCP server
  - Quickly manage addresses from one location

LDAP (Lightweight Directory Access Protocol)
  - tcp/389
- Store and retrieve information in a network directory
  - Commonly used in Microsoft Active Directory

SNMP - Simple Network Management Protocol
- Gather statistics from network devices
  - Queries: udp/161
  - Traps: udp/162
- v1 – The original
  - Structured tables, in-the-clear
- v2 – A good step ahead
  - Data type enhancements
  - Bulk transfers, still in-the-clear
- v3 – A secure standard
  - Message integrity
  - Authentication, encryption

2.1 - Common Network Ports (continued)

Protocol	Port	Name	Description
FTP	tcp/20, tcp21	File Transfer Protocol	Sends and receives files between systems
SSH	tcp/22	Secure Shell	Encrypted console access
Telnet	tcp/23	Telecommunication Network	Insecure console access
SMTP	tcp/25	Simple Mail Transfer Protocol	Transfer email between mail servers
DNS	udp/53, tcp/53	Domain Name System	Convert domain names to IP addresses
HTTP	tcp/80	Hypertext Transfer Protocol	Web server communication
HTTPS	tcp/443	Hypertext Transfer Protocol Secure	Web server communication with encryption
POP3	tcp/110	Post Office Protocol version 3	Receive email into a email client
IMAP4	tcp/143	Internet Message Access Protocol v4	A newer email client protocol
RDP	tcp/3389	Remote Desktop Protocol	Graphical display of remote devices
NetBIOS	udp/137	NetBIOS name service	Register, remove, and find Windows services by name
NetBIOS	udp/138	NetBIOS datagram service	Windows connectionless data transfer
NetBIOS	tcp/139	NetBIOS session service	Windows connection-oriented data transfer
SMB	tcp/445	Server Message Block	Windows file transfers and printer sharing
AFP	tcp/548	Apple Filing Protocol	Mac OS file transfers
SLP	tcp/427, udp/427	Service Location Protocol	Find Mac OS services by name
DHCP	udp/67, udp/68	Dynamic Host Configuration Protocol	Automate the IP address configuration process
LDAP	tcp/389	Lightweight Directory Access Protocol	Directory services
SNMP	udp/161	Simple Network Management Protocol	Gather metrics and manage network devices

2.2 - Network Devices

Network Interface Card (NIC)
- The fundamental network device
  - Every device on the network has a NIC
  - Computers, servers, printers, routers, switches, phones, tablets, cameras, etc.
- Specific to the network type
  - Ethernet, WAN, wireless, etc.
- Often built-in to the motherboard
  - Or added as an expansion card
- Many options
  - Single port, multi-port, copper, fiber

Repeater
- Receive signal, regenerate, resend
  - No forwarding decisions to make
- Common use
  - Boost copper or fiber connections
  - Convert one network media to another
  - Extend wireless network reach

Hub
- "Multi-port repeater"
  - Traffic going in one port is repeated to every other port
- Everything is half-duplex
- Becomes less efficient as network speeds increase
- 10 megabit / 100 megabit
- Difficult to find today

Bridge
- Imagine a switch with two to four ports
  - Makes forwarding decisions in software
- Connects different physical networks
  - Can connect different topologies
  - Gets around physical network size limitations / collisions
- Distributes traffic based on MAC address
- A modern bridge is a wireless access point
  - Bridges wired Ethernet to wireless

Switches
- Bridging done in hardware
  - Application-specific integrated circuit (ASIC)
  - Forwards traffic based on data link address
- Many ports and features
  - The core of an enterprise network
  - May provide Power over Ethernet (PoE)
- Multilayer switch - Includes routing functionality

Unmanaged switches
- Very few configuration options
  - Plug and play
- Fixed configuration
  - No VLANs
- Very little integration with other devices
  - No management protocols
- Low price point
  - Simple is less expensive

Managed switches

- VLAN support
  - Interconnect with other switches via 802.1Q
- Traffic prioritization
  - Voice traffic gets a higher priority
- Redundancy support
  - Spanning Tree Protocol (STP)
- External management
  - Simple Network Management Protocol (SNMP)
- Port mirroring
  - Capture packets

Routers

- Routes traffic between IP subnets
  - Makes forwarding decisions based on IP address
  - Routers inside of switches sometimes called "layer 3 switches"
- Often connects diverse network types
  - LAN, WAN, copper, fiber

Wireless access point (WAP)

- Not a wireless router
  - A wireless router is a router and a WAP in a single device
- WAP is a bridge
  - Extends the wired network onto the wireless network
  - Makes forwarding decisions based on MAC address

Wireless LAN controllers

- Centralized management of WAPs
  - A single "pane of glass"
- Management functions
  - Deploy new access points
  - Performance and security monitoring
  - Configure and deploy changes to all sites
  - Report on access point use
- Usually a proprietary system
  - The wireless controller is paired with the access points
- Can also be cloud-based
  - Manage the console from anywhere

Firewalls

- Filters traffic by port number
  - OSI layer 4 (TCP/UDP)
  - Some firewalls can filter through OSI layer 7
- Can encrypt traffic into/out of the network
  - Protect your traffic between sites
- Can proxy traffic
  - A common security technique
- Most firewalls can be layer 3 devices (routers)
  - Usually sits on the ingress/egress of the network

Cable modem

- Broadband
  - Transmission across multiple frequencies
  - Different traffic types
- Data on the "cable" network
  - DOCSIS (Data Over Cable Service Interface Specification)
- High-speed networking
  - 4 Mbits/s through 250 Mbits/s are common
  - Gigabit speeds are possible
- Multiple services
  - Data, voice

DSL modem

- ADSL (Asymmetric Digital Subscriber Line)
  - Uses telephone lines
- Download speed is faster than the upload speed (asymmetric)
  - ~10,000 foot limitation from the central office (CO)
  - 52 Mbit/s downstream / 16 Mbit/s upstream are common
  - Faster speeds may be possible if closer to the CO

Patch panels

- Combination of punch-down blocks and RJ-45 connectors
- Runs from desks are made once
  - Permanently punched down to patch panel
- Patch panel to switch can be easily changed
  - No special tools
  - Use existing cables

Power over Ethernet

- Power provided on an Ethernet cable
  - One wire for both network and electricity
  - Phones, cameras, wireless access points
  - Useful in difficult-to-power areas
- Power provided at the switch
  - Built-in power - Endspans
  - In-line power injector - Midspans

PoE switch

- Power over Ethernet
  - Commonly marked on the switch or interfaces

Ethernet over Power (EOP)

- Also called Power-line communication (PLC)
  - IEEE standard 1901
- 500 megabits per second
  - Standard includes links to the premise, intra-building networking, vehicles, smart energy devices, and more

The SOHO router
- An all-in-one device
  - Modem, router, switch, wireless AP, firewall, etc.

Routing and switching
- Routing to the outside world
  - WAN / DSL port
- Switching local devices
  - One VLAN / LAN1, LAN2, LAN3, LAN4, etc.
- Not much to configure
  - Routes and switches by default

Access point settings
- Enable/disable frequencies
  - 2.4 GHz and/or 5 GHz
  - Available options will depend on the wireless standard used
- Configure an SSID
  - May need a separate SSID for each frequency
- Security mode
  - WPA2, preferably
  - Pre-shared key or Enterprise
- Channel / channel bandwidth
  - Automatic / other nearby networks

IP addressing
- WAN interface
  - Automatically assigned via DHCP from the ISP
  - May require authentication
- LAN interface
  - Internal IP address and subnet mask of the router
  - DHCP address range for other devices
  - DNS server addresses

NIC configuration
- Wired
  - May not have many options
  - Ports configured for auto speed and duplex
  - Speed: 10/100/1000
  - Duplex: Half/Full
- Wireless
  - Enable/disable

End-user device configuration
- Automatic
  - Auto speed and duplex
  - DHCP addressing
- End-user device configures based on router
  - IP address
  - Subnet mask
  - Default gateway
  - DNS servers

IoT configurations
  - Internet of Things
- Home automation, mostly wireless
  - Security is an issue
- Devices
  - Thermostat
  - Light switches
  - Security cameras
  - Door locks
  - Voice-enabled smart speakers / digital assistants
- Almost all devices communicate outbound
  - No special port-mapping or NAT configurations required

Firewall and DMZ ports
- Every SOHO router is also a firewall
  - No external device can directly access the internal network
  - This normally can't be disabled
- DMZ ports can be configured to allow unrestricted access
  - This is almost always a bad idea
  - Consider creating more specific port forwarding rules
  - Or perhaps don't allow any access

NAT (Network Address Translation)
- It is estimated that there are over 20 billion devices connected to the Internet (and growing)
  - IPv4 supports around 4.29 billion addresses
- The address space for IPv4 is exhausted
  - There are no available addresses to assign
- How does it all work?
  - Network Address Translation
- This isn't the only use of NAT
  - NAT is handy in many situations

Configuring NAT
- For SOHO devices, this is automatic
  - Source NAT, also called PAT (Port Address Translation)
  - All internal devices are translated to a single external address

Port forwarding
- 24x7 access to a service hosted internally
  - Web server, gaming server, security system, etc.
- External IP/port number maps to an internal IP/port
  - Does not have to be the same port number
- Also called Destination NAT or Static NAT
  - Destination address is translated from a public IP to a private IP
  - Does not expire or timeout
  - Port forwarding

UPnP (Universal Plug and Play)
- Allows network devices to automatically configure and find other network devices
  - Zero-configuration
- Applications on the internal network can open inbound ports using UPnP
  - No approval needed
  - Used for many peer-to-peer (P2P) applications
- Best practice would be to disable UPnP
  - Only enable if the application requires it
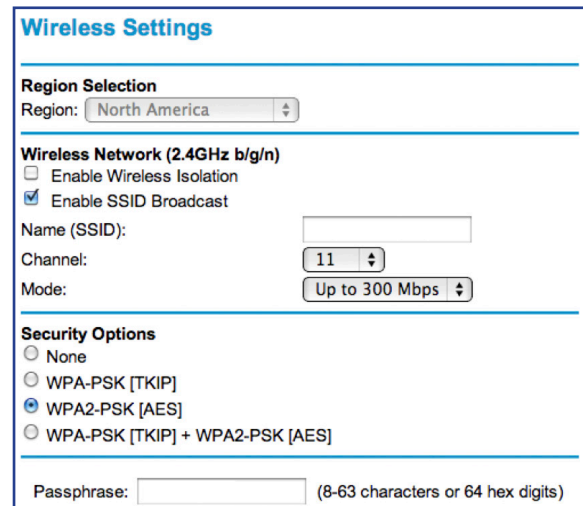 - And maybe not even then

Whitelist/blacklist
- Content filtering, IP address ranges
  - Or a combination
- Whitelisting
  - Nothing pass through the firewall unless it's approved
  - Very restrictive
- Blacklisting
  - Nothing on the "bad list" is allowed
  - Specific URLs
  - Domains
  - IP addresses

MAC filtering
- Media Access Control
  - The "hardware" address
- Limit access through the physical hardware address
  - Keeps the neighbors out
  - Additional administration with visitors
- Easy to find working MAC addresses through wireless LAN analysis
  - MAC addresses can be spoofed
  - Free open-source software
- Security through obscurity

Wireless channels and encryption
- Configure for the highest encryption possible
  - WPA2-AES
  - Choose WPA2 over WPA
  - WEP is not an appropriate option
- Check your devices
  - Not all of them may allow for the highest encryption
- Use an open frequency
  - Some access points will automatically find good frequencies

Managing QoS (Quality of Service)
- Change the priority of your traffic
  - Voice is high, World of Warcraft is low
  - Or vice-versa
- Prioritize applications, ports, or MAC addresses
  - A feature of high-end SOHO routers
- Be careful
  - You could accidentally cause applications to slow down

2.4 - 802.11 Wireless Standards

Wireless Standards
- Wireless networking (802.11)
  - Managed by the IEEE LAN/MAN Standards Committee (IEEE 802)
- Many updates over time
  - Check with IEEE for the latest
- The Wi-Fi trademark
  - Wi-Fi Alliance handles interoperability testing

802.11a
- One of the original 802.11 wireless standards
  - October 1999
- Operates in the 5 GHz range
- 54 megabits per second (Mbit/s)
- Smaller range than 802.11b
  - Higher frequency is absorbed by objects in the way
  - Many rules-of-thumb calculate 1/3rd the range of 802.11b or 802.11g

802.11b
- Also an original 802.11 standard - October 1999
- Operates in the 2.4 GHz range
- 11 megabits per second (Mbit/s)
- Better range than 802.11a
  - Less absorption problems
- More frequency conflict
  - Baby monitors, cordless phones, microwave ovens, Bluetooth

802.11g
- An "upgrade" to 802.11b - June 2003
- Operates in the 2.4 GHz range
- 54 megabits per second (Mbit/s)
  - Same as 802.11a (but a little bit less throughput)
- Backwards-compatible with 802.11b
- Same frequency conflict problems as 802.11b

802.11n
- The update to 802.11g, 802.11b, and 802.11a
  - October 2009
- Operates at 5 GHz and/or 2.4 GHz
  - 40 MHz channel widths
- 600 megabits per second (Mbit/s)
  - 40 MHz mode and 4 antennas
- 802.11n uses MIMO
  - Multiple-input multiple-output
  - Multiple transmit and receive antennas

802.11ac
- Approved in January 2014
  - Significant improvements over 802.11n
- Operates in the 5 GHz band
  - Less crowded, more frequencies
    (up to 160 MHz channel bandwidth)
- Increased channel bonding - Larger bandwidth usage
- Denser signaling modulation - Faster data transfers
- Eight MU-MIMO streams
  - Twice as many streams as 802.11n
  - Nearly 7 gigabits per second

	Frequencies	Maximum MIMO streams	Maximum theoretical throughput (per stream)	Maximum theoretical throughput (total)
802.11a	5 GHz	Not applicable	54 Mbit/s	54 Mbit/s
802.11b	2.4 GHz	Not applicable	11 Mbit/s	11 Mbit/s
802.11g	2.4 GHz	Not applicable	54 Mbit/s	54 Mbit/s
802.11n	5 GHz and/or 2.4 GHz	4 MIMO	150 Mbit/s	600 Mbit/s
802.11ac	5 GHz	8 MU-MIMO	866.7 Mbit/s	~6.8 Gbit/s

2.4 - Wireless Network Technologies

802.11 technologies
- Frequency
  - 2.4 GHz or 5 GHz (and sometimes both)
- Channels
  - Groups of frequencies, numbered by the IEEE
  - Non-overlapping channels would be necessary
- Bandwidth
  - Amount of frequency in use
  - 20 MHz, 40 MHz, 80 MHz, 160 MHz

802.11 channel bandwidths
- 802.11a - 20 MHz
- 802.11b - 22 MHz
- 802.11g - 20 MHz
- 802.11n
  - 20 MHz or 40 MHz
    (two contiguous 20 MHz bonded channels)
  - In 2.4 GHz, a 40 MHz channel uses
    much of the available bandwidth
- 802.11ac
  - 40 MHz for 802.11n stations
  - 80 MHz required for 802.11ac stations
  - 160 MHz optional (contiguous channels or non-contiguous bonded channels)

Bluetooth
- High speed communication over short distances
  - PAN (Personal Area Network)
- Connects our mobile devices
  - Smartphones
  - Tethering and file transfers
  - Headsets and headphones
  - Health monitors
  - Automobile and phone integration
  - Smartwatches
  - External speakers

Near field communication (NFC)
- Two-way wireless communication
  - Builds on RFID, which is mostly one-way
- Payment systems
  - Major credit cards
  - Online wallets
- Bootstrap for other wireless
  - NFC helps with Bluetooth pairing
- Access token, identity "card"
  - Short range with encryption support

RFID (Radio-frequency identification)
- It's everywhere
  - Access badges
  - Inventory/Assembly line tracking
  - Pet/Animal identification
  - Anything that needs to be tracked
- Radar technology
  - Radio energy transmitted to the tag
  - RF powers the tag, ID is transmitted back
  - Bidirectional communication
 - Some tag formats can be active/powered

Zigbee
- Internet of Things networking
  - Open standard - IEEE 802.15.4 PAN
- Alternative to WiFi and Bluetooth
  - Longer distances than Bluetooth
  - Less power consumption than WiFi
- Mesh network of all Zigbee devices in your home
  - Light switch communicates to light bulbs
  - Tell Amazon Echo to lock the door
- Uses the ISM band
  - Industrial, Scientific, and Medical
  - 900 MHz and 2.4 GHz frequencies in the US

Z-Wave
- Proprietary home automation networking
  - Internet of Things (IoT)
  - Control lights, locks, garage doors, etc.
- Wireless mesh networking
  - Nodes can hop through other nodes on the way to the destination
- Uses the ISM band
  - Industrial, Scientific, and Medical
  - 900 MHz frequencies in the US
  - No conflicts with 802.11

2.4 GHz Spectrum for 802.11 - North America
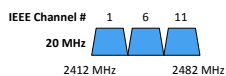
5 GHz Spectrum for 802.11 - North America
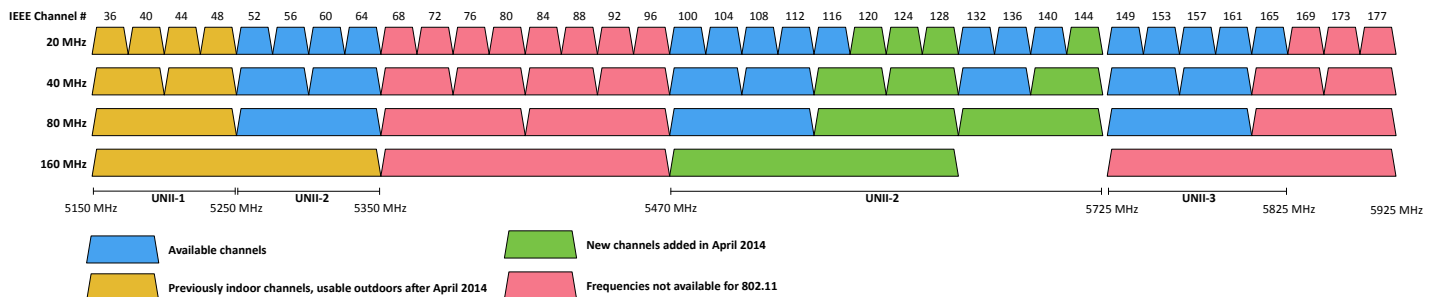
Cellular networks
- Mobile devices
  - "Cell" phones
- Separate land into "cells"
  - Antenna coverages a cell with certain frequencies
- 2G networks
  - GSM - Global System for Mobile Communications
  - CDMA - Code Division Multiple Access
- Poor data support
  - Originally used circuit-switching
  - Minor upgrades for some packet-switching

3G technology
- 3rd Generation
  - Introduced in 1998
- Upgraded data connectivity over 2G
  - Incremental 3G updates improved speeds
  - Usually several megabits per second
- Bandwidth improvement allowed new functionality
  - GPS
  - Mobile television
  - Video on demand
  - Video conferencing

4G and LTE
- Long Term Evolution (LTE)
  - A "4G" technology
  - Converged standard (GSM and CDMA providers)
  - Based on GSM and
  - EDGE (Enhanced Data Rates for GSM Evolution)
  - Standard supports download rates of 150 Mbit/s
- LTE Advanced (LTE-A)
  - Standard supports download rates of 300 Mbit/s

Moving to 5G
- Update to 4G - Rollout in late 2018 and 2019
  - Worldwide launches in 2020
- Significant performance improvements
  - At higher frequencies
  - May not be as significant at lower frequencies
- Technology updates
  - Additional frequencies
  - Improved data transmission methods

2.5 - Network Services

Web server
- Respond to browser requests
  - Using standard web browsing protocols
  - HTML, HTML5
- Web pages are stored on the server
  - Downloaded to the browser
  - Static pages or built dynamically in real-time

File server
- Centralized storage of documents, spreadsheets, videos, pictures, and any other files
- Standard system of file management
  - SMB (Server Message Block),
  - Apple Filing Protocol (AFP), etc.
- The front-end hides the protocol
  - Copy, delete, rename, etc.

