



CompTIA Core 1

220-1101

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CompTIA A+ CORE 1 (220-1101) Exam

- **90-minute time limit**
- **Maximum of 90 Questions**
 - **Multiple choice**
 - Pick one or many answers.
 - **Drag & Drop**
 - Match objects to a diagram.
 - **Performance-based (Simulators)**
 - These are hands-on troubleshooting scenarios where you'll have to perform a series of steps/commands
- **675 (75%) out of a scale of 100-900**
- **\$239 Exam Fee**



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Domain	% of Exam
Mobile Devices	15%
Networking	20%
Hardware	25%
Virtualization and Cloud Computing	11%
Hardware and Network Troubleshooting	29%



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Mobile Devices



Hardware/device replacement

- Hardware/device replacement
 - Battery
 - Keyboard/keys
 - Random-access memory (RAM)
 - Hard disk drive (HDD)/solidstate drive (SSD) migration
 - HDD/SSD replacement
 - Wireless cards



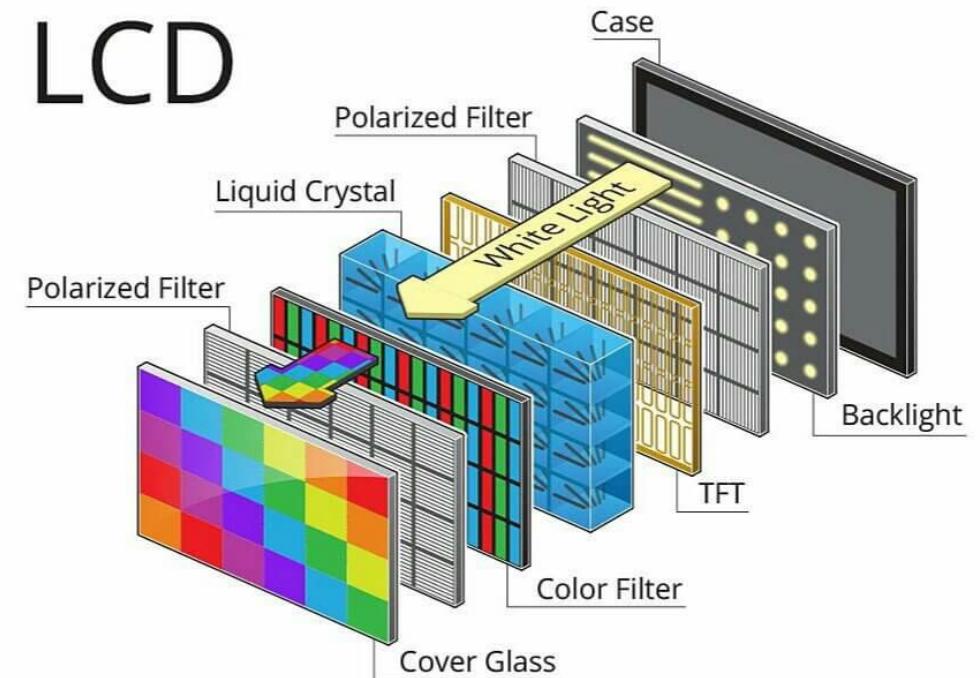
Hardware/device replacement

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 - HDD/SSD replacement
 - Wireless cards



Display components of mobile devices

LCD





Display components of mobile devices

- Liquid crystal display (LCD)
 - Don't produce light
 - Uses a backlight
 - Cold cathode Fluorescent Lamp (CCFL)
 - Can use Strops of LED Lights
 - Inverter
 - Converts DC to AC for the backlight
 - If there is problems with flickering or dimness it might be the inverter



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Display components of mobile devices

- Liquid crystal display (LCD)
 - Twisted nematic (TN)
 - Very old
 - Good response Time
 - Very little lag, high refresh rate, 240 Hz
 - Bad Color
 - In-plane switching (IPS)
 - Great Color
 - Good Viewing Angles
 - Little lag
 - Vertical alignment (VA)
 - Great color
 - Okay response
 - Organic light-emitting diode (OLED)



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Display components of mobile devices

- Organic light-emitting diode (OLED)
 - Light-emitting compound
 - There is no need for a backlight,
 - Contrast ratio of OLED displays exceeds that of LCD panels
 - OLED are the highest-quality
 - OLED is found in smaller devices such as smartphones



Devices

- A digitizer
 - A device that can be written and the content will be converted from analog input to digital images on the computer.