Print server
- Connect a printer to the network
  - Provide printing services for all network devices
- May be software in a computer
  - Computer is connected to the printer
- May be built-in to the printer
  - Network adapter and software
- Uses standard printing protocols
  - SMB (Server Message Block),
  - IPP (Internet Printing Protocol),
  - LPD (Line Printer Daemon)

DHCP server
- Dynamic Host Configuration Protocol
  - Automatic IP address configuration
- Very common service
  - Available on most home routers
- Enterprise DHCP will be redundant
  - Usually running on central servers

DNS server
- Domain Name System
  - Convert names to IP addresses
  - And vice versa
- Distributed naming system
  - The load is balanced across many different servers
- Usually managed by the ISP or enterprise IT department
  - A critical resource

Proxy server
- An intermediate server
  - Client makes the request to the proxy
  - The proxy performs the actual request
  - The proxy provides results back to the client
- Useful features
  - Access control, caching,
  - URL filtering, content scanning

Mail server
- Store your incoming mail
  - Send your outgoing mail
- Usually managed by the ISP or the enterprise IT department
  - A complex set of requirements
- Usually one of the most important services
  - 24 x 7 support

Authentication server
- Login authentication to resources
  - Centralized management
- Almost always an enterprise service
  - Not required on a home network
- Usually a set of redundant servers
  - Always available
  - Extremely important service

SIEM
- Security Information and Event Management
  - Logging of security events and information
- Security alerts
  - Real-time information
- Log aggregation and long-term storage
  - Usually includes advanced reporting features
- Data correlation
  - Link diverse data types
- Forensic analysis
  - Gather details after an event

2.5 - Network Services (continued)

Syslog
- Standard for message logging
  - Diverse systems, consolidated log
- Usually a central logging receiver
  - Integrated into the SIEM
- You're going to need a lot of disk space
  - No, more. More than that.
- WORM drive technology
  - Write Once Read Many - DVD-R
  - Protect important security logs

IDS and IPS
- Network-based Intrusion Detection System / Intrusion Prevention System
- Intrusions
  - Exploits against operating systems, applications, etc.
  - Buffer overflows, cross-site scripting, other vulnerabilities
- Detection vs. Prevention
  - Detection – Alarm or alert
  - Prevention – Stop it before it gets into the network

All-in-one security appliance
- Next-generation firewall, Unified Threat Management (UTM) / Web security gateway
- URL filter / Content inspection
- Malware inspection, spam filter, CSU/DSU, router, switch, firewall, IDS/IPS, bandwidth shaper, VPN endpoint

Endpoint management server
- Manage all devices from one pane of glass
  - Software installations, driver installations, software updates, security patches, remote troubleshooting
- Requires an agent on the device
  - Server sends the commands
  - Agent executes the commands

Legacy and embedded systems
- Legacy systems
  - Another expression for "really old"
  - May also be "really important"
  - Learning old things can be just as important as learning the new things
- Embedded systems
  - Purpose-built device
  - Not usual to have direct access to the operating system
  - Alarm system, door security, timecard system
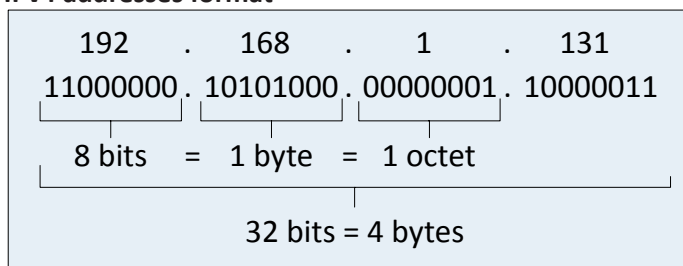
2.6 - An Overview of IPv4 and IPv6

IP addressing
- IPv4 is the primary protocol for everything we do
  - You probably won't configure anything else
  - IPv6 is slowly appearing

IPv4 addresses
- Internet Protocol version 4
  - OSI Layer 3 address

IPv4 addresses format

```
   192   .   168   .    1    .   131
11000000 . 10101000 . 00000001 . 10000011

  8 bits  =  1 byte  =  1 octet

          32 bits = 4 bytes
```
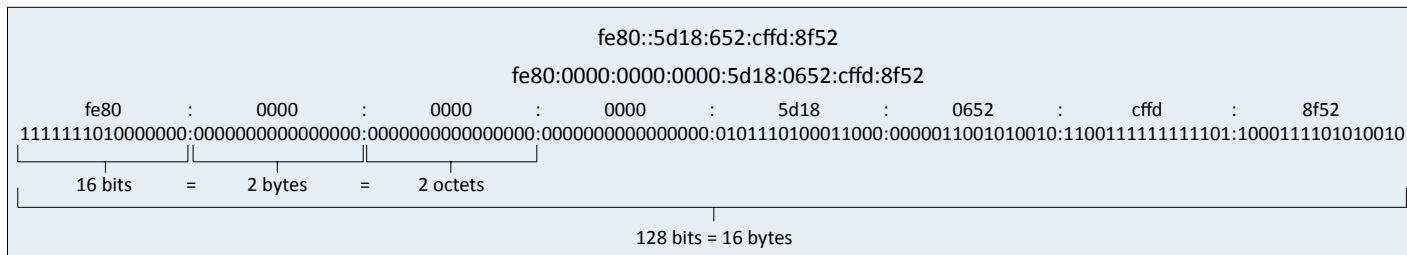
IPv6 addresses
- Internet Protocol v6 - 128-bit address
  - 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses (340 undecillion)
  - 6.8 billion people could have 5,000,000,000,000,000,000,000,000,000 addresses each

Networking with IPv4
- IP Address, e.g., 192.168.1.165
  - Every device needs a unique IP address
- Subnet mask, e.g., 255.255.255.0
  - Used by the local device to determine its subnet
  - The subnet mask isn't (usually) transmitted across the network
- Default gateway, e.g., 192.168.1.1
  - The router that allows you to communicate outside of your local subnet
  - The default gateway must be an IP address on the local subnet

IPv6 addresses format

fe80::5d18:652:cffd:8f52
fe80:0000:0000:0000:5d18:0652:cffd:8f52

| fe80 | : | 0000 | : | 0000 | : | 0000 | : | 5d18 | : | 0652 | : | cffd | : | 8f52 |

1111111010000000:0000000000000000:0000000000000000:0000000000000000:0101110100011000:0000011001010010:1100111111111101:1000111101010010

16 bits = 2 bytes = 2 octets

128 bits = 16 bytes

DNS servers
- We remember names
  - professormesser.com, google.com, youtube.com
- Internet routers don't know names
  - Routers only know IP addresses

- Something has to translate between names and IP addresses
  - Domain Name Services
- You configure TWO DNS servers in your IP configuration
  - That's how important it is

2.6 - Assigning IP Addresses

DHCP
- IPv4 address configuration used to be manual
  - IP address, subnet mask, gateway, DNS servers, NTP servers, etc.
- October 1993 - The bootstrap protocol - BOOTP
- BOOTP didn't automatically define everything
  - Some manual configurations were still required
  - BOOTP also didn't know when an IP address might be available again
- Dynamic Host Configuration Protocol
  - Initially released in 1997, updated through the years
  - Provides automatic address / IP configuration for almost all devices

The DHCP Process
- Step 1: Discover
- Step 2: Offer
- Step 3: Request
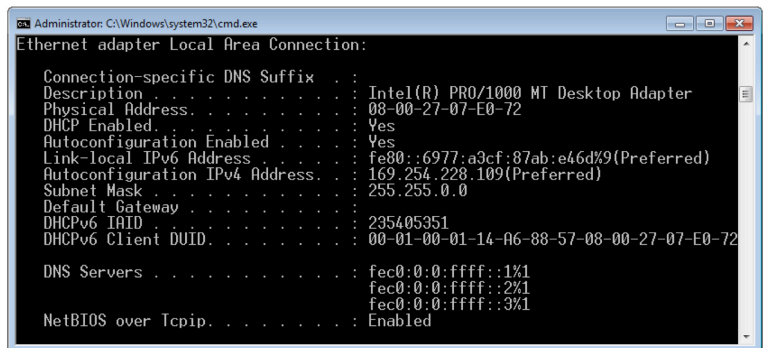- Step 4: Acknowledge

Turning dynamic into static
- DHCP assigns an IP address from the first available from a large pool of addresses
  - Your IP address will occasionally change
- You may not want your IP address to change
  - Server, printer, or personal preference
- Disable DHCP on the device
  - Configure the IP address information manually
  - Requires additional administration
- Configure an IP reservation on the DHCP server
  - Associate a specific MAC address with an IP address

Automatic Private IP Addressing (APIPA)
- A link-local address
  - No forwarding by routers
- IETF has reserved 169.254.0.1 through 169.254.255.254
  - First and last 256 addresses are reserved
  - Functional block of 169.254.1.0 through 169.254.254.255
- Automatically assigned
  - Uses ARP to confirm the address isn't currently in use

IPv6 link-local addresses
- A non-routable local network address
  - Will only work on the local subnet
- Required on every IPv6-enabled interface
  - You may see many IPv6 addresses per interface
- fe80::/10 with only one subnet allocated (all zeros)
  - Effectively becomes fe80::/64
- The last 64 bits are usually created with a modified EUI-64
  - Based on the MAC address

```
Administrator: C:\Windows\system32\cmd.exe

Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Intel(R) PRO/1000 MT Desktop Adapter
   Physical Address. . . . . . . . . : 08-00-27-07-E0-72
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   Link-local IPv6 Address . . . . . : fe80::6977:a3cf:87ab:e46d%9(Preferred)
   Autoconfiguration IPv4 Address. . : 169.254.228.109(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.0.0
   Default Gateway . . . . . . . . . :
   DHCPv6 IAID . . . . . . . . . . . : 235405351
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-14-A6-88-57-08-00-27-07-E0-72

   DNS Servers . . . . . . . . . . . : fec0:0:0:ffff::1%1
                                       fec0:0:0:ffff::2%1
                                       fec0:0:0:ffff::3%1
   NetBIOS over Tcpip. . . . . . . . : Enabled
```

2.6 - Using IP Addresses

SSL VPN (Secure Sockets Layer VPN)
- Uses common SSL/TLS protocol (tcp/443)
  - Avoids running into most firewall issues
- No big VPN clients
  - Usually remote access communication
- Authenticate users
  - No requirement for digital certificates or shared passwords (like IPSec)
- Can be run from a browser or from a (usually light) VPN client
  - Across many operating systems

Configuring VLANs
- Local Area Networks
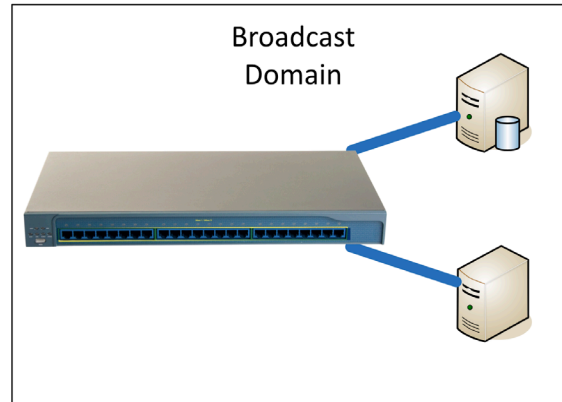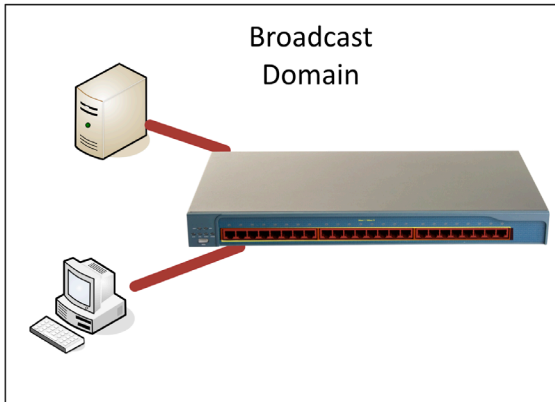 - A group of devices in the same broadcast domain

NAT (Network Address Translation)
- It is estimated that there are over 20 billion devices connected to the Internet (and growing)
  - IPv4 supports around 4.29 billion addresses
- The address space for IPv4 is exhausted
  - There are no available addresses to assign
- How does it all work?
  - Network Address Translation
- This isn't the only use of NAT
  - NAT is handy in many situations
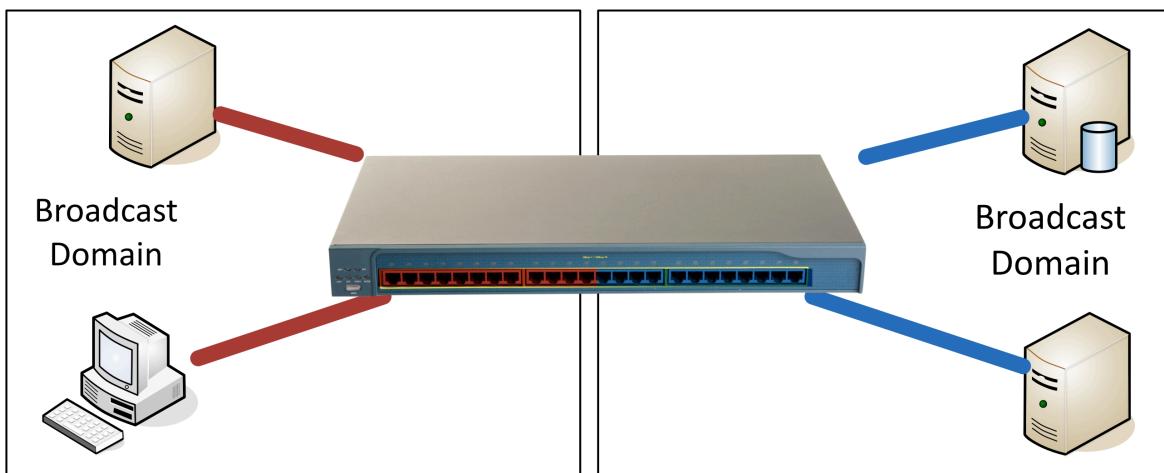
LANs
- Local Area Networks
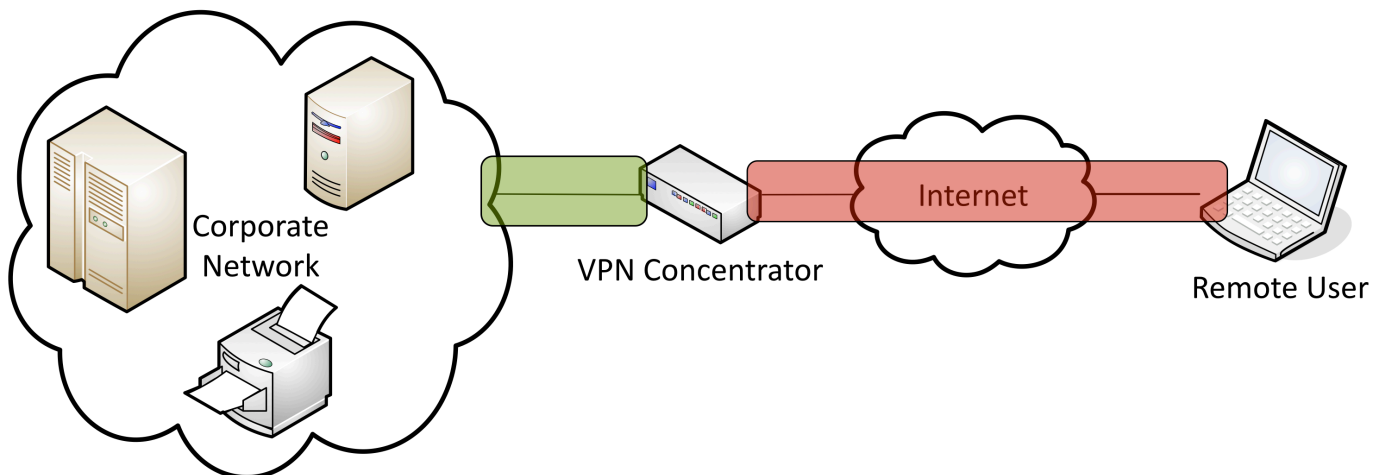 - A group of devices in the same broadcast domain

Virtual LANs
- Virtual Local Area Networks
  - A group of devices in the same broadcast domain
  - Separated logically instead of physically

Client-to-Site VPNs
- Also called "remote access VPN"
- Requires software on the user device
  - May be built-in to existing operating system

2.7 - Internet Connection Types

Cable modem
- Broadband
  - Transmission across multiple frequencies
  - Different traffic types
- Data on the "cable" network
  - DOCSIS (Data Over Cable Service Interface Specification)
- High-speed networking
  - 4 Mbits/s through 250 Mbits/s are common
  - Gigabit speeds are possible
- Multiple services - data, voice

DSL modem
- ADSL (Asymmetric Digital Subscriber Line)
  - Uses existing telephone lines
- Download speed is faster than the upload speed (asymmetric)
  - ~10,000 foot limitation from the central office (CO)
  - 52 Mbit/s downstream / 16 Mbit/s upstream are common
  - Faster speeds may be possible if closer to the CO

Dialup
- Network with voice telephone lines
  - Analog lines with limited frequency response
- 56 kbit/s modems
  - Compression up to 320 kbit/s
- Relatively slow throughput
  - Difficult to scale
- Legacy systems, network utility
  - May be difficult to find a modem

Fiber
- Fiber optics to the home - high speed networking
- Converged services - Voice, Video, Data
- Enhanced features
  - Hundreds of HD channels
  - 1 Gbit/sec Internet access
  - 1 Terabyte of cloud storage
  - 2 Terabyte DVR

Satellite networking
- Communication to a satellite
  - Non-terrestrial communication
- High cost relative to terrestrial networking
  - 50 Mbit/s down, 3 Mbit/s up are common
  - Remote sites, difficult-to-network sites
- High latency - 250 ms up, 250 ms down
- High frequencies - 2 GHz
  - 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
  - Delivered over a T1 or E1
  - T1 – 23B + D
  - E1 – 30B + D + alarm channel
  - Commonly used as connectivity from the PSTN to large phone systems (PBX)

Cellular networks
- Mobile devices - "Cell" phones
- Separate land into "cells"
  - Antenna coverages a cell with certain frequencies
- Tethering
  - Turn your phone into a wireless router
- Mobile hotspot
  - Standalone devices
  - Use your phone for other things

Line-of-sight services
- Line-of-sight
  - Visual path between antennas - high frequencies
- Common in metropolitan areas
  - Cover many homes simultaneously
- Also options for non-line-of-sight - lower frequencies
- WiMAX networking
  - Worldwide Interoperability for Microwave Access
  - Wireless high-speed Internet access

2.7 - Network Types

LAN
- Local Area Network - Local is relative
- A building or group of buildings
  - High-speed connectivity
- Ethernet and 802.11 wireless
  - Any slower and it isn't "local"

WAN
- Wide Area Network - Spanning the globe
- Generally connects LANs across a distance
  - And generally much slower than the LAN
- Many different WAN technologies
  - Point-to-point serial, MPLS, etc. - Terrestrial and non-terrestrial

PAN
- Personal Area Network
  - Your own private network
  - Bluetooth, IR, NFC
- Automobile
  - Audio output
  - Integrate with phone
- Mobile phone
  - Wireless headset
- Health
  - Workout telemetry, daily reports

MAN
- Metropolitan Area Network
  - A network in your city
  - Larger than a LAN, often smaller than a WAN
- Historically MAN-specific topologies
  - Everyone's moving to Metro Ethernet
- Common to see government ownership
  - They "own" the right-of-way

WMN
- Wireless mesh network
  - All devices connect together
  - A mesh "cloud"
- Self form - Connects to each other automatically
- Self heal - Reacts automatically to changes
- Many different network technologies
  - 802.11, Zigbee, Z-Wave, etc.

2.8 - Network Tools

Cable crimper
- "Pinch" the connector onto a wire
  - Coaxial, twisted pair, fiber
- Connect the modular connector to the Ethernet cable
  - The final step of the process
- Metal prongs are pushed through the insulation
- The plug is also permanently pressed onto the cable sheath

Crimping best practices
- Get a good crimper
  - And a good pair of electrician's scissors / cable snips
  - And a good wire stripper
- Make sure you use the correct modular connectors
  - Differences between wire types
- Practice, practice, practice
  - It won't take long to become proficient

Multimeter
- AC voltage
  - Check wall outlet voltage
- DC voltage
  - PC power supply output voltages
  - CMOS battery power
- Continuity
  - Cable connectivity
  - Fuse status

Tone generator
- Where does that wire go?
  - Follow the tone
- Tone generator
  - Puts an analog sound on the wire
- Inductive probe
  - Doesn't need to touch the copper
  - Hear through a small speaker

Using the tone generator and probe
- Easy wire tracing
  - Even in complex environments
- Connect the tone generator to the wire
  - Modular jack, coax, punch down connectors
- Use the probe to locate the sound
 - The two-tone sound is easy to find

Cable testers
- Relatively simple
  - Continuity test
- Can identify missing pins
  - Or crossed wires
- Not usually used for frequency testing
 - Crosstalk, signal loss, etc.

Loopback plugs
- Useful for testing physical ports
  - Or fooling your applications
- Serial / RS-232 (9 pin or 25 pin)
- Network connections
  - Ethernet, T1, Fiber
- These are not cross-over cables
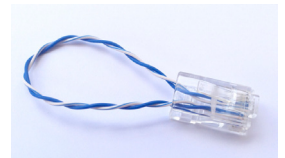
Punch-down tools
- "Punch" a wire into a wiring block
  - 66 block
  - 110 block
- Can be tedious
  - Every wire must be individually punched
- Trims the wires during the punch
  - Very efficient process
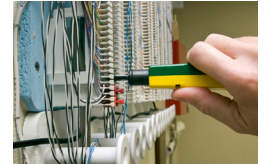
Punch-down best-practices
- Organization is key
  - Lots of wires
  - Cable management
- Maintain your twists
  - Your Category 6A cable will thank you later
- Document everything
  - Written documentation, tags, graffiti

WiFi analyzer
- Wireless networks are incredibly easy to monitor
  - Everyone "hears" everything
- Purpose-built hardware or mobile device add-on
  - Specializes in 802.11 analysis
- Identify errors and interference
  - Validate antenna location and installation

The importance of cable
- Fundamental to network communication
  - Incredibly important foundation
- Usually only get one good opportunity at building your cabling infrastructure
  - Make it good!
- The vast majority of wireless communication uses cables
  - Unless you're an amateur radio operator

Twisted pair copper cabling
- Balanced pair operation
  - Two wires with equal and opposite signals
  - Transmit+, Transmit- / Receive+, Receive-
- The twist is the secret!
  - Keeps a single wire constantly moving away from the interference
  - The opposite signals are compared on the other end
- Pairs in the same cable have different twist rates

Network cabling standards
- Electronic Industries Alliance (EIA)
  - Alliance of trade associations, develops standards for the industry
  - Standards start with RS-# (Recommended Standard) or EIA-#
  - http://www.eia.org
- Telecommunications Industry Association (TIA)
  - Standards, market analysis, trade shows, government affairs, etc.
  - ANSI/TIA/EIA-568 - Commercial Building Telecommunications Cabling Standard
  - http://www.tiaonline.org
- International ISO/IEC 11801 cabling standards
  - Defines classes of networking standards

Copper cable categories

| Cable Category	Maximum Supported Ethernet Standard	Maximum Supported 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

Plenum-rated cable
- Traditional cable jacket
  - Polyvinyl chloride (PVC)
- Fire-rated cable jacket
  - Fluorinated ethylene polymer (FEP) or low-smoke polyvinyl chloride (PVC)
- Plenum-rated cable may not be as flexible
  - May not have the same bend radius
- Worst-case planning
  - Important concerns for any structure

Unshielded and shielded cable
- UTP (Unshielded Twisted Pair)
  - No additional shielding
  - The most common twisted pair cabling
- STP (Shielded Twisted Pair)
  - Additional shielding protects against interference
  - Shield each pair and/or the overall cable
  - Requires the cable to be grounded
  - Unshielded and shielded cable
- Abbreviations
  - U = Unshielded
  - S = Braided shielding
  - F = Foil shielding
- (Overall cable) / (individual pairs)TP
  - Braided shielding around the entire cable and foil around the pairs is S/FTP
  - Foil around the cable and no shielding around the pairs is F/UTP

Coaxial cables
- Two or more forms share a common axis
- RG-6 used in television/digital cable
  - And high-speed Internet over cable
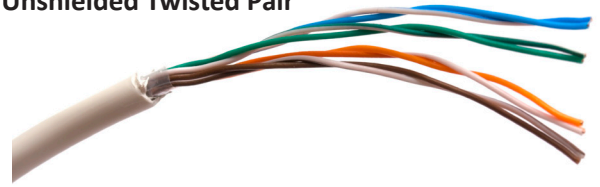- RG-59 used as patch cables
  - Not designed for long distances

Plastic jacket

Metal shielding
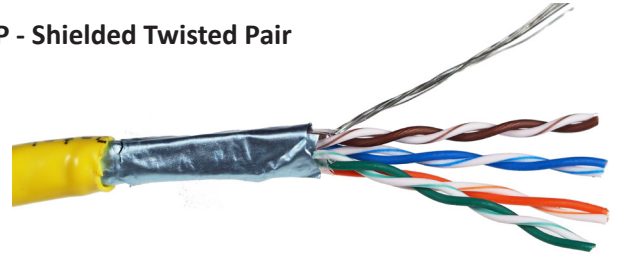
Dielectric insulator
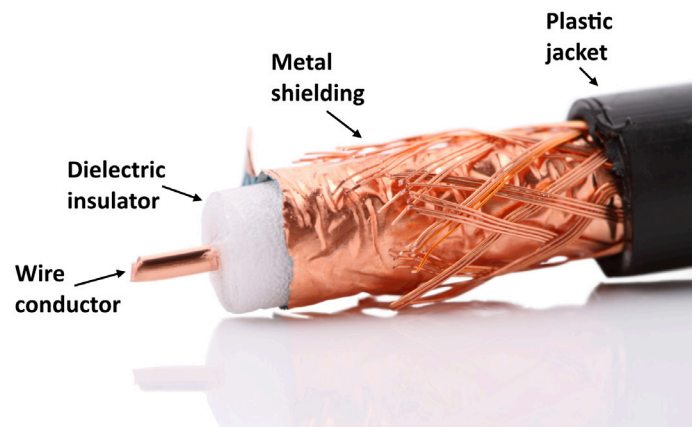
Wire conductor

T568A and T568B termination
- Pin assignments from EIA/TIA-568-B standard
  - Eight conductor 100-ohm balanced twisted-pair cabling
- T568A and T568B are different pin assignments for 8P8C connectors
  - Assigns the T568A pin-out to horizontal cabling
- Many organizations traditionally use 568B
  - Difficult to change in mid-stream
- You can't terminate one side of the cable with 568A and the other with 568B
  - You'll run into problems

UTP - Unshielded Twisted Pair

STP - Shielded Twisted Pair

TIA/EIA 568A

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

TIA/EIA 568B

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

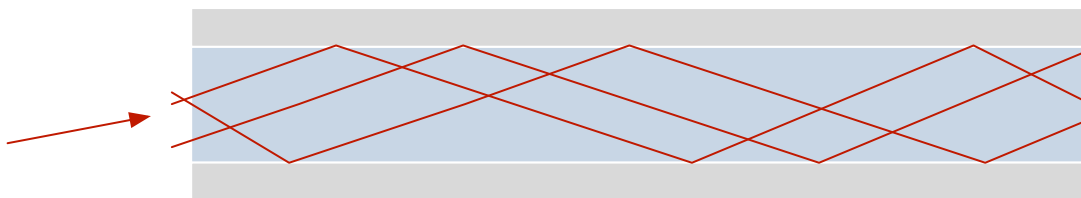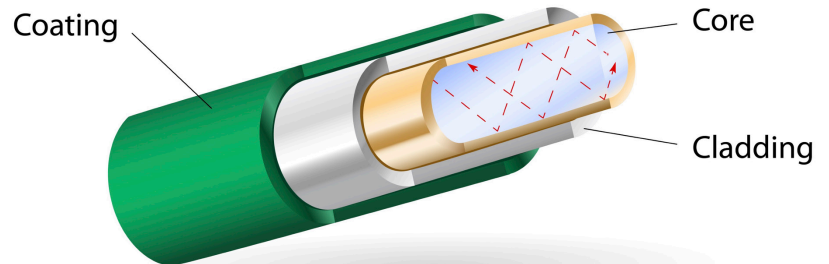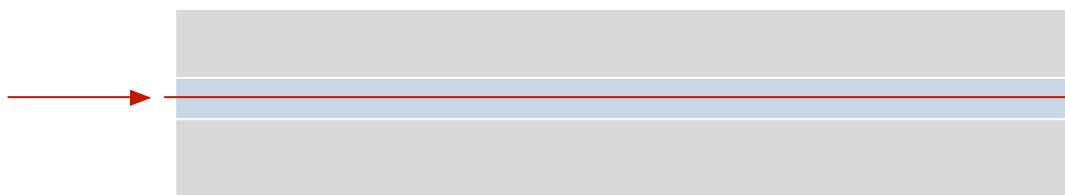# 3.1 - Fiber Network Cables

Optical fiber communication
- Transmission by light
  - The visible spectrum
- No RF signal
  - Very difficult to monitor or tap
- Signal slow to degrade
  - Transmission over long distances
- Immune to radio interference - There's no RF

Coating

Core

Cladding

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

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

VGA (Video Graphics Array)
- DB-15 connector
  - More accurately called DE-15
- Blue color
  - PC System Design Guide
- Analog signal
  - No digital
  - Image degrades after 5 to 10 meters

HDMI (High-Definition Multimedia Interface)
- Video and audio stream
  - All digital, no analog
  - ~ 20 meter distance before losing too much signal
- 19-pin (Type A) connector
  - Proprietary connector
- miniHDMI
  - Type C connector
  - Designed for smaller devices

DisplayPort
- VESA standard
  - Video Electronics Standards Association
  - A royalty-free standard
- Data is sent in packetized form
  - Like Ethernet and PCI Express
- Compatible with HDMI and DVI
  - Passive adapter

DVI (Digital Visual Interface)
- Single and dual link
  - Single link; 3.7 Gbps (HDTV at 60 fps)
  - Dual link; 7.4 Gbps (HDTV at 85 fps)
- DVI-A
  - Analog signals
- DVI-D
  - Digital signals
- DVI-I
  - Integrated
  - Digital and analog in the same connector

VGA

HDMI and miniHDMI

DisplayPort

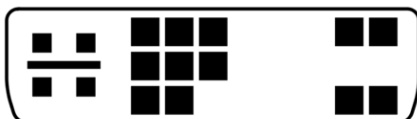**Mini DisplayPort
or Thunderbolt**

DVI (Digital Visual Interface)

DVI-A

DVI-D (Single Link)

DVI-I (Single Link)

DVI-D (Dual Link)

DVI-I (Dual Link)

3.1 - Multipurpose Cables

Lightning
- Apple proprietary
  - 8-pin digital signals - iPhone, iPad, iPod devices
- Some advantages over Micro-USB
  - Higher power output for phones and tablets
  - Can be inserted either way
  - Simpler design, more durable

Thunderbolt
- High-speed serial connector
  - Data and power on the same cable
  - Based on Mini DisplayPort (MDP) standard
- Thunderbolt v1
  - Two channels
  - 10 Gbit/s per channel
  - 20 Gbit/s total throughput
  - Mini DisplayPort connector
- Thunderbolt v2
  - 20 Gbit/s aggregated channels
  - Mini DisplayPort connector
- Thunderbolt v3
  - 40 Gbit/s aggregated throughput
  - USB-C connector
- Maximum 3 meters (copper)
  - 60 meters (optical), daisy-chain up to 6 devices

USB (Universal Serial Bus)
- Simplify connections
  - Printers, storage devices, keyboard, mouse
- USB 1.1
  - Low speed: 1.5 megabits per second, 3 meters
  - Full speed: 12 megabits per second, 5 meters
- USB 2.0 - 480 megabits per second, 5 meters
- USB 3.0 - SuperSpeed
  - 5 gigabits per second, ~3 meters
  - Standard does not specify a cable length

USB 3.1 and USB 3.2
- USB 3.1
  - Released July 2013
  - SuperSpeed+
  - 10 Gbit/sec
- USB 3.2
  - Released September 2017
  - SuperSpeed+ over a USB-C connector
  - 10 Gbit/sec and 20 Gbit/sec

USB-C
- USB has a lot of different connectors
  - And they have changed over time
- Can be annoying to connect USB-A
  - Third time's a charm
- USB-C replaces all of these
  - One connector to rule them all
- USB-C isn't necessarily USB 3.1
  - The cable must support the function
    - USB 3.1 speeds
    - Power delivery (> 7.5 watts)
    - Alternate mode (additional data wires)

DB-9 serial cable connector
- D-subminiature or D-sub
  - Different sizes, A through E
- Commonly used for RS-232
  - Recommended Standard 232
  - An industry standard since 1969
- Serial communications standard
  - Built for modem communication
  - Used for modems, printers, mice, networking
- Commonly used as a configuration port
  - Serial console interface

| USB 1.0/2.0 Standard-A Plug | USB 1.0/2.0 Standard-B Plug | USB 1.0/2.0 Mini-B Plug | USB 1.0/2.0 Micro-B Plug |

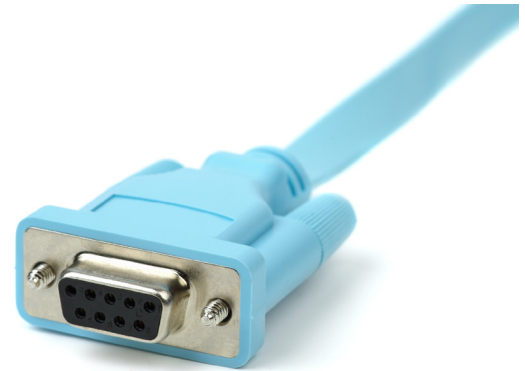| USB 3.0 Standard-B Plug | USB 3.0 Standard-A Plug | USB 3.0 Micro-B Plug |

USB 3.1/3.2 USB-C Connector

**Lightning Connector and
USB Standard-A Plug**

DB-9 / RS-232 Connector

3.1 - SATA Drive Cables

SATA (Serial AT Attachment)
- SATA Revision 1.0
  - SATA 1.5 Gbit/s, 1 meter
- SATA Revision 2.0
  - SATA 3.0 Gbit/s, 1 meter
- SATA Revision 3.0
  - SATA 6.0 Gbit/s, 1 meter
- SATA Revision 3.2
  - SATA 16 Gbit/s, 1 meter

Power (15 pins)   Data (7 pins)
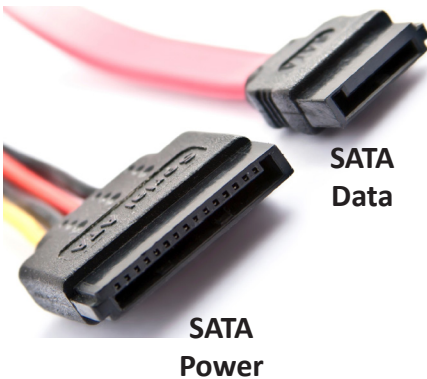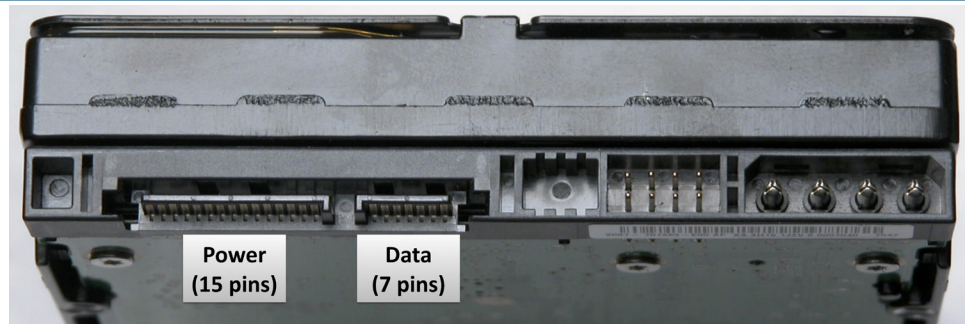
SATA Data

SATA Power
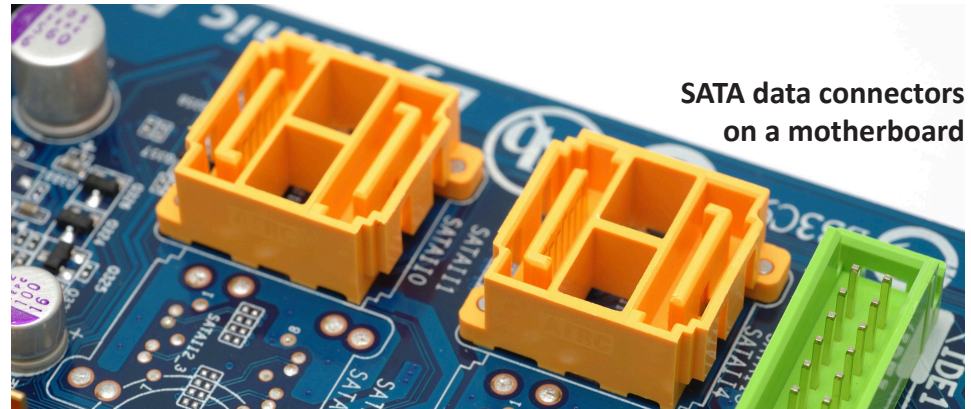
**SATA data connectors
on a motherboard**