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Connection methods

- Universal Serial Bus (USB)
 - C/microUSB/miniUSB
- Lightning
- Serial interfaces
- Near-field communication (NFC)
- Bluetooth
- Hotspot



Connection methods

- Universal Serial Bus (USB)
 - C/microUSB/miniUSB



Micro-USB



Mini-USB



USB-C



Connection methods

- Lightning (Apple)





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Connection methods

- Serial interfaces





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Connection methods

- Near-field communication (NFC)
 - Use for payments mostly
 - Only 4cm
- Bluetooth
 - Device must be paired to the phone
 - Supports many devices including:
 - Headsets, mouses, keyboards
- Hotspot
 - Allows internet sharing from a mobile smartphone to laptop



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Accessories

- Touch pens
- Trackpad
- Headsets
- Speakers
- Webcam



Connection methods

- Port replicator
 - Reproduces the functions of the ports on





Connection methods

- Docking station
 - similar to a port replicator but offers more functionality. Docking stations also replicate ports but can contain things like full-sized drive bays, expansion bus slots, optical drives, memory card slots, and ports that are not otherwise available on a laptop.





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Cellular Networking Standards

- 2G
 - digital technology and were able to handle phone calls, text messaging (SMS) and sending out limited amounts of data
 - GSM
 - Global System for Mobile Communications
 - Used by AT&T and T-Mobile
 - CDMA
 - Code-division multiple access (CDMA)
 - Used by Sprint and Verizon
 - Uses a PRL (Preferred Roaming List)
 - It indicates which radio bands, sub-bands, and service provider IDs will be searched for, then allows the phone to connect to the correct tower
 - GSM and CDMA were not compatible with each other.



Cellular Networking Standards

- 3G
 - allows additional features such as mobile Internet access, video calls and mobile TV
- 4G
 - WiMAX and Long-Term Evolution (LTE) where 2 standards, LTE won.
 - Faster than 3G, Theoretical max is 300Mbps down and 75Mbps Up.
 - No need for GSM or CDMA
 - One standard



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Cellular Networking Standards

- 5G
 - Much faster than 4G, up to 100x faster.
 - May hit speeds of 20Gbps
 - Used to stream large amounts of data such as digital video and movies.
 - Low - latency links



Bluetooth

- Enable Bluetooth
- Enable pairing
- Find a device for pairing
- Enter the appropriate PIN code
- Test connectivity



MDM

- Mobile device management (MDM)/mobile application management (MAM)
 - Corporate email configuration
 - Two-factor authentication
 - Corporate applications



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Mobile device synchronization

- Account setup
 - Microsoft 365
 - Google Workspace
 - iCloud
- Data to synchronize
 - Mail
 - Photos
 - Calendar
 - Contacts
 - Recognizing data caps



2.0

Networking



Introduction to Networks

- **LANs (Local Area Networks)** are the private networks found in homes, offices, and schools. LANs can vary in size from a single room to an entire building.
 - SOHO Network
 - Enterprise/Corporate Networks
- **WLAN (Wireless Local Area Networks)** can exist within a LAN or on their own



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Protocols

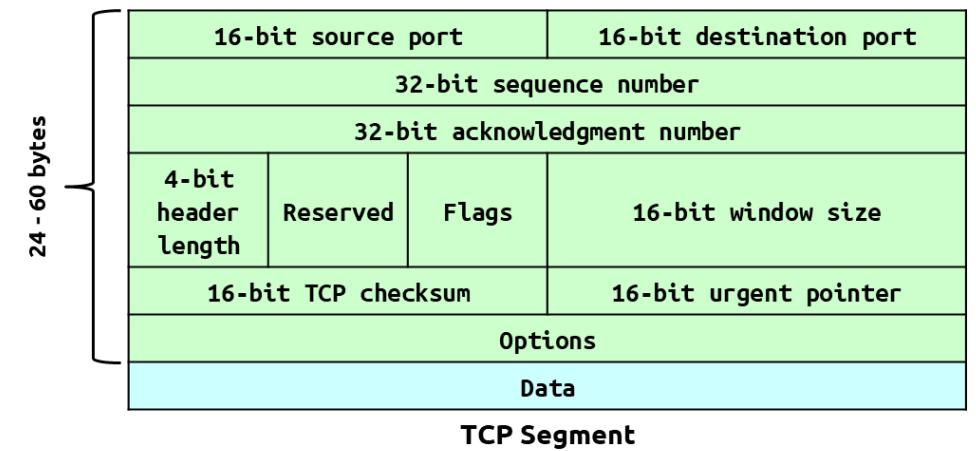
- A language used by the computer to speak to each
- All computers today uses a protocol suite, Transmission control Protocol/Internet protocol
 - TCP/IP
 - Made of many of the protocols we used today are part of TCP/IP such as HTTP or FTP
 - **TCP and UDP are used by other protocol to send and receive data**



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Protocols

- **TCP (Transmission Control Protocol)**
 - Reliable
 - Connection-oriented
 - Virtual circuit
 - Sequenced
 - Acknowledgements
 - 24 - 60 bytes (high overhead)