3.1 - PATA Drive Cables

The PATA Standard
- Parallel AT Attachment
  - Remember the PC/AT?
- An evolutionary process
  - Circa 1999
- Originally called Integrated
  Drive Electronics (IDE)
  - A Western Digital invention
  - 2nd generation called EIDE (Enhanced IDE)
- The evolution
  - Promised faster speeds
  - From 16 MB/s through 133 MB/s
  - Additional devices
- Now called Parallel ATA (PATA)
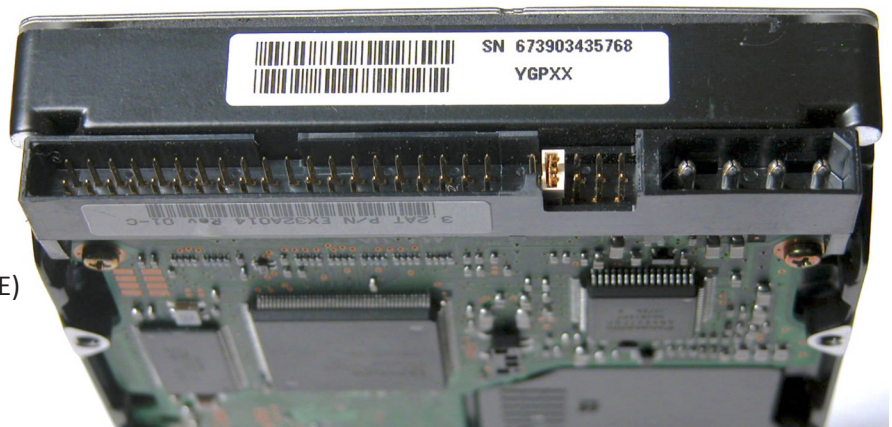
**Hard drive with PATA connector,
jumpers, and Molex power connector**
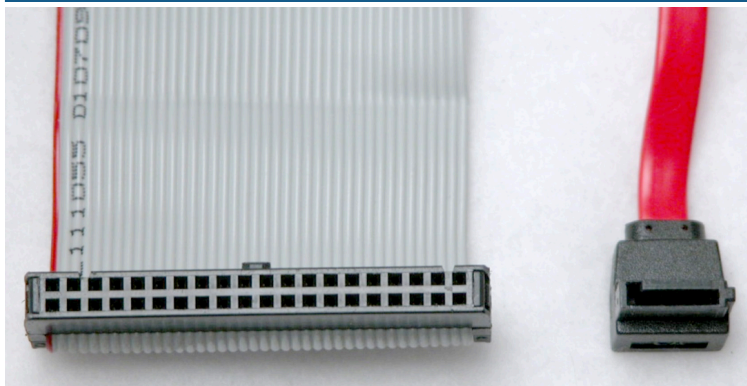
PATA data cable   **SATA data cable**   **Motherboard PATA connector**

3.1 - SCSI Drive Cables

The SCSI standard
- Small Computer Systems Interface
  - Not really "small" any longer
- Originally designed to string many peripherals together onto a single cable/controller
  - Up to 16 devices in a SCSI "chain"
- Many different formats
  - Fast SCSI, Ultra SCSI, Ultra Wide SCSI, Ultra2 SCSI,
  - Ultra3 SCSI, Ultra-320 SCSI, Ultra-640 SCSI,
  - iSCSI (SCSI over IP)
- Parallel and serial options

SCSI advantages
- Not just for hard drives
  - Scanners, tape drives, CD-ROM drives
- Many devices on a single bus
  - 8 on narrow bus, 16 on wide bus
- Very intelligent interface functionality
  - Much of the difficult configuration work is done between the SCSI devices
- Industry longevity
  - Well supported in the enterprise
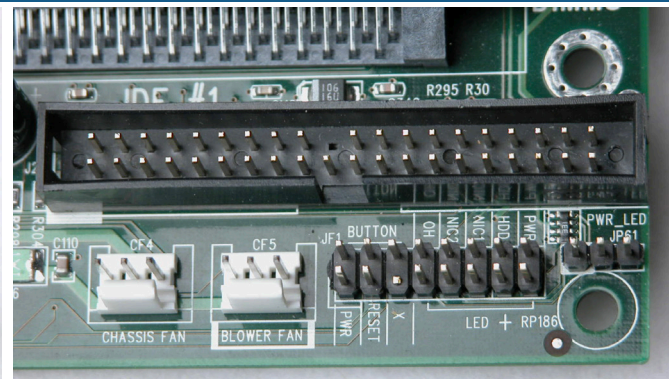 - A standard drive for virtual systems

SCSI ID and logical unit (LUN)
- Every SCSI device on a single bus is assigned a separate ID number
  - SCSI ID 0 (SCSI controller), ID 2 (hard drive), ID 3 (CD-ROM)
- Logical units (LUNs) are defined within each SCSI ID
  - Separate drives in a storage array or virtual machine
- The signal at the "end" of a physical SCSI bus is terminated
  - Can be internal to the device or a separate termination device
- Serial attached SCSI (SAS) devices have no jumpers, terminators, or settings.

Serial attached SCSI
- Move from parallel to serial
  - Increased throughput
  - Similar to the move from PATA to SATA
- Point-to-point connection
  - No more daisy chains
- No termination required
  - The bus has two devices on it
- The control and management of SCSI
  - The speed of a serial connection
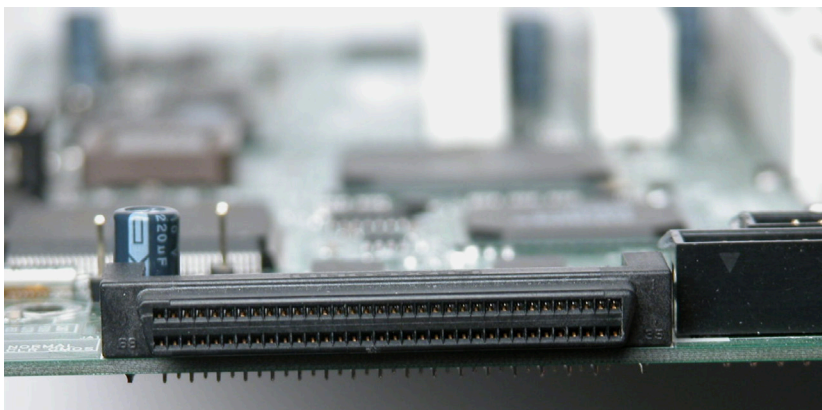
Motherboard SCSI connector

Internal SCSI cable and connectors
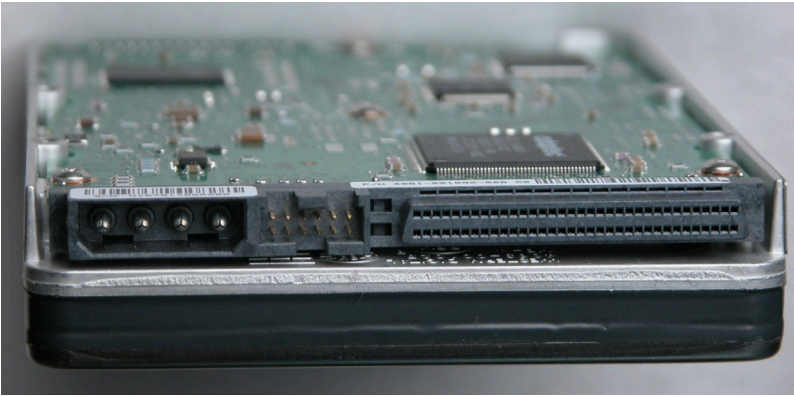
Hard drive with Molex power connector, jumpers, and SCSI connector

Internal SCSI Cable
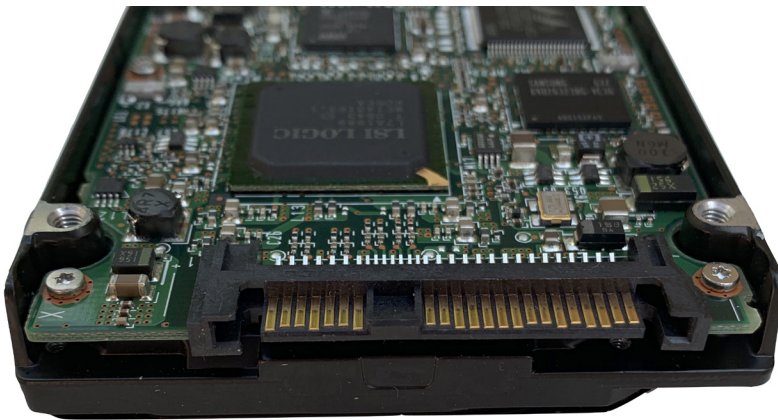
2.5" SAS hard drive

High-density internal SAS connector

3.1 - Adapters and Converters

Adapters and converters
- The best laid plans…
  - Need an adapter
- Convert between different connectors
  - Electrically compatible
- Convert from one format to another
  - You need Ethernet but you only have USB
- A good temporary fix
  - Or a good permanent one

DVI to HDMI
- DVI-D and HDMI are electrically compatible
  - HDMI is backward-compatible with DVI-D
  - No signal conversion required
  - No loss of video quality

DVI to VGA
- DVI-A includes analog signals
  - Backward compatible with VGA
  - Only 640 x 480 is officially supported
- May only need an adapter
  - Analog to analog
- VGA to DVI digital will need a converter
  - Check your interface specifications

USB to Ethernet
- Some laptops don't have an Ethernet connection
  - Convert USB to Ethernet

DVI-A

VGA

USB to Ethernet adapter

3.2 - Connectors

RJ11
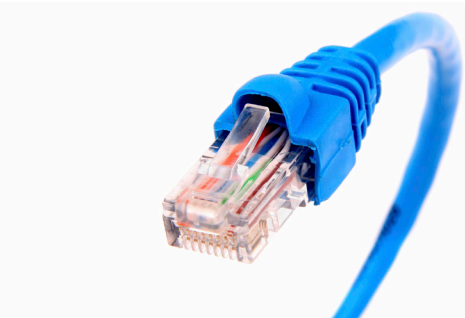
RJ45
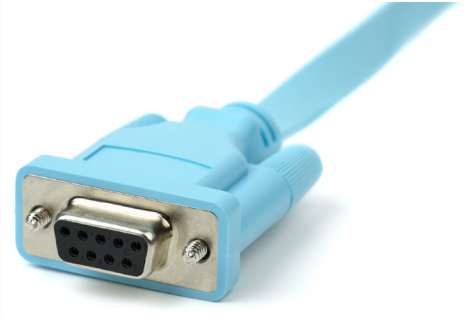
DB-9 / RS-232 Connector
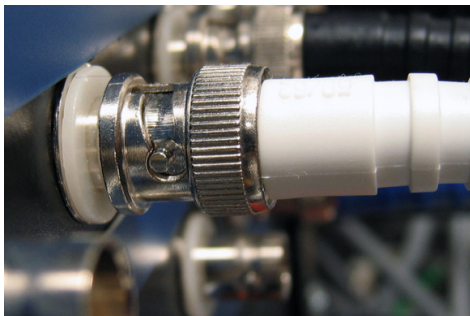
BNC connector

F-connector
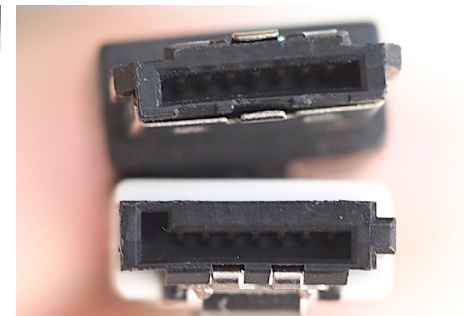
eSATA and SATA connectors
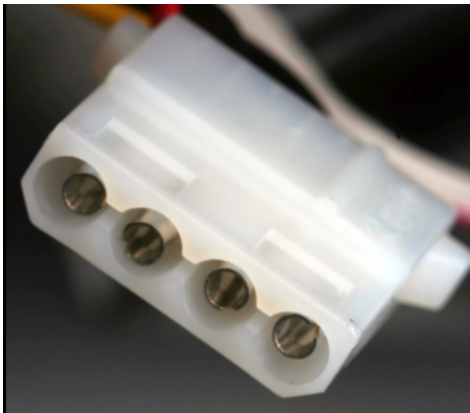
Molex connector
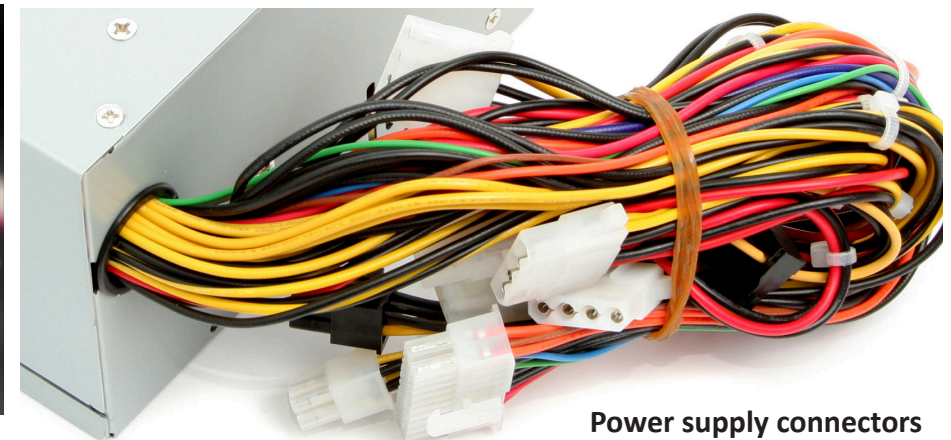
Power supply connectors

3.3 - Overview of Memory

What is memory?
- Random Access Memory (RAM) is the most common
  - But it's not the only kind of memory
- RAM is not referring to hard drive or SSD storage
  - Don't mix the two terms
- Data is stored permanently on the drive
  - Data and programs can only be used when moved to RAM

RAM (Random Access Memory) slots
- Memory types have changed through the years
  - Driven by standardization and technology
- One of the most important components of your computer
  - Speed, speed, speed
- Every motherboard is different
  - Check your documentation

DIMM - Dual inline memory module
- Electrical contacts are different on each side
- 64 bit data width

SO-DIMM
- Small Outline Dual In-line Memory Module
  - About half the width as a DIMM
- DDR2, DDR3, and DDR4 SDRAM
- Used in laptops and mobile devices

Dynamic Random Access Memory (DRAM)
- The memory on the DIMM
- Dynamic - Needs constant refreshing
  - Without refreshing, the data disappears
- Random access
  - Any storage location can be accessed directly
  - Unlike magnetic tape

SDRAM

- Synchronous DRAM (SDRAM)
- SDRAM is synchronous with the common system clock
  - Queue up one process while waiting for another
  - Classic DRAM didn't wait for a clock signal

Double Data Rate 2 (DDR2) SDRAM

- Faster speeds
  - Twice as fast as DDR
- Not backwards compatible
  - DDR2 won't work in DDR slots

Double Data Rate 3 (DDR3) SDRAM

- Twice the data rate of DDR2
  - Larger chip capacities - Maximum 16 GB per DIMM
- No backwards compatibility
  - Speed brings sacrifice

Double Data Rate 4 (DDR4) SDRAM

- Speed increases over DDR3
  - Faster frequencies
  - Maximum 64 GB per DIMM
- Again, no backwards compatibility
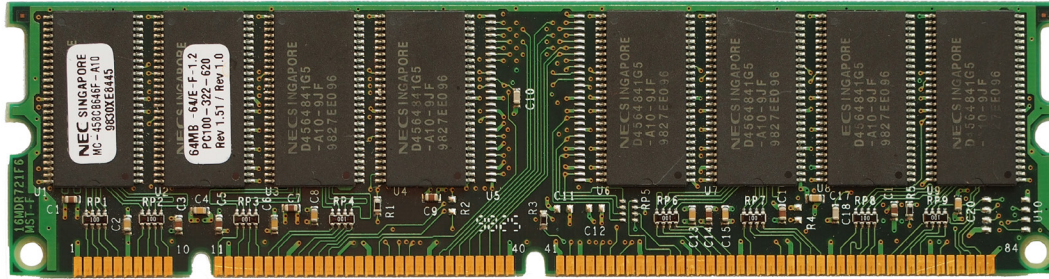
**DIMM
(Dual Inline
Memory Module)**
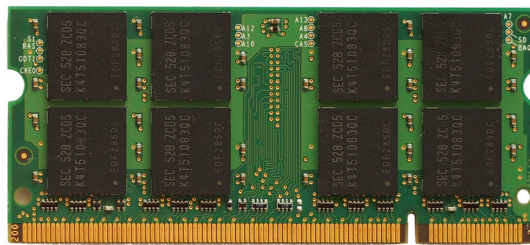
**SO-DIMM
(Small Outline Dual
Inline Memory Module)**

SDR vs. DDR
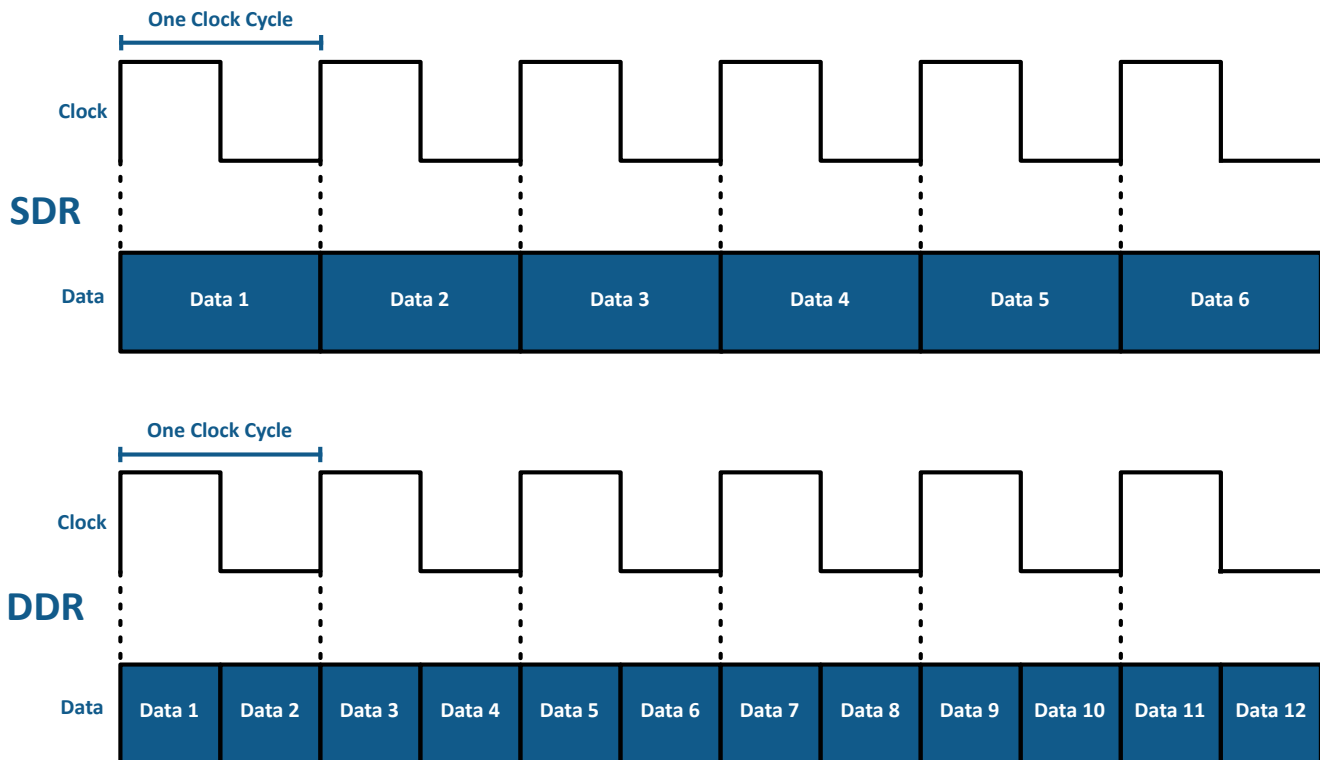
Multi-channel memory
- Dual-channel, triple-channel, or quad-channel
- Memory combinations should match
  - Exact matches are best
- Memory module slots are often colored differently

Memory that checks itself
- Used on critical computer systems
  - VM servers, database servers, any server

- Parity memory
  - Adds an additional parity bit
  - Won't always detect an error
  - Can't correct an error
- Error Correcting Code (ECC)
  - Detects errors and corrects on the fly
  - Not all systems use ECC
  - It looks the same as non-ECC memory

3.4 - Storage Devices

Optical formats
- Small bumps read with a laser beam
  - Microscopic binary storage
- CD-ROM (Compact Disc ROM)
  - 700 megabytes (MB) capacity
- DVD-ROM (Digital Versatile Disc)
  - 4.7 gigabytes (GB) for single-layer
  - 8.5 GB for dual-layer
- Blu-ray Disc
  - 25 GB for single-layer, 50 GB for dual-layer

Writing to optical media
- "Burners" don't create bumps
  - They darken photosensitive dye
- Compact Disc-ReWritable (CD-RW)
- DVD Read and Rewritable (DVD-R/RW)
  - And Dual Layer (DVD-R DL)
- Blu-ray Disc Recordable (BD-R)
- Blu-ray Disc Recordable Erasable (BD-RE)

Solid-state drives (SSD)
- Non-volatile memory
  - No moving parts - Very fast

AHCI vs. NVMe
- SATA was designed for hard drives
  - Uses AHCI (Advanced Host Controller Interface) to move drive data to RAM
  - SATA revision 3 throughput up to 600 MB/s
  - SSDs need a faster communication method
- NVMe
  (Non-volatile Memory Express)
  - Designed for SSD speeds
  - Lower latency,
    supports higher throughputs
  - Take advantage of NVMe
    with an M.2 interface

M.2 interface
- Smaller storage device
  - No SATA data or power cables
- Can use a PCI Express bus connection
  - 4 GByte/second
    throughput or faster

- Different connector types
  - Needs to be compatible with the slot key/spacer
  - B key, M key, or B and M key
  - Some M.2 drives will support both

B-key and M-key
- M.2 doesn't guarantee NVMe
  - Your M.2 interface may be using AHCI
  - Check your documentation
- Your motherboard may only support one type of M.2 key

Hard disk drives
- Non-volatile magnetic storage - rapidly rotating platters
- Random-access
  - Retrieve data from any part of the drive at any time
- Moving parts
  - Spinning platters, moving actuator arm
  - Mechanical components limit the access speed
  - Mechanical components can also break

Hybrid drives
- Solid State Hybrid Drive (SSHD)
  - Both a spinning drive and SSD in a single device
- SSD caches the slower spinning hard drive data
  - Increases speed without the cost of an SSD-only system
- Looks like a normal hard drive or SSD - Same form factor

USB flash drives
- Flash memory
  - EEPROM (Electrically erasable programmable read-only memory)
  - Non-volatile memory - No power required to retain data
- Limited number of writes - Can still read the data
- Not designed for archival storage - Easy to lose or damage

USB Flash Drive

Flash memory

Secure Digital (SD) **miniSD** **microSD**

CompactFlash (CF) **xD-Picture Card** **eMMC**
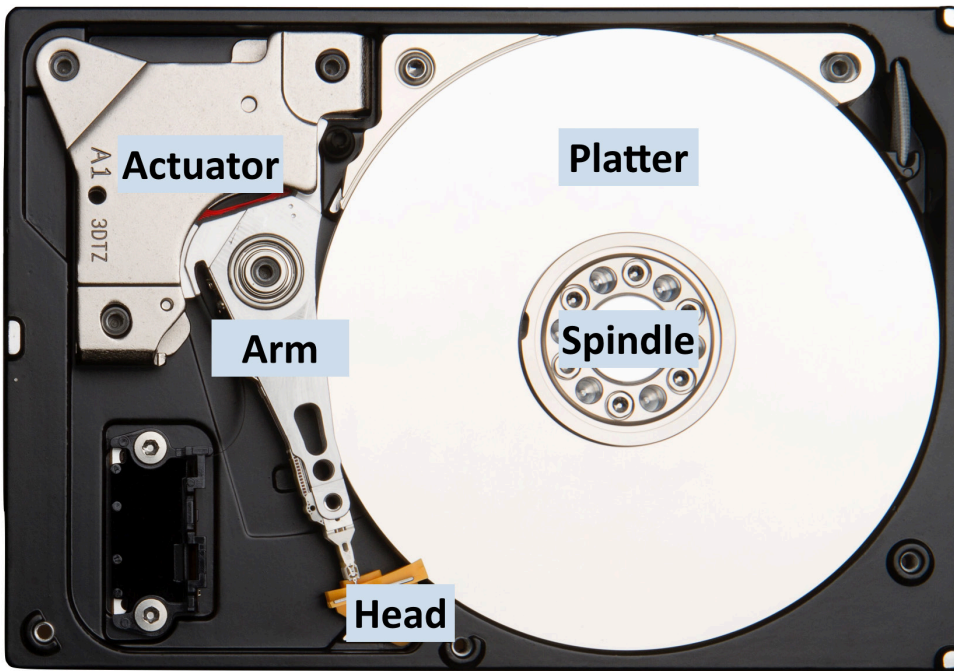
Rotational Speed (rpm)	Average Rotational Latency
15,000	2 ms
10,000	3 ms
7,200	4.16 ms
5,400	5.55 ms

3.4 - RAID

RAID
- Redundant Array of Independent Disks
  - They're also inexpensive disks.
- Different RAID levels
  - Some redundant, some not
- RAID 0 – Striping
- RAID 1 - Mirroring
- RAID 5 – Striping with Parity
- Nested RAID - RAID 1+0 (a.k.a. RAID 10)
  - A stripe of mirrors

Software RAID vs. hardware RAID
- Software-based RAID
  - A feature of the operating system
  - Doesn't require any special hardware
  - Usually lower-performance than hardware-based
- Hardware-based RAID
  - A feature of the hard drive controller
  - Configured outside of the OS
  - Usually invisible to the operating system
  - High performance, designed for speeds

Hot swappable drives
- Add and remove while the system is running
  - The connection is "hot"
- Drive chassis
  - Two or more drives
- Easy to repair
  - Replace a drive while the system is running
  - Combine with RAID for 100% uptime

RAID 0 - Striping
- File blocks are split between two or more physical drives
- High performance
  - Data written quickly
- No redundancy
  - A drive failure breaks the array
  - Raid 0 is zero redundancy

RAID 1 - Mirroring
- File blocks are duplicated between two or more physical drives
- High disk utilization
  - Every file is duplicated
  - Required disk space is doubled
- High redundancy
  - Drive failure does not affect data availability

RAID 5 – Striping with parity
- File blocks are striped
  - Along with a parity block
  - Requires at least three disks
- Efficient use of disk space
  - Files aren't duplicated, but space is still used for parity
- High redundancy
  - Data is available after drive failure
  - Parity calculation may affect performance

RAID 10 (1+0) – A stripe of mirrors
- The speed of striping, the redundancy of mirroring
  - The best of both worlds
- Need at least 4 drives

RAID 0 - Striping

Block 1A	Block 2A
Block 3A	Block 4A
Block 5A	Block 6A
Block 7A	Block 8A

Disk 0   **Disk 1**

RAID 1 - Mirroring

Block 1	Block 1
Block 2	Block 2
Block 3	Block 3
Block 4	Block 4

Disk 0   **Disk 1**

RAID 5 - Striping with Parity

Block 1A	Block 2A	Block 3A	Parity A
Block 1B	Block 2B	Parity B	Block 3B
Block 1C	Parity C	Block 2C	Block 3C
Parity D	Block 1D	Block 2D	Block 3D

Disk 0   **Disk 1**   **Disk 2**   **Disk 3**

RAID 1+0 - A Stripe of Mirrors

RAID 0   **RAID 0**

RAID 1   **RAID 1**   **RAID 1**

Block 1	Block 1	Block 2	Block 2	Block 3	Block 3
Block 4	Block 4	Block 5	Block 5	Block 6	Block 6
Block 7	Block 7	Block 8	Block 8	Block 9	Block 9
Block 10	Block 10	Block 11	Block 11	Block 12	Block 12

3.5 - Motherboard Form Factors

Motherboard form factors
- Physical size - case sizing
- Basic layout - room for small changes
- Power - standard connectors
- Airflow - increasingly important
- Wikipedia: There are 40 different motherboard types categorized!

ATX form factor
- Advanced Technology Extended
- Standardized by Intel in 1995
  - Seen many updates over the years
- Power
  - 20 pin connector
  - 24 pin connector, additional 4/8 pin connector
- ATX motherboards are still manufactured in 2019

microATX (uATX)
- Smaller than an ATX motherboard
  - Limited expansion slots
- Backward compatibility
  - Similar mounting points
  - Similar power
- Very popular form factor
  - Actively manufactured as of 2019

ITX form factor
- A series of low-power motherboards
  - Developed by VIA Technologies in 2001
- Mini-ITX is screw-compatible with ATX and microATX
  - Fits almost any enclosure
- Small form factor uses
  - Single-purpose computing, i.e., streaming media

A computer bus
- Communication path
  - A city of technology
- Internal PC growth
  - Independent pathways
- System expansion
  - Additional capabilities

The expansion bus
- "Width" in bits
  - Big roads, little roads
  - Width is changing to bandwidth
- Clock speed of the bus
  - The expansion bus gets its own clock
  - 1 MHz (megahertz) = 1 million cycles per second
  - 1 GHz = 1000 MHz = 1 billion cycles per second
- Clock speed does not necessarily equal transfer rate
  - DDR3 SDRAM can transfer 64 times the memory clock speed

Conventional PCI
- Peripheral Component Interconnect
  - Nobody ever calls it that
  - Created in 1994
- A common expansion interface
  - 32-bit and 64-bit bus width
  - Parallel communication
- Throughput varies by bus version
  - 133 MB/s (32-bit at 33 MHz)
  - 266 MB/s (32-bit at 66 MHz or 64-bit at 33 MHz)
  - 533 MB/s (64-bit at 66 MHz)

PCI Express
- Also known as PCIe
  - Replaced PCI, PCI-X, and AGP (Accelerated Graphics Port)
- Communicates serially
  - Unidirectional serial "lanes"
  - Slower devices don't slow down everyone
- One, two, four, eight, sixteen, or thirty-two full-duplex lanes
  - x1, x2, x4, x8, x16, x32
  - "x" is pronounced "by" i.e., "by 4," "by 16"

PCI Express throughput
- Different versions of PCIe
  - Improvement in speed with each iteration
- Per-lane throughput in each direction
  - v1.x: 250 MB/s
  - v2.x: 500 MB/s
  - v3.0: ~ 1 GB/s
  - v4.0: ~ 2 GB/s
  - v5.0 (expected in 2019): ~ 4 GB/s

PCI Express Device A

PCI Express x4 Lanes

PCI Express Device B
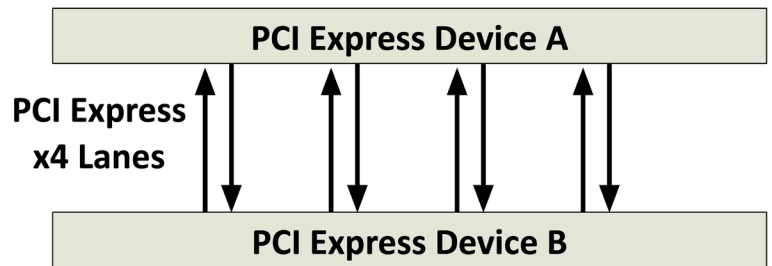
CPU sockets
- Motherboards are matched with CPUs
  - CPUs have specific socket requirements
- CPU socket is usually the largest thing on the board
  - And usually central to everything
- Not easily upgradable - and often not an option

Land Grid Array (LGA)
- Reverse the PGA - pins are on the motherboard
- No pin to damage on the CPU
  - Easier to damage the motherboard

Computer case
- Various front-panel connections
  - Not directly connected to the motherboard

Internal USB connector
- USB on the motherboard
- Integrated - part of the motherboard
  - On the back - keyboard, mouse
- Internal case connection
  - Pins for case interfaces

Zero Insertion Force (ZIF)   Pin Grid Array (PGA)
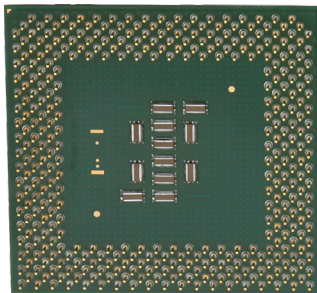
Land Grid Array (LGA)
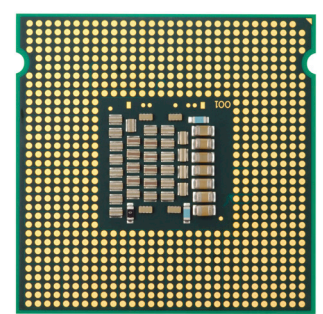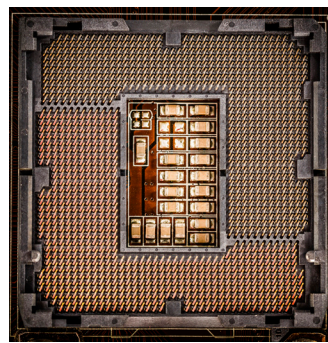
3.5 - BIOS

BIOS - Basic Input/Output System
- The software used to start your computer
  - The firmware
  - System BIOS, ROM BIOS
  - ROM or flash memory
- Initializes CPU and memory
  - Build the workspace
- POST - Power-On Self-Test
- Look for a boot loader - Start the operating system

Legacy BIOS
- The original / traditional BIOS
  - It's been around for more than 25 years
- Older operating systems talked to hardware through the BIOS
  - Instead of accessing hardware directly
- Limited hardware support
  - No drivers for modern network, video, and storage devices

UEFI BIOS
- Unified Extensible Firmware Interface
  - Based on Intel's EFI
  - (Extensible Firmware Interface)
- A defined standard
  - Implemented by the manufacturers
- Designed to replace the legacy BIOS
  - Need a modern BIOS for modern computers
  - Graphical and text-based

UEFI advantages
- Boot from large (> 2.2 TB) GUID partition table (GPT) disks
  - Also supports FAT and removable media
- Includes a pre-boot environment
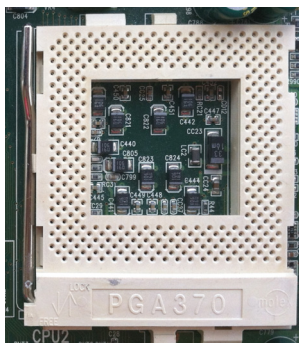 - This isn't an operating system
  - Has its own shell, drivers, and applications
  - Browse the Internet, backup a storage drive
  - Remote diagnostics, even without an OS

Nonvolatile BIOS memory
- Store the BIOS configuration
  - Your settings
- Complementary metal-oxide semiconductor (CMOS)
  - A type of memory
  - May be backed up with a battery
- Usually flash memory these days
  - Easily stored and accessed

The "CMOS" battery
- Not needed for today's flash-based storage
  - Maintains older BIOS configurations
  - May only be used to maintain date/time
- A bad battery will require a BIOS configuration or date/time configuration on every boot
- On older systems, can reset the BIOS configuration by removing the battery
  - Newer computers use a jumper

3.5 - BIOS Options

The secret button(s)
- Launching the system setup
  - Del, F1, F2, Ctrl-S, Ctrl-Alt-S
- Microsoft Virtual PC (Windows 7)
  - https://support.microsoft.com/en-us/kb/958559
- Hyper-V (Windows 8/10)
  - Turn Windows features on and off
- VMware Workstation Player
  - http://www.vmware.com/products/player/
- But not VirtualBox
  - http://www.virtualbox.org

Fast startup
- Windows 8 and Windows 10
  - Doesn't actually shut down all the way
  - Starts up very quickly
- Starts up so quickly, you can't open the BIOS configuration
  - This can be an issue
- Disable fast startup in Control Panel / Power Options
  - If you can
- Most motherboards have a separate process
  - Hold F2, then press the power button, for example

Configure component information
- RAM - View and configure memory settings
- Hard drive / SSD
  - Drive settings
  - Boot order
- Optical drive
  - Enable / Disable
- CPU - CPU types

Built-in diagnostics
- Part of the BIOS
  - Always available
- Run from the BIOS menu
  - No additional media or software required
- Focused on hardware checks
  - Doesn't touch the operating system

Important tips
- Have a backup of your BIOS configuration
  - Make notes or take a picture
- Don't make a change unless you're certain of the setting
  - It's difficult to leave it alone
- Did I mention the backup?
  - It can save a lot of time!

3.5 - BIOS Security

BIOS passwords
- BIOS Password / User Password
  - System won't start
  - Need the password to start the operating system
- Supervisor Password
  - Restrict BIOS changes
  - Must use supervisor password to change any BIOS configurations

Full disk encryption
- Everything is encrypted
  - Not just individual files
- Windows BitLocker disk encryption
  - BIOS integrates with TPM
- TPM - Trusted Platform Module
  - Can be added to many motherboards
  - Built-in to some systems
  - Adds advanced cryptographic functions

LoJack for Laptops
- Originally called CompuTrace
  - Name licensed from the vehicle recovery service
- Built into the BIOS - software installed into the OS
  - Reinstalls itself if removed or new storage drive installed
- "Phone home" function - provides location information
- Theft mode`- remotely lock the laptop and/or delete files
  - Forces a startup password

Secure Boot
- Malicious software can "own" your system
  - Malicious drivers or OS software
- Secure boot - part of the UEFI specification
- Digitally sign known-good software
  - Cryptographically secure
  - Software won't run without the proper signature
- Support in many different operating systems
  - Windows and Linux support

3.5 - Installing BIOS Upgrades

Firmware upgrades
- Firmware
  - Non-volatile memory and software
  - Older-style ROMs
  - Newer-style flash memory
- Computer BIOS, video adapter firmware, game console, etc.
  - Improve performance, fix bugs
- Not usually part of a normal maintenance process
  - Upgrade for a specific reason

Identify current BIOS version
- May appear when system starts
  - Can be difficult to catch
- Easier to look in System Information (msinfo32)
  - Version and date details
- Compare the current to the existing
  - An upgrade may not be available
- If possible, get a copy of the current version
  - Always good to have a backup plan

Run the upgrade program
  - Really-old BIOS upgrades may require a boot disk
  - Floppy or optical media
- Most modern upgrades run as an executable
  - Close all of your other applications before running
  - May also run in the BIOS from a flash drive
- Most upgrade apps will check for prerequisites
  - Don't rely on this
- Requires a reboot
  - Save your documents!