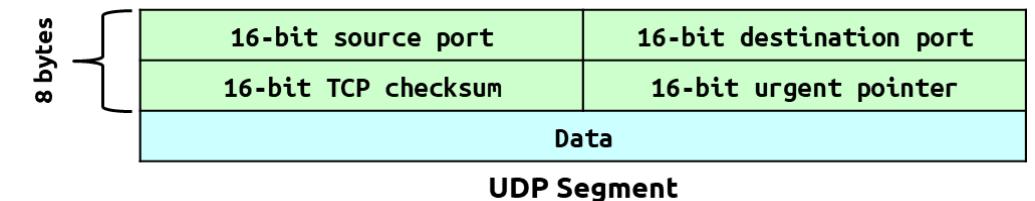




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Protocols

- **UDP (User Datagram Protocol)**
 - Unreliable
 - Connectionless
 - No virtual circuit
 - Un-sequenced
 - No acknowledgments
 - 8 bytes (lightweight)





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File Transfer Protocol

- **File Transfer Protocol** is used to **share files with users** in a LAN or a WAN
 - TCP Port 20, 21
 - Supports authentication, authorization, and directory browsing
 - Unencrypted – not recommended, use sftp.
- **Trivial File Transfer Protocol**
 - Used to push(put) or pulls(get) files from a server
 - Commonly use to manage devices like IP phones, routers and switches
 - Does NOT support authentication, authorization, or directory browsing
 - UDP port 69
 - Unencrypted – not recommended, use sftp
- **Secure File Transfer Protocol (SFTP) is a secure implementation of FTP**
 - Supports all the same functions as FTP but with encryption
 - SFTP is an extension of SSH which is why they use the same port number
 - TCP Port 22



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Mail Protocols

- Simple Mail Transfer Protocol sends
 - outgoing mail to a server
 - Sends outgoing mail to a server
 - TCP Port 25
- Post Office Protocol (POP3)
 - Downloads incoming mail from a server
 - TCP Port 110
- Internet Message Access Protocol (IMAP)
 - synchronizes incoming mail from a server
 - TCP Port 143



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Telnet

- Telnet provides remote command line access to interact with a server
- Considered insecure and should no longer be used, use SSH instead
- Used TCP Port 23

A screenshot of a Windows Command Prompt window titled "Administrator: C:\Windows\system32\cmd.exe". The window shows the following text:

```
Microsoft Windows [Version 6.1.7601]
Copyright <c> 2009 Microsoft Corporation. All rights reserved.

C:\Users\test>telnet rpc.acronis.com 443
```

The window has a standard blue title bar and a black background for the command area.



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Secure Shell

- Secure Shell provides encrypted remote command line access to interact with a server
- SSH version 2 added SFTP and SCP support
- TCP Port 22



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DNS

- Domain Name Service (DNS):
 - provides name to IP address resolution for host
 - Resolves Domain name to IP address
 - TCP/UDP Port 53



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DHCP

- Dynamic Host Configuration Protocol
 - provides various configurations to clients in an IP network via broadcast
 - UDP port 67 is the server port, and 68 is the client port



HTTP

- Hyper Text Transfer Protocol
 - is used to transmit webpages
 - TCP Port 80



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HTTPS

- Hyper Text Transfer Protocol Secure is
 - used to securely transmit encrypted webpages using SSL or TLS
 - TCP Port 443



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NetBios

- **Network Basic Input/Output System** provides various network communication features in a Windows network
 - Used in Windows before IP networking
 - NetBIOS over TCP/IP is still used in Windows
 - TCP/UDP Port 137/139



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SNMP

- Simple Network Management Protocol is
 - used to query, configure, and monitor host in a LAN
 - SNMPv3 encrypts communication where previous versions did not
 - UDP Port 161/162



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LDAP

- Lightweight Directory Access Protocol
 - is used in domain-based network environments to facilitate system and user management.
 - TCP/UPD Port 389



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Server Message Block

- Server Message Block (SMB) provides file sharing, network browsing, and printing services
- Commonly used in Windows networks but supported in Linux, macOS, and many other devices
- CIFS(Common Internet File System) is an open implementation used on Linux and macOS
- TCP Port 445



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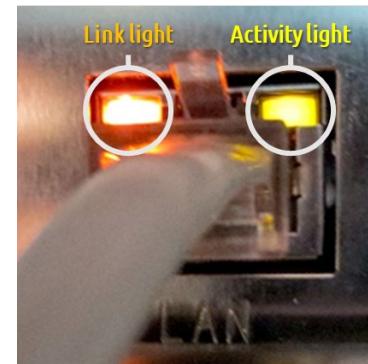
RDP

- Remote Desktop Protocol is
 - used to securely remotely access a Windows desktop
 - TCP Port 3389



Network Interface Card

- **Network Interface Cards (NICs)** are used to connect devices to a network
 - It's common for NICs to be built-in into modern computer systems
 - Each NIC has a **unique 48-bit MAC address**
 - The **link light** and **activity lights** are used to trouble connections made to the NIC
 - **Link light** verifies the cable is plugged in at both ends
 - **Activity light** will blink as data goes through the interface