Other options
  - Newer options may be available
  - Modern motherboards have advantages
- Multiple BIOS versions
  - Two separate BIOS versions
  - Easily switch between them
- Upgrade from a USB flash drive
  - Computer may not even need to be powered on

Before upgrading...
- Read the documentation
  - Some BIOS updates are bland
  - Others are full of new features
  - Check for OS prerequisites
- Locate a reliable power source
  - Laptop: Connect to AC power and have a full battery
  - Desktop: Use a UPS, if possible

Processor cores
- Dual-core / Quad-core / Octa-core / Multi-core
  - And more all the time
- Multiple cores
  - Each core has its own cache
  - The entire chip may have a shared cache

CPU cache
- Super fast memory
  - There's not much of it
  - Holds data, instructions, and/or results
- Level 1 cache
  - First check
- Level 2 cache
  - Secondary data
- Level 3 cache
  - Still on the chip
  - These days

Virtualization support
- Run other operating systems within a single hardware platform
  - Multiple operating systems share physical hardware components
- Virtualization in software was limited
  - Performance and hardware management challenges
- Virtualization added to the processor
  - Hardware is faster and easier to manage
  - Intel Virtualization Technology (VT)
  - AMD Virtualization (AMD-V)

Hyper-threading
- Hyper-Threading Technology (HTT)
- One CPU, acts like two
- Doesn't actually work as fast as two
  - 15% to 30% performance improvement
- Operating system must be written for HTT
  - Windows XP and later (any modern OS)

Processor speed
- Real speed: CPU clock
  - Historical qualification of speed
  - Megahertz (MHz) or gigahertz (GHz)
- Actual speed
  - Combination of different factors
  - Clock speed, CPU architecture, bus speed, bus width,
  - L1 cache size, L2 cache size, operating system capabilities
- CPU manufacturers have moved away from marketing performance in clock cycles
- No broadly accepted measure of performance
  - Use a benchmark that works for you

Overclocking
- When fast isn't fast enough
  - Increase the clock speed past the rated value
- A balancing act
  - More power required, more heat created
  - At some point, the system becomes unstable
- Change the base clock (BCLK) - Need an unlocked CPU
  - Run a stress test to confirm the stability
- This will void your warranty
  - You can break more than your CPU

Integrated GPU
- Graphics processing unit
  - Part of a video adapter, motherboard or CPU
- Graphics rendering requires a lot of work
  - Dedicated hardware speeds the process
- On-die GPUs are increasingly common
  - But not as powerful as separate adapters

Intel and AMD
- Two solid CPU manufacturers - The differences are subtle
- Cost - AMD tends to be a bit less expensive
- Laptops
  - Intel has a large portfolio of options
- Choosing a side
  - Historically, AMD is value and Intel is performance
  - This is a dynamic technology segment
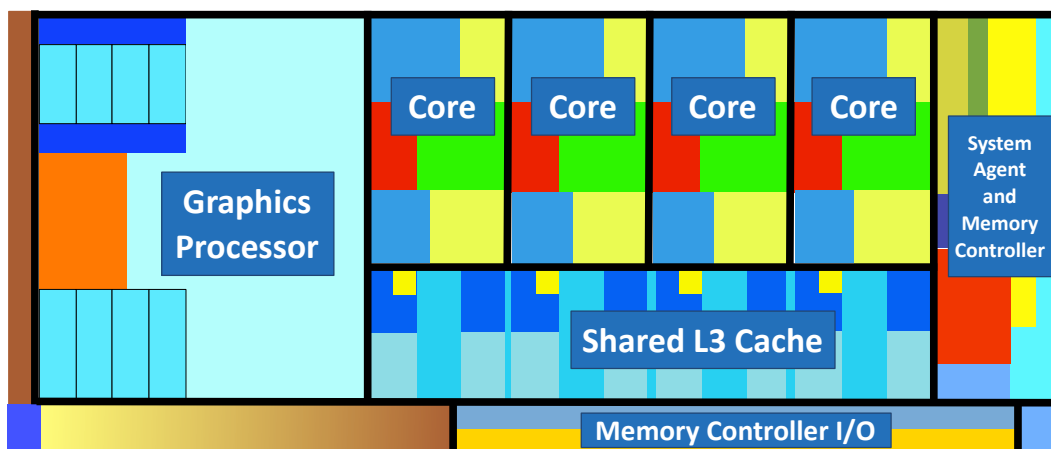
3.5 - CPU Cooling

Case fans
- Cool air is pulled through a personal computer
  - Always check for good airflow
- Motherboard layout becomes important
- Component location is key
  - Devices, wiring, power
- Many different sizes and styles
  - And volume levels

On-board fans
- Designed to cool an entire adapter card
- Can be bulky
  - May take additional adapter card space
- Usually seen on high-end graphics cards

Fan specifications
- Standard sizes i.e., 80 mm, 120 mm, 200 mm
- Different speeds
  - Variable speed
- Different noise levels
  - Not all fans sound the same

Heat sink
- Dissipate heat through thermal conduction
  - Copper or aluminum alloy
- Fins/grid increase surface area
  - Heat is then transferred to the cooler air
- Thermal paste creates a good contact between the chip and the heat sink
- They get HOT – don't touch them!

Fanless / passive cooling
- No fans, no noise
  - Silent operation
- Specialized functions
  - Video servers, TV set top box, satellite receiver, media server
- Functions are very controlled
  - Carefully measured thermal tests
- Low-power components
  - Heat sinks

Liquid cooling
- Coolant is circulated through a computer
  - Not a new concept
  - Automobiles, mainframe computers
- High-end systems
- Gaming, graphics
- Overclocking
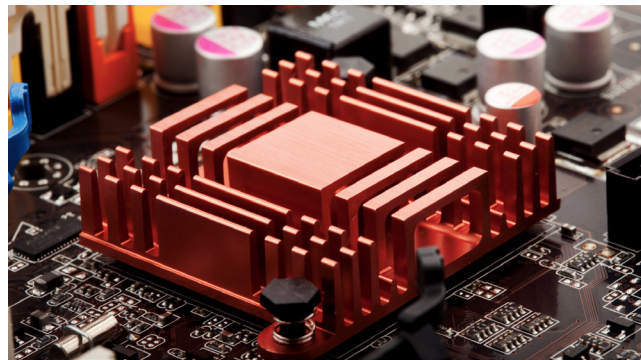
3.5 - Expansion Cards

Expansion cards
- Extend the functionality of your computer
  - You may need more than the motherboard provides
- Relatively simple process
  - Designed for end-user installation
- Install hardware
  - Add a card
- Install a driver
  - Software for the operating system

Documentation
- Check the motherboard documentation
  - Number and type of slots
- Check the adapter card documentation
  - Minimum requirements - Hardware, software
- Knowledge base
  - Any "gotchas?"
- Support forums
  - What are other people saying?
- You may need to perform a driver installation before installing hardware

Driver installation
- You checked the documentation first, right?
- Check the web for the latest version
- Uninstall previous drivers through Windows Device Manager
- Manufacturer provided setup program
- Manual installation through
- Windows Device Manager
- Check the Device Manager for the status
  - Does it work?

Printer

- Color and B&W output
  - Paper documents, photos
- All-in-one - AIO
  - Printer, scanner, copier, fax
- Connectivity
  - USB
  - Ethernet
  - 802.11 Wireless
  - Bluetooth / Infrared

Scanner

- Connected via USB or 802.11 wireless
- Different form factors
  - All-in-one
  - Flatbed
- May include an ADF
  - Automatic Document Feeder

Barcode/QR code reader

- Serial or USB connector
  - Or 802.11 wireless
- Or with your phone
  - Built-in camera

Display devices

- The human's display device
  - The most popular output device
- Many different connections
  - Different standards through the years
- Many different standards
  - And sizes
  - And resolutions

VR headset

- Virtual reality
  - Headset determines what you see
- Motion tracking
  - X, Y, and Z axis
- Interact with a virtual environment
  - Gaming
  - Education
  - Art
  - Travel

Optical / DVD Drive

- Store and read data with light
  - Uses a laser to read and write
- Read/write media
  - Store backups and documents
- Read-only media
  - Data can't be deleted
  - Common for video distribution
- Limited storage sizes
  - Dual-layer Blu-ray holds 50 GB

Mouse

- USB connection
  - Or an adapter for PS/2
- Optical mice have few moving parts
  - May need the right surface
  - Glass may cause a problem

Keyboard

- Connected via USB
  - Or an adapter for PS/2
- Additional features may require additional drivers and/or software

Touch pads

- Integrated into the keyboard
  - May be a standalone device
  - Connected via USB or Bluetooth
- Replaces a mouse
  - Uses no additional space

Signature pad

- We've gone paperless
  - But we still need somewhere to sign
- Small digitizer
  - And stylus
- USB connection
  - Driver may be required

Gaming input

- Game pad and Joystick
  - USB connected
  - Used almost exclusively for games

Webcam

- Video capture
  - Built-in camera
  - USB connected
  - 802.11 Wireless
- Usually includes both audio and video
  - Specialized drivers and software

Microphone

- Integrated into most new laptops and multimedia devices
  - Also external
- Connectivity
  - Analog - TRS (Tip / Ring / Sleeve)
  - Digital - USB

Speakers

- Analog output devices
  - Compatible with our ears
- Connectivity
  - TRS (Tip / Ring / Sleeve) jacks
  - Speaker output, audio adapter

Headset
- Headphones and microphone
  - One unit
- Desk and mobile use
  - USB
  - TRS plug
  - Wireless / Bluetooth
- Talk and listen
  - Desktop telephone
  - Mobile communication
  - Gaming

Digital projectors
- Not always LCD
  - But common to see LCD
- Metal-halide lamp
  - Very bright (very hot) light
  - Brightness measured in lumens
  - Relatively expensive
  - (~ $35 to $350+ US)
- Always let bulbs cool
  - Fan will run after shutting off
  - Keep it plugged in

External storage devices
- Storage outside the computer, and often removable
  - Very portable, easy to move large files
  - USB flash drive, SSD, hard drive
- Many different connectivity options
  - USB, Thunderbolt, eSATA, etc.
- Very large storage options
  - And very mobile
  - Can be a security concern

KVM
- Keyboard, Video and Mouse
  - Use many computers with a single keyboard, video display, and mouse

Magnetic reader / chip reader
- Point of sale terminal
  - Method of payment
  - Credit card
- Support for different formats
  - Integrated circuit
  - Physically inserted into reader
  - Magnetic strip
  - Backward compatibility
- Reader is USB connected
  - To a point of sale (POS) terminal

NFC / Tap-to-pay device
- Near-field communication
  - ~10 centimeter wireless range
- Built into many phones
  - Integrates with a payment terminal
- Many different uses
  - Contactless payment systems
  - Identity token / door key
  - Gaming and entertainment

Smart card reader
- Smart card
  - Card with embedded circuitry
  - Used in payment cards, identification cards
- Useful form of authentication
  - Username, password, physical smart card
- Readers are built-in or external - USB connected

WARNING
- **Always disconnect from the power source when working on a device**
  - Always. Seriously.
- Some devices store a charge in capacitors
  - Know how to discharge before touching
- **Never connect your body to any part of an electrical system**
  - **Do not connect yourself to an electrical ground**
- Respect electricity - It does not respect you

Computer power supply
- Computer uses DC voltage
  - Most power sources provide AC voltage
- Convert 115 V AC or 220 V AC
  - To 3.3V DC, 5.5 V DC, and 12 V DC
- You'll know when this isn't working

Amp and volt
- Ampere (amp, A) – The rate of electron flow past a point in one second
  - The diameter of the hose
- Voltage (volt, V)
 - Electrical "pressure" pushing the electrons
  - How open the faucet is

Power
- Watt (W)
  - Measurement of real power use
  - volts * amps = watts
  - 120V * 0.5A = 60W

Current
- Alternating current (AC)
  - Direction of current constantly reverses
  - Distributes electricity efficiently over long distances
  - Frequency of this cycle is important
  - US/Canada – 110 to 120 volts of AC (VAC), 60 hertz (Hz)
  - Europe – 220-240 VAC, 50 Hz
- Direct current (DC)
  - Current moves in one direction with a constant voltage

Dual-voltage input options
- Voltage varies by country
  - US/Canada – 110 to 120 volts of AC (VAC), 60 hertz (Hz)
  - Europe – 220-240VAC, 50 Hz
- Manually switch between 110 V/115 V and 220 V/230 V
  - Get your meter! Or use an auto-switching power supply
- Don't plug a 115 V power supply into a 230 V power source!

24-pin motherboard power
- Main motherboard power
  - Provides +3.3 V, +/-5 V, and +/- 12 V
- 20 pin connector was the original ATX standard
  - 24 pin was added for PCI Express power
- You can connect a 24-pin connector to a 20-pin motherboard
  - Some cables are 20-pin + 4-pin

Power supply output
- Different voltages - For different components
- Positive and negative voltage
  - Voltage is a difference in potential
  - The electrical ground is a common reference point
  - Depends on where you measure from
- At the front door of your house
  - The second floor is +10 feet
  - The basement is -10 feet

- +12 V
  - PCIe adapters, hard drive motors, cooling fans, most modern components
- +5 V
  - Some motherboard components
  - Many components are now using +3.3 V
- +3.3 V
  - M.2 slots, RAM slots, motherboard logic circuits
- -12 V
  - Integrated LAN
  - Older serial ports
  - Some PCI cards
- -5 V
  - Available for ISA adapter cards
  - Most cards didn't use it
  - Today's motherboards don't have ISA slots

Sizing a power supply
- Power supplies are rated by watts
  - Overall and by individual voltages
- Bigger isn't necessarily better
  - More expensive
  - Doesn't speed up your computer
- Physical size is relatively standard
  - Older cases and systems may have proprietary sizes
- Calculate the watts required for all components
  - CPU, storage devices, video adapter
  - Many online calculators
- Video adapters are usually the largest power draw
  - Many video card specifications list a recommended power supply wattage
- 50% capacity is a good rule of thumb
  - Power supply runs efficiently and there's room to grow

3.8 - Custom Computer Systems

Graphics workstations
- Computer Aided Design (CAD) /
  - Computer Aided Manufacturing (CAM)
- SSD
  - High-speed storage
- High-end video
  - Complex graphics
- Maximum RAM
  - Significant memory use

Audio/Video editing workstation
- Specialized audio and video card
  - High quality audio
  - Powerful video

- Large fast hard drive
  - Constant disk writes
  - SSD
- Dual monitors
  - Edit in one monitor, view output in the other

Virtualization workstation
- Maximum RAM
  - Every OS needs its own memory
  - It adds up quickly!
- Maximum CPU cores
  - Constant processing
  - Need an efficient CPU
  - Most virtualization apps can use multiple cores

Gaming PC
- SSD
  - Fast start and load times
- High-end video/specialized GPU
  - Graphically complex
- High definition sound card
  - Multiple layers, atmosphere
- High-end cooling
  - High utilization for hours at a time

Standard thick client
- Desktop applications
  - Executable programs running in local memory and using local CPU
- Meets recommended requirements for running the operating system
  - CPU, total RAM, disk space

Thin client
- Basic application usage
  - Applications actually run on a remote server
  - Virtual Desktop Infrastructure (VDI)
  - Local device is a keyboard, mouse, and screen.
- Minimal operating system on the client
  - No huge memory or CPU needs
- Network connectivity
  - Big network requirement
  - Everything happens across the wire

Network attached storage device
- NAS - Access from anywhere
- Media streaming - Central location
- File sharing - Easy access
- Gigabit NIC - High speed transfers
- RAID array - Redundant hard drives

Workstation	Processor	Video	RAM	Storage	Audio	Notes
Graphics/CAD/CAM		✓	✓	✓		SSD storage, maximum RAM
Audio/Video Editing		✓		✓	✓	Large and fast storage, dual monitor
Virtualization Workstation	✓		✓			Maximum CPU and RAM
Gaming		✓		✓	✓	SSD storage, high-end cooling
Thick Client						Recommended OS requirements
Thin Client						Basic applications
Network attached storage				✓		High-capacity hard drives

3.9 - Common Devices

Thin client
- Very little client configuration
  - All the work is done on the server
- Mouse, keyboard, network, monitor
  - And power on
- Minimal OS on the client
  - Most of the OS is on the server
  - Apps are centralized on the server
- Few moving parts, if any
  - Inexpensive to buy
  - Easy to replace

Thick client
- A traditional computer
  - With all of the requirements
- Local resources
  - Operating system
  - Device drivers
  - Applications
- Ongoing support
  - Security patches
  - Operating system updates
  - Application updates

Account setup and settings
- Centralized account management
  - Microsoft Active Directory
  - User account added to the directory
- Thin client - No local permissions required
- Thick client
  - Device is added to the Microsoft domain
  - User authenticates to gain access to the thick client

Laptop
- A thick client that moves
  - Mobility brings additional administrative concerns
- Touchpad configuration - Finger combinations and swiping
- Synchronization and backup - Cloud-based or local drive
- Wireless connections - Mobility in the office and elsewhere
- Additional security - VPN connectivity, local drive encryption

Phone / tablet
- Centralized management - Mobile Device Manager (MDM)
- Touchscreen configuration - Lock codes and biometric access
- Application installations - Set by policy and requirement
- Synchronization and backup - Cloud-based
- Wireless enabled - Includes VPN connectivity

SOHO multifunction devices
- SOHO
  - Small-office / Home-office
- Multifunction devices
  - Printer
  - Scanner
  - Fax (yes, really)
  - Network connection
  - Phone line connection
  - Print from web
- There are a lot of things that can go wrong
  - You're going to fix them

Printer drivers
- Specific to a printer model
  - Get this exactly right
- Get the right operating system drivers
  - Windows 7, Windows 8/8.1, Windows 10
- Get the right version of the operating system
  - 32-bit drivers are very different than 64-bit drivers
- You can't mix and match drivers
  - It's a very specific task

Configuration settings
- Duplex
  - Printing on both sides of the page without manually flipping over the paper
  - Not all printers can do this
- Collate
  - Print multiple copies in their proper order
  - Non-collated:
    - Page 1, 1, 1, 1, 2, 2, 2, 2, 3, 3, 3, 3, 4, 4, 4, 4
  - Collated:
    - Page 1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4
  - Very useful for many copies of large documents
- Orientation
  - Portrait vs. Landscape
  - The paper doesn't rotate
  - The printer compensates
- Quality
  - Resolution
  - Color, greyscale
  - Color saving

Wired device sharing
- USB type B
  - The most common connector
  - USB Type B on the printer,
  - USB Type A on the computer
- Parallel
  - Legacy systems
  - Centronics interface on the printer
  - DB-25 on the computer
- Ethernet
  - RJ45 connector
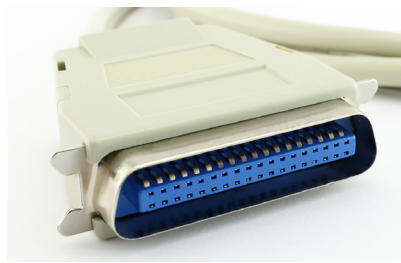
Centronics connector
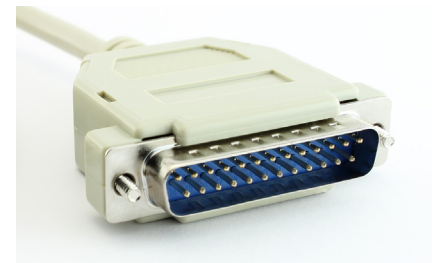
DB-25 parallel connector

Wireless device sharing
- Bluetooth
  - Limited range
- 802.11 a/b/g/n/ac Infrastructure mode
  - Many devices using an access point
- 802.11 Ad hoc mode
  - No access point
  - Direct link between wireless devices

Device sharing
- Integrated print server
  - Print directly to the printer
  - Jobs are queued on the printer
  - Jobs are managed on the printer
  - Web-based front-end
  - Client utility
- Cloud printing
  - Print to the cloud
  - Useful from mobile devices
  - The cloud sends to your printer
  - Google, Brother, HP, etc.

Sharing from an operating system
- Network ports
  - Common on Windows devices
  - Commonly uses tcp/139, tcp/445, udp/137, and udp/138
- Bonjour
  - Discover Apple devices on the LAN
  - Part of macOS
  - Can be added to Windows (iTunes, etc.)
- AirPrint
  - Print from iOS devices to compatible printers

Printer data privacy
- User authentication
  - Everyone can print
  - Set rights and permissions
  - Printing vs. managing the printer
- Print and scan caching
  - Click print
  - Local system creates a file of the output
  - Output file is sent to the print server spooler
  - Printing is done from the spool file
  - Spool file is deleted when done (but not always)

3.11 - Laser Printers

Laser printer
- Combine a laser, high voltage, charged ions, powdered ink, heat, and paper
- Very high quality
- Fast printing speeds
- Very complex, many moving parts, requires on-printer memory and messy on the inside

Imaging drum
- Image is drawn onto a photosensitive drum
  - "Painted" with a laser
- Picks up toner - Transfers toner to the paper
- Can be separate from the toner cartridge or combined

Fuser assembly
- Heat and pressure - Melt plastic toner powder
  - Permanently bond toner to paper

Transfer belt and roller
- Color laser printers
  - Cyan, yellow, magenta, black
- Four separate toner cartridges
- Image is transferred from all cartridges to the single belt
  - And then to a single transfer roller

Pickup rollers
- Pickup paper - Should be a single page at a time
  - Problems if no paper is picked up or multiple sheets are picked
- Should be periodically cleaned or replaced

Separation pad
- Pull just the top sheet from the paper tray
  - Not multiple sheets
- Small and inexpensive - Easy to clean or replace

Duplexing assembly
- Printers usually print on a single side
  - Not both sides simultaneously
- Printing on both sides is a two step process
  - Print side one, print side two
- You need mechanisms to "flip" the page
  - Automatically
- Can be built-in to the printer
  - Or available as an add-on
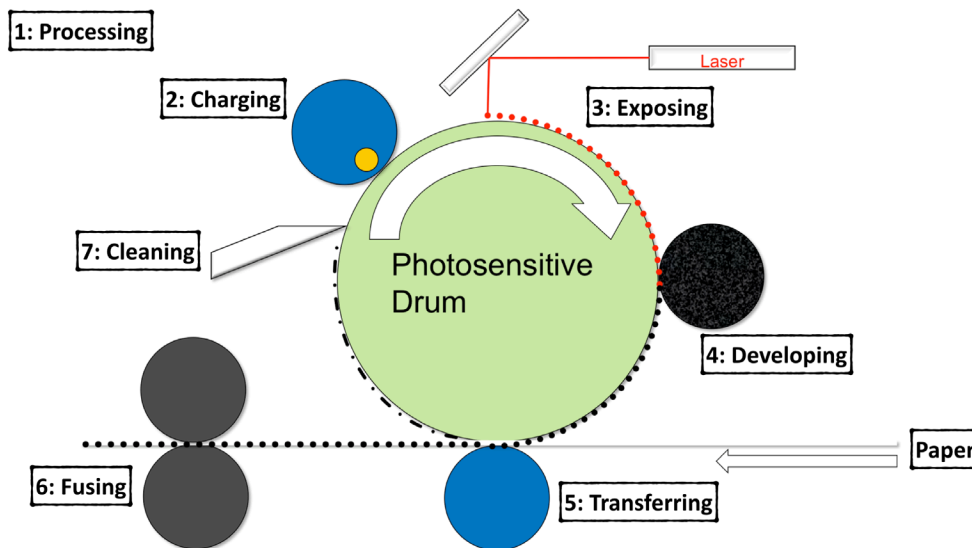
Step 1: Processing
- Build the entire page in memory

Step 2: Charging
- Prepare the drum with a negative electrostatic charge

Step 3: Exposing
- Write the image with the laser

Step 4: Developing
- Add toner to the charged areas of the imaging drum

Step 5: Transferring
- Move the toner from the drum to the paper

Step 6: Fusing
- Heat and pressure

Step 7: Cleaning
- Remove excess toner

3.11 - Laser Printer Maintenance

Replacing the toner cartridge
- Look for the messages
  - Low doesn't mean empty
- The toner can also contain the OPC drum
  - Organic Photoconductor drum
  - Sensitive to light; keep it in the bag
- Power down the printer
  - Safety first
- Remove packing strips from the new drum
  - Replace it with the old

Laser printer maintenance kit
- Laser printers wear out
  - All those moving parts
  - Heat and pressure
- Standard maintenance kits
  - Replacement feed rollers, new fuser unit, etc.
- When to perform maintenance?
  - Check the printer's page counter
- Power down and replace the components
  - Fuser units are HOT
- Reset the page counter when you're done!

Laser printer calibration
- Different toner cartridges print with different densities
  - Some dark, some light
- Laser printer calibration can adjust the density
  - Makes it looks perfect
- Can be automated or a manual process
  - Every printer is different
  - Check the printer manual

Laser printer cleaning
- Laser printers are dirty - All that toner and paper dust
- Check the manufacturer's recommendations
  - Water, isopropyl alcohol (IPA)
  - Don't use harsh chemicals!
- Outside - Damp cloth
- Inside - Wipe dust away
  - Don't use a normal vacuum cleaner or compressed air
  - Wash off skin with cold water
  - Clean rollers with IPA

3.11 - Inkjet Printers

Inkjet (ink-dispersion) printer
- Relatively inexpensive technology
- Quiet
- High-resolution
- Expensive ink
  - Proprietary
- Eventually fades
- Clogs easily

Ink cartridge
- Place drops of ink onto a page
  - Pulled from a set of cartridges
- CMYK
  - Cyan, Magenta, Yellow, Key (black)

Print head
- Some consumer printers integrate the print head into the ink cartridge
  - Change the cartridge, get a new print head
- Others separate the ink cartridge from the print head

Feed rollers
- Pick up and feed paper through the printer
  - Must be clean and not worn
- Duplexing
  - Print on both sides of the paper
  - Included with some printers

Carriage and belt
- Ink cartridges are moved over the paper
  - Carriage may include its own print head
- Belt moves the carriage back and forth
  - Another moving part

Inkjet printer calibration
- Align nozzles to the paper
  - Lines should be crisp
  - Colors should align
- Printer includes a calibration option
  - May need to make minor adjustments

3.11 - Inkjet Printer Maintenance

Cleaning print heads
- Small droplets of ink
  - And small holes in a print head
- Clogged heads is a big issue
  - Many printers automatically clean every day
  - Output has streaks or sections of missing color
- Cleaning process can be started manually
  - Only takes a few minutes
- Some print heads/cartridges can be removed
  - Manually cleaning may help

Replacing inkjet cartridges
- Usually separate colors
  - Cyan, Magenta, Yellow, and Key (CMYK)
  - Some cartridges will combine these
- Takes seconds to replace
  - Takes a few minutes to calibrate and prepare the cartridge
- Recycle the empty cartridge
  - All plastic

Inkjet printer calibration
- Align nozzles to the paper
  - Lines should be crisp
  - Colors should not overlap
- Printer includes a calibration option
  - May need to make minor adjustments

Clearing jams
- Lots of turns and twists
  - A jam is inevitable
- Remove tray paper
  - Any loose paper
- Remove paper from the path
  - Firm pressure, don't rip
- Check for any scraps of paper
  - Remove all loose paper

3.11 - Thermal Printers

Thermal printer
- White paper
  - Turns black when heated
  - No ink!
- VERY quiet
  - Almost silent
- Paper is sensitive to light and heat
  - And clear tape

Feed assembly
- Pull paper through the printer
  - Relatively small paper path

Heating element
- Full-length heating element
  - No moving print head

Thermal paper
- Paper covered with a chemical
  - Changes color when heated
- Cash registers, credit card terminals
  - And quiet areas
- Looks like normal paper
  - Feels a bit different

3.11 - Thermal Printer Maintenance

Thermal paper replacement
- Relatively inexpensive
  - But impossible to substitute
- Different sizes
  - Not like laser printer paper
  - Keep a list
- Actual replacement process is easy
  - Simple paper feed
  - Small device

Cleaning the heating element
- Liquid cleaner
  - Isopropyl alcohol (IPA)
  - Get a cleaning pen
  - Check manufacturer's recommendations

- Swab gently
  - Usually small areas
- Use a cleaning card
  - Cleans the head
  - And paper pathways

Removing debris
- Relatively small amount
  - Paper bits and dust
  - No toner!
- Blow out the printer
  - Take it outside
- Wipe it out
  - Damp cloth
- Avoid using a vacuum
  - Unless it's designed for computers
  - Resists static buildup/discharge

3.11 - Impact Printers

Dot-matrix (impact) printers
- Print head with a small matrix of pins
  - Presses against a ribbon to make a mark on paper
- Good for carbon/multiple copies
- Low cost per page
- NOISY
- Poor graphics
- Niche use - Car rental, airports

Dot-matrix printer head
- Moves back and forth
  - Pins hit ribbon and paper
- One matrix - Must move across the page to print

Printer ribbon
- Fabric
  - One long ribbon - Never ending circle
- Easy to replace - Once single unit
- Proprietary size - Specific to printer model

Tractor feed
- Paper pulled through with holes on the side of the paper
  - Instead of using friction
- Continuous paper feed
  - Perforations between pages
- Holes have to line up perfectly
  - Tractor paper can be perforated to remove holes

3.11 - Impact Printer Maintenance

Printer ribbon replacement
- Single ribbon
  - Self-contained - One long circle
- Replace when ink becomes too light
  - Ink is eventually consumed
- Designed to be modular - Replace in less than a minute

Print head replacement
- Takes a lot of abuse
  - Directly hits the ribbon and paper
- Gets hot - Watch your fingers
  - Another modular part - Look for a release lever or bar
- Replace with the ribbon for the best effect
  - The output should look perfect

3.11 - Impact Printer Maintenance (continued)

Replacing paper
- Not as easy as a laser printer
  - Paper must feed perfectly into holes
  - Tractor feed
- Forms must be positioned correctly
  - Text needs to fit a predefined space
- Paper must feed without constraint
  - Make sure nothing is in the way

3.11 - Virtual and 3D Printers

Virtual printers
- No physical output
  - Output to a "digital" document
- No additional hardware required
  - No printer, no paper
- Useful for sending electronically
  - Easy to manage

Print to file
- You need to print to a printer at work
  - You're at home
- Print to the work printer driver
  - But save it as a file
- File will be in an output format specific to that printer
  - You can't open it with another program
- Must use the command line to copy the file to the printer, i.e., copy filename LPT1:

Print to PDF
- Adobe PDF
  - Portable Document Format
  - A one-way path from application to PDF
  - Cross-platform compatibility
- Proprietary Adobe format
  - Requires specialized software to create and view a PDF
  - PDF viewers built into many Internet browsers
- Many third party tools available
  - Some applications will print to PDF without any additional software

Print to XPS
- Microsoft XPS
  - XML Paper Specification
- Similar use case to Adobe PDF
  - But XPS is included in Windows
  - And available all the way back to Windows XP
- Print to XPS, view in any operating system
  - If there's an XPS reader

Print to image
- Print to a graphics image
  - For later image editing or sharing
- Not integrated into the OS
  - A feature of the application
- Some third-party image print drivers are available
  - Application may export graphics formats natively

3D printers
- "Print" in three dimensions
  - Create a 3D item based on an electronic model
- Additive manufacturing
  - Melt plastic filament in layers to create the object
  - No machining process required
- Rapid prototyping
  - Design and create relatively quickly and inexpensively
- Deploy designs anywhere in the world
  - Or into space

4.1 - Cloud Models

Infrastructure as a service (IaaS)
- Sometimes called Hardware as a Service (HaaS)
  - Outsource your equipment
- You're still responsible for the management and security
- Your data is out there, but more within your control
- Web server providers

Software as a service (SaaS)
- On-demand software - No local installation
  - Why manage your own email distribution or payroll?
- Central management of data and applications
  - Your data is out there
- A complete application offering
  - No development work required, i.e., Google Mail

Platform as a service (PaaS)
- No servers, no software, no maintenance team, no HVAC
  - Someone else handles the platform, you handle the development
- You don't have direct control of the data, people, or infrastructure
  - Trained security professionals are watching your stuff
- Put the building blocks together
  - Develop your app from what's available on the platform
  - SalesForce.com

Cloud deployment models

- Private - Your own virtualized local data center
- Public - Available to everyone over the Internet
- Hybrid - A mix of public and private
- Community
  - Several organizations share the same resources

Local and cloud resources

- On-premise
  - Your applications are on local hardware
  - Your servers are in your data center in your building
- Hosted
  - Your servers are not in your building
  - They may not even be running on your hardware
  - Usually a specialized computing environment
- Cloud
  - Entire application instances can be created and torn down on-demand
  - Resources are available as needed

Shared resources

- Internal cloud
  - No resources are shared
  - Build your own cloud
  - Pay for everything up front
  - No ongoing costs
- External cloud
  - Share resources with a public cloud
  - Underlying infrastructure owned by a third-party
  - Cost may be metered or up-front

Cloud computing characteristics

- Rapid elasticity
  - Scale up and scale down as needed
  - Seamless to everyone
- On-demand self-service
  - Adding software, networks, servers, storage is a challenge outside the cloud
  - The cloud enables instant resource provisioning
- Resource pooling
  - All of the computing power in one place
  - One large resource instead of many small resources
- Measured service
  - Costs and utilization are very closely tracked
  - Resource planning and granular chargebacks

Metered and non-metered

- Metered cloud services
  - You pay for what you use
  - Cost to upload
  - Cost to store
  - Cost to download
- Non-metered
  - You pay for a block of storage
  - No cost to upload
  - No cost to download

4.1 - Cloud Services

Off-site email applications

- Email is a staple
  - Detailed electronic communication
- A challenge to maintain
  - Expensive hardware and storage
  - Trained support team
  - Ongoing backup and maintenance
- Cloud-based email hosting
  - Flat cost per user per month
  - Personal options may have no direct cost
  - Looks and feels the same for the user
- Microsoft Office 365, Google Mail

Cloud file storage services

- Store your files in the cloud
  - Access, share, and edit from anywhere
- Easy to collaborate - One place for all files
- Synchronization app
  - Store files on a local drive
  - The app synchronizes to the cloud
  - Sync files to other devices
- Cloud storage providers
  - Dropbox, Google Drive, Box, Microsoft OneDrive

Virtual application streaming

- On-demand applications
  - No local installation
  - Globally distributed
- User starts the application
  - The components are downloaded as needed
  - If you don't use a component, you don't download it
  - User data is stored securely in the cloud
- Easy to update
  - The application is in one place
  - Some data is cached, only update the changes

Application streaming

- Mobile phones / tablets
  - Run an app (or portion of an app) in real-time
  - Try many different apps or components
  - Can be cached locally for later use
- Applications for laptop/desktops
  - No complex deployment process
  - Apps are only streamed if they are used
  - New applications are simply added to the cloud offering
  - Quickly manage and make changes

Cloud-hosted virtual desktops
- A virtual desktop infrastructure (VDI) in the cloud
  - Users connect to a pre-built desktop
- Access from almost any OS
  - Windows, Mac OS, Linux,
  - iOS, Chromebook, web browser
- Virtual NIC
  - All communication in the desktop are local to the virtual desktop
  - No sensitive information sent from the local device
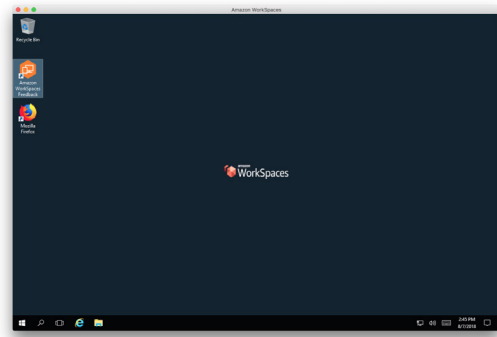
4.2 - Client-side Virtualization

Virtualization
- One computer, many operating systems
  - Mac OS X, Windows 7, Linux Ubuntu, all at the same time!
- Separate OS, independent CPU, memory, network, etc.
  - But really one computer
- Host-based virtualization
  - Your normal desktop plus others
- Standalone server that hosts virtual machines
  - Enterprise-level
- Been around since 1967
  - IBM mainframe virtualization

The hypervisor
- Virtual Machine Manager
  - Manages the virtual platform and guest operating systems
- May require a CPU that supports virtualization
  - Can improve performance
- Hardware management
  - CPU
  - Networking
  - Security

Resource requirements
- CPU Processor Support
  - Intel: Virtualization Technology (VT)
  - AMD: AMD-V
- Memory
  - Above and beyond host OS requirements
- Disk space
  - Each guest OS has it's own image
- Network
  - Configurable on each guest OS (standalone, NAT, bridged, etc.)
  - Virtual switch

Emulation vs. virtualization
- Virtualization is a native operating system
  - Performing native OS processes
  - This is identical to using a non-virtual system

- Emulation is one device running processes designed for a completely different architecture
  - One device is pretending to be another
  - Original code is used
  - Code is interpreted for running on the current hardware
  - This is commonly slower than running natively
  - Emulation is not easy to do

Hypervisor security
- Hypervisor is a sweet spot for the bad guys
  - No significant vulnerabilities yet
- VM escaping
  - Malware recognizes it's on a virtual machine
  - Malware compromises the hypervisor
  - Malware jumps from one guest OS to another
- Many hosted services are virtual environments
  - Malware on one customer's server can gather information from another

Guest operating system security
- Every guest is self-contained - Like a real computer
- Use traditional security controls
  - Host-based firewall - Anti-virus, anti-spyware
- Watch out for rogue virtual machines (VMs)
  - The bad guys try to install their own system
  - You're in big trouble
- Self-contained VMs provided by
  - 3rd parties can be dangerous
  - You have no idea what's running on there

Network requirements
- Most client-side virtual machine managers have their own virtual (internal) networks
- Shared network address
  - The virtual machine shares the same IP address as the physical host
  - Uses a private IP address internally
  - Uses NAT to convert to the physical host IP
- Bridged network address
  - The VM is a device on the physical network
- Private address
  - The VM does not communicate outside of the virtual network

Uh oh. It's broken! → Identify the Problem → Establish a Theory → Test the Theory

Test the Theory → Evaluate Results: Is it working?

Evaluate Results: Is it working? — Not fixed yet! → Establish a Theory

Evaluate Results: Is it working? — Yes! → Establish a Plan of Action → Implement the Plan

Evaluate Results: Is it working? → Verify Full System Functionality

Implement the Plan → Verify Full System Functionality → Document Findings → It works! Yay!

Change management
- Change control
  - A formal process for managing change
  - Avoid downtime, confusion, and mistakes
  - Corporate policy and procedures
- Nothing changes without the process
  - Plan for a change
  - Estimate the risk associated with the change
  - Have a recovery plan if the change doesn't work
  - Test before making the change
  - Document all of this and get approval
  - Make the change

Identify the problem
- Information gathering
  - Get as many details as possible
  - Duplicate the issue, if possible
- Identify symptoms - May be more than a single symptom
- Question users - Your best source of details
- Determine if anything has changed
  - Who's in the wiring closet?
- Approach multiple problems individually
  - Break problems into smaller pieces
- Backup everything
  - You're going to make some changes
  - You should always have a rollback plan
- What else has changed?
  - The user may not be aware
  - Environmental changes
  - Infrastructure changes
- There may be some clues - Check OS log files
  - Applications may have log information

Establish a theory
- Start with the obvious
  - Occam's razor applies
- Consider everything
  - Even the not-so-obvious
- Make a list of all possible causes
  - Start with the easy theories
  - And the least difficult to test
- Research the symptoms
  - Internal knowledgebase
  - Google searches

Test the theory
- Confirm the theory
  - Determine next steps to resolve problem
- Theory didn't work?
  - Re-establish new theory or escalate
  - Call an expert
- The theory worked!
  - Make a plan...