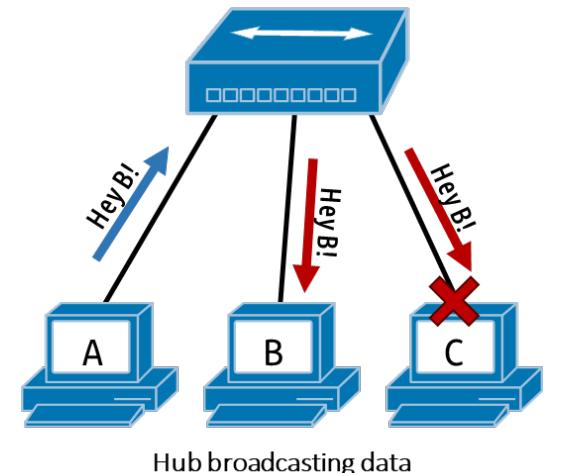
Connect NIC



PCIe NIC

Hub

- A **Hub** is a legacy device used to connect and manage wired communications in a LAN
 - Communicates by **broadcasting**
 - Uses **CSMA/CD** to manage the collisions



5 port hub

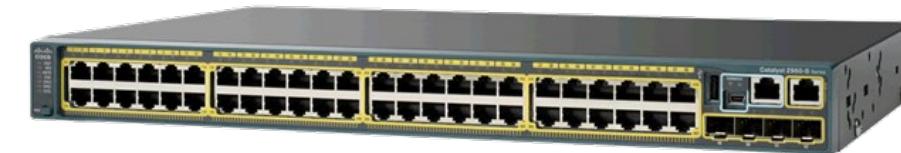
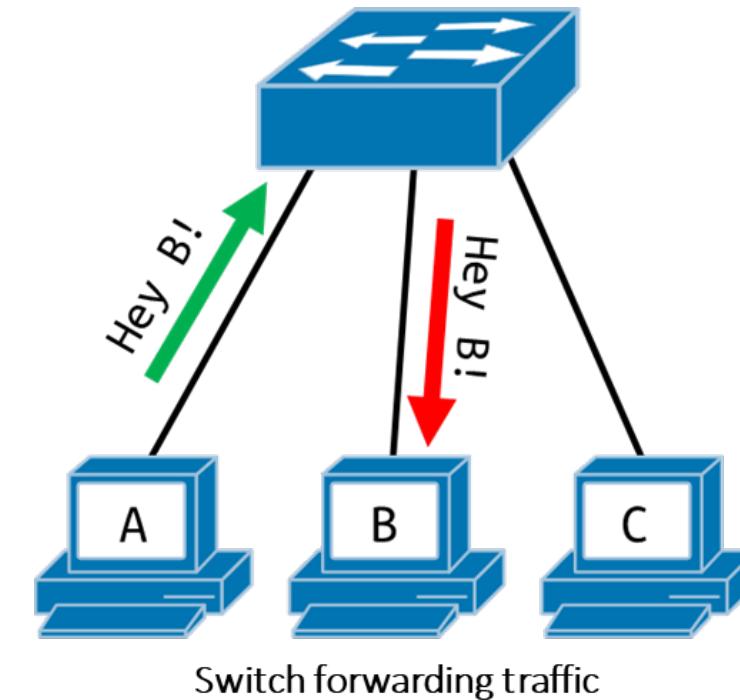


Switch

- A **Switch** is used to connect and manage wired communications in a LAN
 - Forward frames based on MAC addresses
 - Managed switches vs Unmanaged switches
 - Managed switches can be configured
 - Used in enterprise LANs to meet their needs for enforcing policies
 - Provide additional functions like VLANs, port security, DHCP snooping, and dynamic ARP inspection
 - Expensive
 - Unmanaged switches can NOT be configured
 - Used in SOHO networks
 - Lower cost



Switch



48 port managed switch



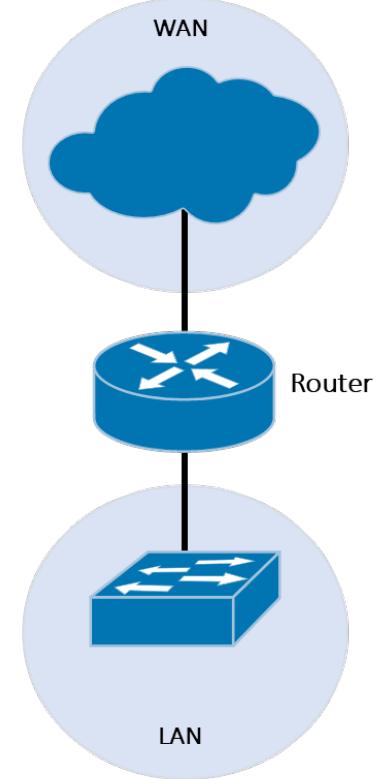
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Router

- **Routers** are used to connect different broadcast domains to each other
 - Commonly used to connect a LAN to a WAN (**Site to site or the Internet**)
 - Forwards traffic based on **IP Addresses** in **packets**
 - Can usually provide DHCP



Router



Cisco 2901 branch router

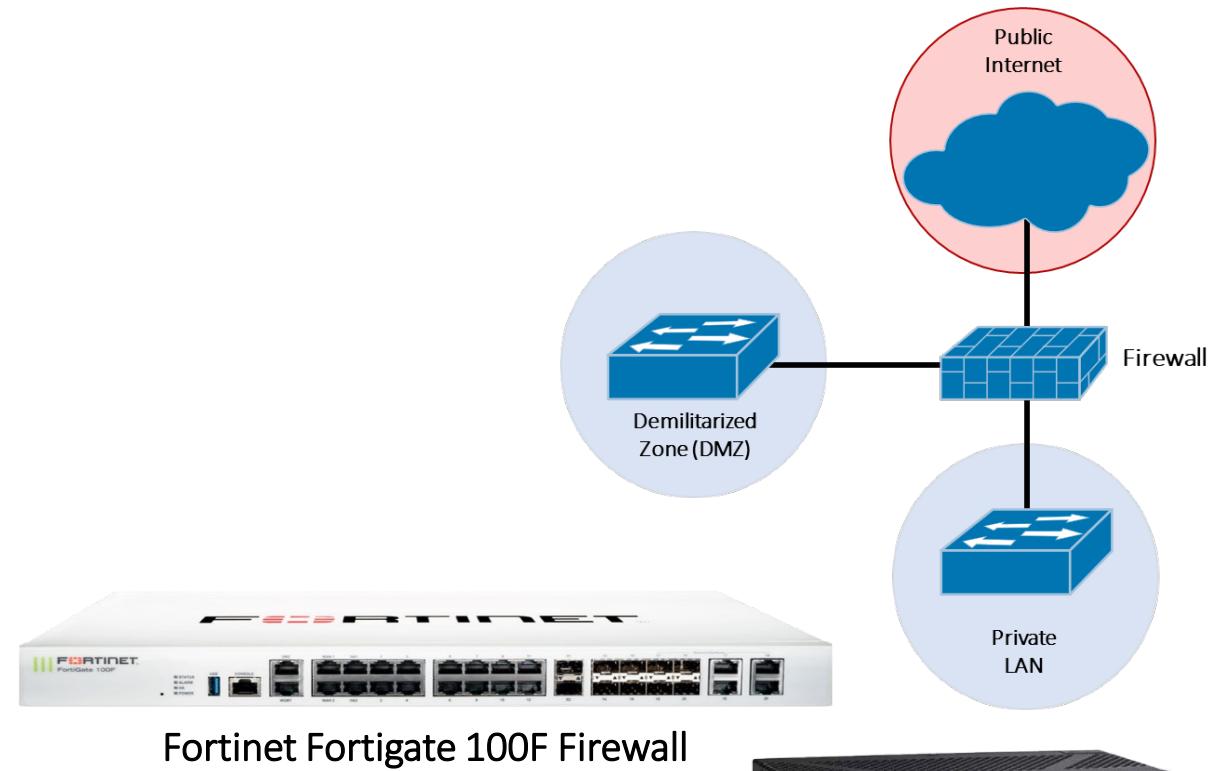


Firewall

- **Firewalls** are security devices used to prevent authorized access to a LAN from the Internet.
 - Can be a **hardware appliance** or **host-based software**
 - The **Demilitarized Zone (DMZ)** is a segment of the network that a firewall does not protect, this is used to intentionally expose a device to the Internet



Firewall



Fortinet Fortigate 100F Firewall



Cisco ASA 5506-X Firewall



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Access Point (AP)

- **Access Points(APs)** are used to provide and manage wireless communications in a LAN
 - Uses Radio Frequencies (RF) to transmit host data



Access Point (AP)





SOHO Router

- **SOHO Routers** are multifunction devices offering many features beyond routing
 - Always includes wireless, switching, firewall security, and DHCP
 - Can include content filtering, file server, print server, VPN client and server, and other features
 - Used to connect a **LAN to the Internet**
 - Forwards traffic based on **IP Addresses** in packets