Create a plan of action
- Build the plan
  - Correct the issue with a minimum of impact
  - Some issues can't be resolved during production hours
- Identify potential effects
  - Every plan can go bad
  - Have a plan B
  - And a plan C

Implement the solution
- Fix the issue
  - Implement during the change control window
- Escalate as necessary
  - You may need help from a 3rd party

Verify full system functionality
- It's not fixed until it's really fixed
  - The test should be part of your plan
  - Have your customer confirm the fix
- Implement preventative measures
  - Let's avoid this issue in the future

Document findings
- It's not over until you build the knowledge base
  - Don't lose valuable knowledge!
- What action did you take?
  - What outcome did it have?
- Consider a formal database
  - Help desk case notes
  - Searchable database

5.2 - Troubleshooting Common Hardware Problems

Unexpected shutdowns
- No warning, black screen
  - May have some details in your Event Viewer
- Heat-related issue
  - High CPU or graphics, gaming
  - Check all fans and heat sinks
  - BIOS may show fan status and temperatures
- Failing hardware
  - Has anything changed?
  - Check Device Manager, run diagnostics
- Could be anything
  - Eliminate what's working

Lockups
- System completely stops
  - Completely. Usually not much in the event log
  - Similar to unexpected shutdowns
- Check for any activity
  - Hard drive, status lights, try Ctrl-Alt-Del
- Update drivers and software patches
  - Has this been done recently?
- Low resources
  - RAM, storage
- Hardware diagnostics may be helpful

POST (Power On Self Test)
- Test major system components before booting the operating system
  - Main systems (CPU, CMOS, etc.)
  - Video
  - Memory
- Failures are usually noted with beeps and/or codes
  - BIOS versions can differ, check your documentation
- Don't bother memorizing the beep codes
  - They're all different between manufacturers
  - Know what to do when you hear them

POST and boot
- Blank screen on boot
  - Bad video
  - Listen for beeps
  - BIOS configuration issue

- BIOS time and setting
  - Maintained with the motherboard battery
  - Replace the battery
- Attempts to boot to incorrect device
  - Set boot order in BIOS configuration
  - Confirm that the startup device has a valid operating system
  - Check for media in a startup device

Continuous reboots
- How far does the boot go before rebooting?
  - BIOS only? OS splash screen?
- Bad driver or configuration
  - F8, "Boot from last known working configuration"
- Try F8, Safe Mode
  - If system starts, disable automatic restarts in System Properties
- Bad hardware
  - Try removing or replacing devices
  - Check connections and reseat

No power
- No power
  - No power at the source
  - No power from the power supply
  - Get out your multimeter
- Fans spin - no power to other devices
  - Where is your fan power connected?
  - No POST - bad motherboard?
  - Case fans have lower voltage requirements
  - Check the power supply output

Overheating
- Heat generation
  - CPUs, video adapters, memory
- Cooling systems
  - Fans and airflow
  - Heat sinks
  - Clean and clear
- Verify with monitoring software
  - Built into the BIOS
  - Try HWMonitor - http://www.cpuid.com/

Loud noises
- Computers should hum
  - Not grind
- Rattling
  - Loose components
- Scraping
  - Hard drive issues
- Clicking
  - Fan problems
- Pop
  - Blown capacitor

Intermittent device failure
- Sometimes it works
  - Sometimes it doesn't
- Bad install
  - Check and reseat
  - Use all the screws
- Bad hardware
  - Poor connection
  - Heat and vibration

Indicator lights
- POST codes on the motherboard
- Power
- Link light
- Speed
- Activity

Smoke and burning smell
- Electrical problems
  - The smoke makes everything work
- Always disconnect power
  - There should never be a burned odor
- Locate bad components
  - Even after the system has cooled down
  - Replace all damaged components

Crash screens
- Windows Stop Error
- Blue Screen of Death - You don't want this
- Contains important information
  - Also written to event log
- Useful when tracking down problems
  - Sometimes more useful for manufacturer support

The spinning ball of death
- The Mac OS X Spinning Wait Cursor
  - Feedback that something is happening
- The spin starts, but it never stops
  - You never get back control of your computer
- Many possible reasons
  - Application bug, bad hardware, slow paging to disk
- Restart the computer
  - There may be details in the console logs

Log entries
- Windows
  - Event Viewer
  - Boot logs
  - System Configuration
  - C:\Windows\ntbtlog.txt
- Linux
  - Individual application logs - `/var/log`
- Mac OS X - Utilities / Console.app

Error messages
- The details of an error message can make or break a troubleshooting session
  - Write down everything
  - Take a picture, make a video
  - Train your users
- The error might not make sense
  - Write it down anyway
  - The Internet will tell you what it means
  - Spend your time troubleshooting the right things

5.3 - Troubleshooting Hard Drives

Disk failure symptoms
- Read/write failure
  - "Cannot read from the source disk"
- Slow performance
  - Constant LED activity
  - Retry...retry...retry
- Loud clicking noise
  - The click of death

Troubleshooting disk failures
- Get a backup
  - First thing - a bad drive is bad
- Check for loose or damaged cables
- Check for overheating
  - Especially if problems occur after startup

- Check power supply
  - Especially if new devices were added
- Run hard drive diagnostics
  - From the drive or computer manufacturer
  - Preferably on a known-good computer

Boot failure symptoms
- Drive not recognized
  - Lights (or no lights)
  - Beeps
  - Error messages
- Operating system not found
  - The drive is there
  - Windows is not

Troubleshooting boot failures
- Check your cables
  - Physical problem
- Check boot sequence in BIOS
  - Check for removable disks (especially USB)
  - Check for disabled storage interfaces
- For new installation, check hardware configuration
  - Data and power cables
  - Try different SATA interfaces
- Try the drive in a different computer

RAID not found
- Missing or faulty RAID controller

RAID stops working
- Each RAID is different
  - Don't start pulling drives until you check the console!

Crash screens
- Windows Stop Error,
  - Apple spinning wait cursor - A very serious issue
- May indicate a storage device issue
  - Diagnostics needed for drive and motherboard

S.M.A.R.T. errors
- Self-Monitoring, Analysis, and Reporting Technology
  - Use third-party utilities
- Avoid hardware failure
  - Look for warning signs
- Schedule disk checks
  - Built-in to most drive arrays
- Warning signs
  - Replace a drive

RAID	Disks Required	Failure Condition
RAID 0	2 or more	A single drive failure breaks the array with data loss
RAID 1	2 or more	Array will work as long as one drive is operational
RAID 5	3 or more	Need all drives operational but one
RAID 10	4 or more	Can lose all but one from each set of mirrors

5.4 - Troubleshooting Video and Display Issues

No video image
- Is it connected?
  - We wouldn't ask if it wasn't a real solution
  - Check both power and signal cable
- Input selection on monitor
  - HDMI, DVI, VGA, etc.
- Image is dim
  - Check brightness controls
- Swap the monitor
  - Try the monitor on another computer
- No video after Windows loads
  - Use VGA mode (F8)

Image quality problems
- Flickering, color patterns incorrect
  - You can almost work with this
- Check the cable pins
  - Especially if missing a color
- Distorted image and geometry
  - Check the OS refresh rate and resolution settings
  - Need to match the display specifications
  - Native resolution is important on LCD displays
  - Check or replace cable
- Disable hardware acceleration
  - Troubleshoot with the software drivers

- Oversized images and icons
  - Resolution set too low
  - Lower = larger
- Burn-in
  - A problem across all monitor types
  - Some displays will pixel-shift
    - But you won't notice it
  - LCDs have "image sticking"
    - Remove by displaying a white screen for an extended period

Other video issues
- Pixel problems
  - Stuck pixels (constantly bright)
  - Dead pixels (always black)
- Artifacts
  - Unusual graphics - check adapter
  - Image persistence - Turn off display
  - Motion trails
  - Disable advanced video features
- BSOD and Overheating
  - Video drivers
  - Monitor the internal temperature

5.5 - Troubleshooting Laptops

LCD display troubleshooting
- No display or dim video
  - Verify the backlight
  - Look closely, it may be barely visible
  - No backlight, replace the inverters
- Confirm video with an external display
  - Video good, but LCD bad
  - Replace the LCD display
- Flickering video
  - Connector problem
  - Bad video cable
  - Bad video hardware

Input issues
- Sticking keys
  - Difficult to clean
  - Keycaps are very (very) delicate!
- Ghost cursor / Pointer drift
  - Mousepad causes cursor to bounce around
  - Modify the configuration to check for palm press
  - Update your drivers
- Num lock indicator lights
  - The letters are numbers!

Wireless troubleshooting
- Multiple antennas
  - WiFi main and aux, Bluetooth
  - Antenna wires wrap around the laptop screen
- Easy to accidentally disconnect during maintenance
  - No 802.11 wireless, no Bluetooth
- Check the connectors
  - Loose cables can cause intermittent wireless access

Power issues
- Battery not charging
  - Batteries lose capacity over time
  - Laptop charging hardware may be faulty
- No power
  - Check the external power adapter "brick" with multimeter
  - Master laptop reset
  - Hold power for 10 seconds - Each laptop is different

External monitor issues
- Toggle Fn keys
  - Secondary functions
  - Toggle between LCD / external monitor / both
- Use external monitor
  - Bypass the LCD (but not the video hardware)

5.5 - Troubleshooting Mobile Devices

Touchscreen non-responsive
- Touchscreen completely black or touchscreen not responding to input
  - Buttons and screen presses do not register
- Apple iOS reset
  - Press power button, slide to power off, press power button
  - Hold down power button and Home|volume for 10 seconds
- Android device restart
  - Remove battery, put back in, power on
  - Hold down power and volume down until restart
  - Some phones have different key combinations
  - Some phone do not have a key-based reset

App issues
- Problematic apps
  - Apps not loading, Slow app performance
- Stop the app and restart
  - iPhone: Double-tap home button, slide app up
  - Android: Settings/Apps, select app, Force stop
- Restart the phone
  - Hold power button, power off
- Update the app
  - Get the latest version

Unable to decrypt email
- Protect your email
  - Encrypted communication channels
- Built-in to corporate email systems
  - Microsoft Outlook
- Each user has a private key
  - You can't decrypt without the key
- Install individual private keys on every mobile device
  - Use a Mobile Device Manager (MDM)

Short battery life
- Bad reception
  - Always searching for signal
  - Airplane mode on the ground
- Disable unnecessary features
  - 802.11 wireless, Bluetooth, GPS
- Check application battery usage
  - iPhone: Settings/Battery
  - Android: Settings/Battery
- Replace aging battery
  - There's only so many recharges

Overheating
- Phone will automatically shut down
  - Avoid overheating damage
- Charging/discharging the battery,
  - CPU usage, display light - creates heat
- Check app usage - Some apps can use a lot of CPU
- Avoid direct sunlight - Quickly overheats

Frozen system
- Nothing works
  - No screen or button response
- Soft reset
  - Hold power down and turn off
- Hard reset
  - iOS: Hold power and home|volume for 10 seconds
  - Android: Various combinations of power, home, and volume buttons
- Ongoing problems may require a factory reset
  - Install latest operating system and reload

No sound from speakers
- No sound from a particular app
  - Check volume settings
  - Both app and phone settings
  - Bad software / delete and reload
  - Try headphones
- Sound starts but then stops
  - Dueling apps / keep app in foreground
- No speaker sound from any app
  (no alarm, no music, no audio)
  - Load latest software or factory reset

GPS not functioning
- Check settings to enable GPS
  - iOS: Settings / Privacy / Location Services
  - Android: Settings / Location
- Configure location mode
  - iOS: Settings / Privacy / Location Services
  - Android: Settings / Location / Location mode
- Need a good view of the sky
  - You're listening to satellites in space

Swollen battery
- Buildup of gas
  - Designed to self-contain
  - Do NOT open the battery packet/container
  - Significant fire risk
  - You'll be sorry
- Faulty battery
  - Stop using immediately
  - Dispose of properly
- Device can be damaged
  - Better than having a fire

5.5 - Device Disassembly Best Practices

Device disassembly
- Different than working on a desktop computer
  - Many different pieces
  - Intricately engineered
  - Tight quarters
- Taking it apart is easy
  - Getting it back together...
- Easy to break something
  - Very delicate parts

Mapping the puzzle
- Document and label
  - It seems obvious when disassembling
  - It's not obvious at all when assembling
  - Check iFixit and similar sites
- Cable locations
  - There are a lot of cables
  - Antennas, drives, video, etc.
- Screw locations
  - There are a LOT of screws
  - Different sizes
  - "Hidden" locations

Organize parts
- Laptops disassemble in sections
  - Outer shell, keyboard, video connector, etc.
- Step-by-step
  - Take pictures
  - Use a big workspace

- Use containers to separate the sections
  - Glasses, boxes, etc.
  - Magnetic grid
  - Multi-day projects should be sealed or protected
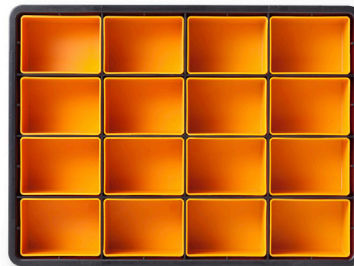
Get the right information
- Refer to manufacturer resources
  - Often provide step-by-step repair guides
- The Internet provides the rest
  - Online written guides, YouTube videos
- Specialized sites can help - http://www.ifixit.com/

The tools
- Use appropriate hand tools
  - Sometimes a single screwdriver
  - Get a good tweezer
  - Sometimes specialized tools
- Magnification will be needed
  - Smaller and smaller devices
- Get a big anti-static cloth
  - Something soft to protect screens
  - Easy to break tiny parts

5.6 - Troubleshooting Printers

Testing the printer
- Print or scan a test page
  - Built into Windows
  - Not the application
- Use diagnostic tools
  - Web-based utilities
  - Built into the printer
  - Vendor specific
  - Download from the web site
  - Generic
  - Available in LiveCD form

Bad output
- Streaks and blurs
  - Inkjet: Clean print heads
  - Laser: Check for scratched photosensitive drum
- Faded prints, blank pages
  - Low toner or ink
- Ghost images
  - Laser printer optical drum not cleaned properly
  - Ghost or "shadow" from previous drum rotation

Final print
- Color prints in wrong print color
  - Low ink in one cartridge
  - Everything else works fine
- Laser printer output smudges everywhere
  - Toner not fused to the paper
  - Should be permanently melted and pressed
  - May not be hot
  - Fuser problem

Paper jam
- Careful when removing
  - Don't rip the paper
  - Don't damage internal components
- Paper not feeding
  - Check the tray
  - Pickup rollers
  - Part of a laser printer maintenance kit
- Creased paper
  - Problems in the paper path
  - Check the paper weight

Network issues
- No connectivity
  - Powered on?
  - User intervention required
  - Wired cabling / Wireless settings
- Access denied
  - Security tab
  - Print
  - Manage this printer
  - Manage documents

Bad output
- Garbled characters on paper
  - Bad printer driver / wrong model
  - Incorrect page description language
  - (PCL or PostScript?)
  - Bad application
  - Check with a test page

OS issues
- Unable to install printer
  - Drivers are important OS updates
  - User must have proper rights
  - Check the printer driver
  - 32 bit vs. 64 bit
- Backed up print queue
  - Print server not working
  - Print spooler crash
  - Restart the spooler
  - Change recovery options

Error messages
- Error codes
  - On the printer display
  - Today's printers have large LCDs
- Low memory errors
  - Laser printers build the entire page in memory
 - Complex images and graphics consume more memory

No output
- Check the printer
  - Getting power? Check for display messages
  - Run a test print from the printer
- Check the connectivity
  - Print a test page from a computer
  - Check direct connection
  - Try across the network
  - Tests the operating system, network, drivers, and spooler
- Check other applications
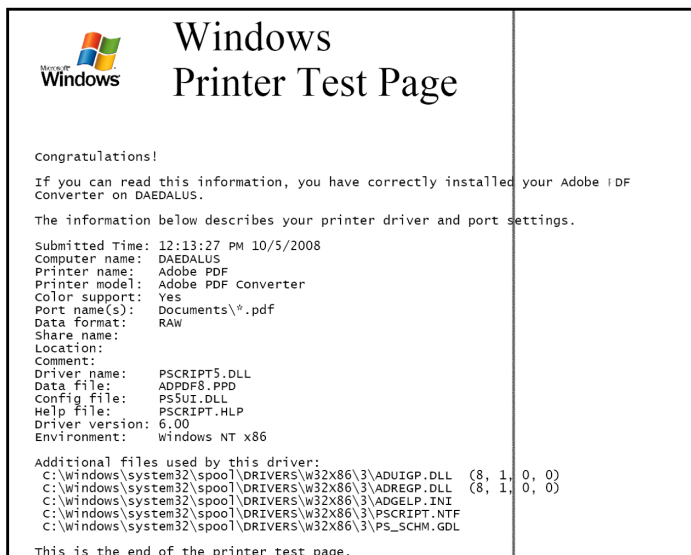 - Print from a different program

Multiple failed jobs in logs
- Corrupted print jobs
  - Print spooler will crash
  - Most spooler configuration will automatically restart
- Problems are logged
  - Windows Event Viewer, Windows-PrintService
- One job may be causing the issue
  - Monitor the queue for details
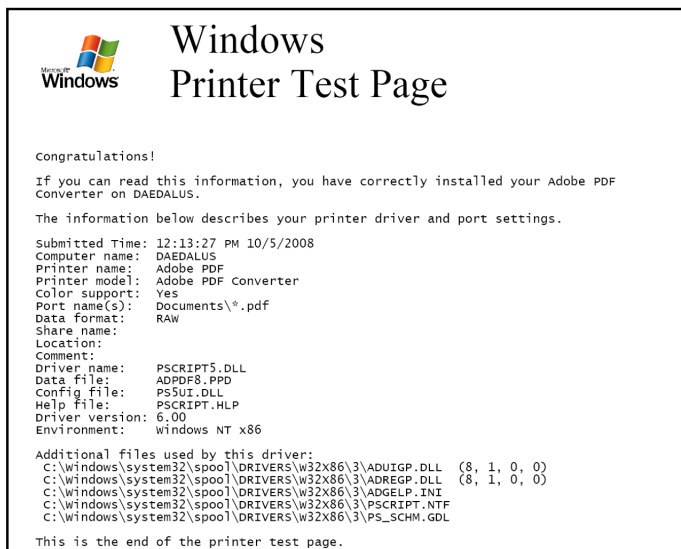
Normal Windows Printer Test Page

Windows Printer Test Page from a laser printer with a scratched photosensitive drum

A "ghosting" Windows Printer Test Page from a laser printer with a faulty cleaning subsystem

Printer Test Page printed with the incorrect page description language or incorrect driver

5.7 - Troubleshooting Networks

No network connectivity
- Do you have a link light?
  - Is it plugged in?
- Ping loopback (127.0.0.1)
  - Is the protocol stack working?
  - Availability and intermittent connectivity
- Ping local IP address
  - Checks local configuration, adapter, and link signal
- Ping default gateway
  - Connectivity on the local network
- Ping devices on router's other side
  - 8.8.8.8

Automatic Private IP Addressing (APIPA)
- A link-local address
  - No forwarding by routers
- IETF has allocated 169.254.1.0 through 169.254.254.255
  - 169.254.0.0/24 and 169.254.255.0/24 are reserved
- Automatically assigned
  - Uses ARP to confirm the address isn't currently in use
- Check your IP address
  - Is it an APIPA address?

Local resources unavailable
- Shares
  - Server unavailable
  - Share permissions have been modified
  - Relies on DNS to find the server
- Printers
  - Device sharing printer (or printer) is unavailable
  - Printer permissions have been modified
- Email
  - Service is associated with a specific server
  - May be a cluster of servers
  - Problems may be related to the servers or the network path

Limited or no connectivity
- Windows alert in the system tray
  - "Limited or No connectivity"
  - "No Internet Access"
- Check the local IP address
  - An APIPA address will only have local connectivity
- If DHCP address is obtained, perform the ping tests
  - Local gateway, remote IP address

Intermittent connectivity
- Internet access
  - Then nothing
- Check the system tray
  - A broken LAN icon is a loss of signal
  - Check for a cable problem
  - Might have bad network interface
- Problem with switch or wireless access point
  - Bad interfaces
  - Router rebooting

IP conflicts
- DHCP helps
  - But static addresses can conflict
- Windows will identify a duplicate
  - And prevent a conflict
- Two identical IP addresses will conflict
  - Intermittent connectivity, if any
- Reboot or reset the NIC
  - Start over from the beginning

Slow transfer speeds
- Frustrating to the user
  - Challenging to the technician
- Router or infrastructure congestion
  - Overloaded network or devices
- Speed and duplex incompatibility
  - An easy fix
- Hardware issue with the adapter
  - Or your cabling
- Malware infection

Low RF wireless signal
- Interference - Something else is using our frequency
- Signal strength
  - Transmitting signal, transmitting antenna, receiving antenna, etc.
- Incorrect channel
  - Usually automatic; look for manual tuning
- Bounce and latency
  - Multipath interference; flat surfaces
- Incorrect access point placement
  - Locate close to the users

Wireless interference
- Predictable
  - Florescent lights
  - Microwave ovens
  - Cordless telephones
  - High-power sources
- Unpredictable
  - Multi-tenant building
- Measurements
  - Signal strength
  - Performance Monitor

SSID not found
- Network name doesn't appear
  - Other networks are there
- Too far away
  - Local networks are louder
- Wireless router has disabled SSID advertisements
  - It will never appear on a list
  - You can still manually connect