Netgear LAX20 WiFi Router



Linksys WRT54G WiFi Router



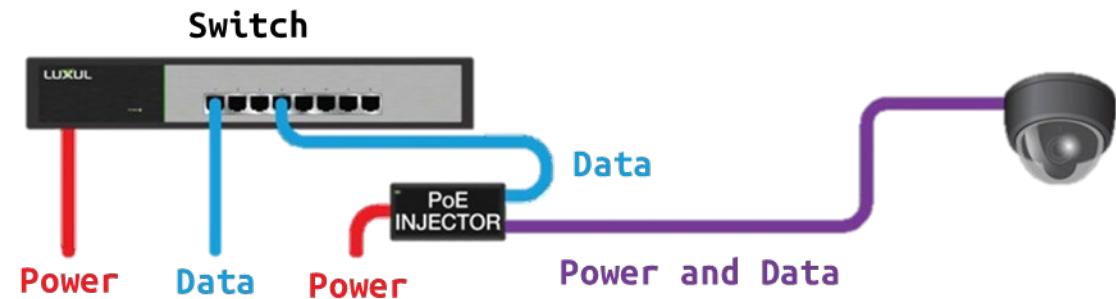
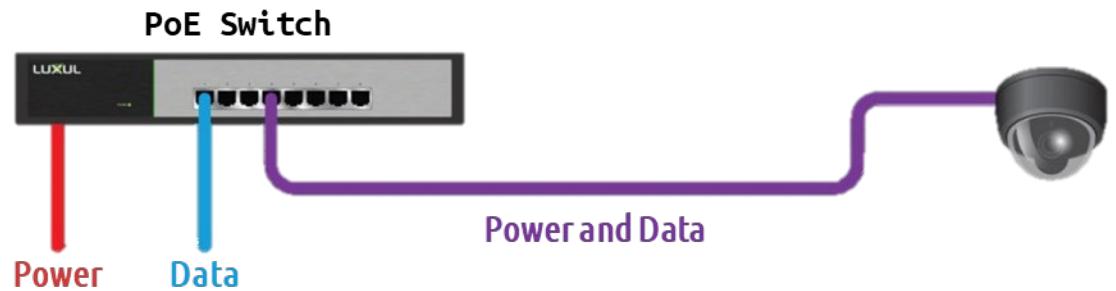
PoE (Power over Ethernet)

- **Power over Ethernet (PoE)** allows you to power devices using just an Ethernet cable
 - A PoE switch is required if you want to power many PoE devices
 - PoE devices are manufactured and sold with PoE built-in as a feature
 - PoE injectors can be used to power a **single** PoE device if a PoE switch is NOT available
 - PoE standards operate at **different wattages**, verify which is required for your devices

	PoE 802.3af	PoE+ 802.3at	PoE++ 802.3bt
Min Wattage	12.95 watts	25.50 watts	51 watts
Max Wattage	15.40 watts	30.0 watts	60 watts
Max Current	350 mA	600 mA	600 mA



PoE (Power over Ethernet)



PoE Power Injector



DSL Modem

- **Digital subscriber line (DSL)**
 - Type of internet that uses telephone lines
- **Connect a network to a DSL connection**





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Optical network terminal (ONT)

- Converts the optical signal coming through the fiber into separate signals for TV, voice, and data





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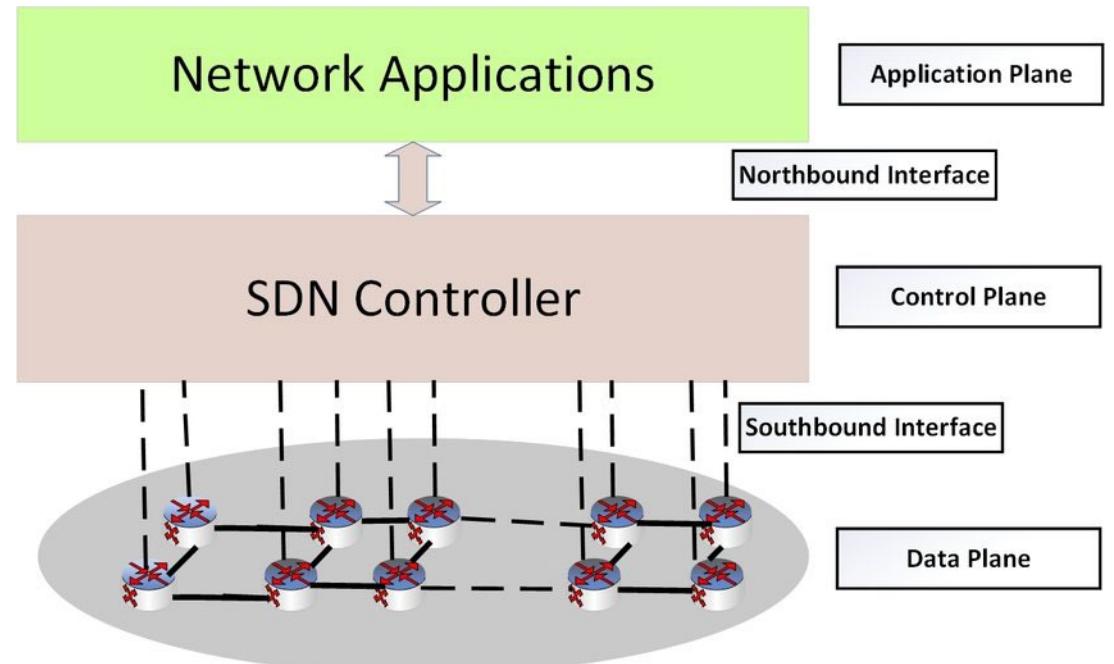
Software-defined networking (SDN)

- An approach to network management that enables dynamic, programmatically efficient network configuration in order to improve network performance and monitoring, making it more like cloud computing than traditional network management.
- Disassociating the forwarding process of network packets (data plane) from the routing process (control plane).
- Uses a controller to manage network traffic



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Software-defined networking (SDN)





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Wireless Networking

- Allows devices to connect, to transfer and receive data.

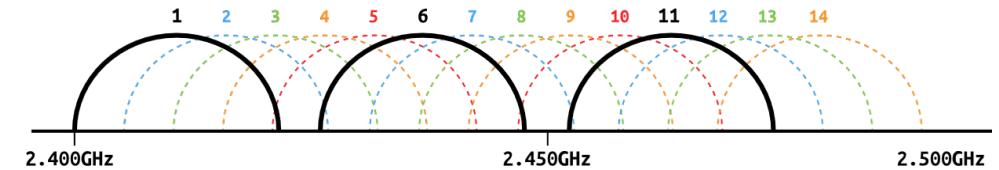


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Wireless Frequencies

• 2.4 GHz Spectrum

- Long **range** communications because it has better penetration through barriers
- **Slower** data rates compared to 5GHz
- Higher rate of **interference** because of its longer range
- Has 11 Channels in total
- **Non-overlapping** channels 1, 6, and 11 offer the best chance of minimizing interference



• 5 GHz Spectrum

- Short **range** communication because of poor penetration through barriers
- **Faster** data rates than 2.4GHz
- Has 45 in total and 24 non-overlapping
- 20Mhz use, 36,40,44,48,149,153,157,161,165
- 40MHz use 38,46,151,159
- Low chance of interference because of its shorter range



Wireless Standards

Standard	Frequency	Max Data Rate	Compatibility	Feature	Year
802.11a Wi-Fi 1	5 GHz	54 Mbps	802.11n/ac/ax		1999
802.11b Wi-Fi 2	2.4 GHz	11 Mbps	802.11g/n/ac/ax		1999
802.11g Wi-Fi 3	2.4 GHz	54 Mbps	802.11b/n/ac/ax		2003
802.11n Wi-Fi 4	2.4 GHz, 5 GHz	600 Mbps	802.11a/b/g/ac/ax	MIMO	2009
802.11ac Wi-Fi 5	2.4 GHz, 5 GHz	3.5 Gbps	802.11a/b/g/n/ax	MU-MIMO (4 x 4)	2012
802.11ax Wi-Fi 6	2.4 GHz, 5 GHz	9.6 Gbps	802.11a/b/g/n/ac	MU-MIMO (8 x 8)	2019



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Access Point Configurations

- **SSID(Service Set Identifier)**
 - Name of the wireless network (WLAN)
 - Always change the default SSID
 - Set to an easy-to-identify unique name
 - SSIDs are case-sensitive; “CompanyWiFi” is NOT the same as “companywifi”
- **IP Address**
 - Assign a static IP address for administration
- **Password**
 - Change the default administrator username and password
- **Wireless Channel**
 - 2.4GHz networks should only use channels 1, 6, or 11
 - 5GHz networks should worry avoid busy channels but it is less of a concern than 2.4GHz



Signal Degradation

- **Distance**

- All wireless signals will degrade the further away you are from the access point
- 2.4GHz transmit further than 5GHz

- **Walls and Other Barriers**

- Barriers will reduce the transmission distance of any wireless signal
- Wall with metals (pipes and vents) will reflect wireless signals limiting their transmission distance
- Thicker reinforced walls will degrade signals more than thinner walls

- **Interference**

- Other wireless networks and devices can cause interference
- Microwaves, toaster ovens, HVAC systems, and other high voltage appliances can also cause interference



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Long-range fixed wireless

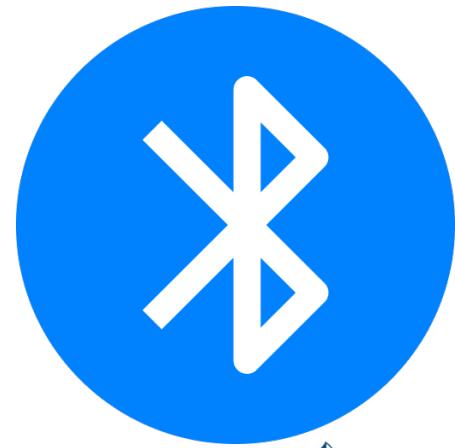
- Used to connect wireless devices over miles
- Usually installed using point-to-point directional antennas
- Licensed or Unlicensed
 - May have to go to the FCC to get a license for the radio frequency





Bluetooth

- Connect devices to devices
- Usually used for connecting:
 - Mouses, keyboards, headsets
- Setup includes:
 - Enable Bluetooth
 - Enable pairing
 - Find a device for pairing
 - Enter the appropriate PIN code
 - Test connectivity





Near-field communication (NFC)

- A set of communication protocols that enables communication between two electronic devices over a distance of 4 cm (1 1/2 in) or less.
- Can use to :
 - payment from a phone or watch
 - Enter a building with a phone





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Radio-frequency identification (RFID)

- Uses electromagnetic fields to automatically identify and track tags attached to objects.
- Use an access card, ez-pass(toll collection), or work in inventory management.





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Server Roles

- **DNS**
 - Translate domain name to IP address
- **DHCP**
 - Gives out IP address on a network
- **Fileshare**
 - Shares files and folders on a network
- **Print servers**
 - Shares printers
- **Mail servers**
 - Allows users to connect and send and receive email
- **Syslog**
 - Receives logs from devices in a network
- **Web servers**
 - Serves web pages using the HTTP or HTTPS protocol



Server Roles

- Authentication
 - Ensures you are the correct person.
 - Uses passwords, key cards, or biometrics
- Authorization
 - Ensure you can access the right data
 - Usually done with file permission
- Accounting
 - Keeps tracks of what users are doing in their network



Internet appliances

- **Spam gateways**
 - Keeps spam from entering your emails
- **Unified threat management (UTM)**
 - A combination of antimalware, firewall and intrusion detection system (IDS)
- **Load balancers**
 - Allows multiple servers served the same amount of traffic
- **Proxy servers**
 - Request webpages on behalf of users
 - Can be used to filter out web traffic, such as blocking users from seeing facebook



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Legacy/embedded systems

- Older systems still on a network
- May not be secured as no updates are available.
- Supervisory control and data acquisition (SCADA)
 - Older utility systems such as providing gas and electric power.
 - May have to be section off the network to ensure no access



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Internet of Things (IoT) devices

- All devices connect to the internet
 - Phones
 - Cars
 - Household appliance
 - Watch
 - ETC
- Can use many wireless protocols to work:
 - Z-Wave
 - Zigbee
 - Bluetooth
 - NFC
 - IR
 - RFID
 - 802.11



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DNS (Domain Name Service)

- **Domain Name Service (DNS):** provides name to IP address resolution for host
 - DNS servers can be in your LAN or out on the Internet
 - A host is normally assigned a DNS server via DHCP, but it can also be assigned manually
 - **DNS Name Types**
 - Host names identify a specific device in a network
 - **Hostname = workstation01**
 - Domain names identify a specific network
 - **Domain name = companyx.lan**
 - Fully Qualified Domain Name (FQDN) identify a specific in a specific network
 - **FQDN = workstation01.companyx.lan**



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DNS Records

Record Type	Description	Example
A	Resolves a name to an IP Address	example.com => 123.234.34.56
AAAA	Resolves a name to an IPv6 Address	example.com => 2101:2345:6789:abcd:ef01:2345:6789:abcd
TXT (SPF)	Sender Policy Framework list of hostnames/IP and IPv6 addresses that mail can be sent from	v=spf1 ip4:40.113.200.201 ip6:2001:db8:85a3:8d3:1319:8a2e:370:7348 include:company.com ~all
TXT (DKIM)	Domain Keys Identified Mail provides authentication of mail being sent and received to prevent spam	email_provider._domainkey_.companyx.com v=DKIM1; p=76E629F05F70 9EF665853333 EEC3F5ADE69A 2362BECE4065 8267AB2FC3CB 6CBE
TXT (DMARC)	Domain-based Message Authentication, Reporting, and Conformance controls what happens if authentication fails to prevent spam	v=DMARC1; p=reject; rua=mailto:dmarc@example.com
CNAME	Canonical Name records resolves an alias to a domain name	bn.com => barnesandnoble.com
MX	Resolves a name to a mail exchanger (email server)	imap.gmail.com => 142.250.31.108



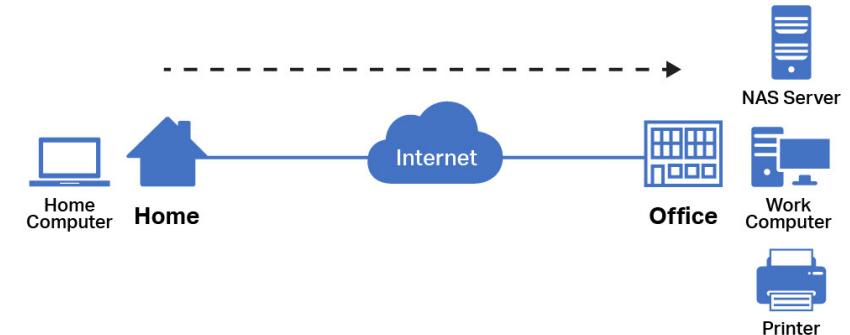
DHCP (Dynamic Host Configuration Protocol)

- The **Dynamic Host Configuration Protocol (DHCP)** is used to assign various configurations to the host of a network.
 - **Common configurations**
 - **Scope** is the range of addresses the server can assign
 - **Example:** 192.168.50.100 – 192.168.50.250
 - **Exclusion range** is the range of addresses the server can NOT assign
 - **Reservations** allow you to bind a MAC address to a specific IP address
 - Allows DHCP to consistently assign the same IP address to a device without having to manually configure a static IP address
 - **Lease time** defines how long an IP address is “owned” by a host before it can be assigned to another host **Available leases** identify how many addresses are still available from the scope



VPN(Virtual Private Network)

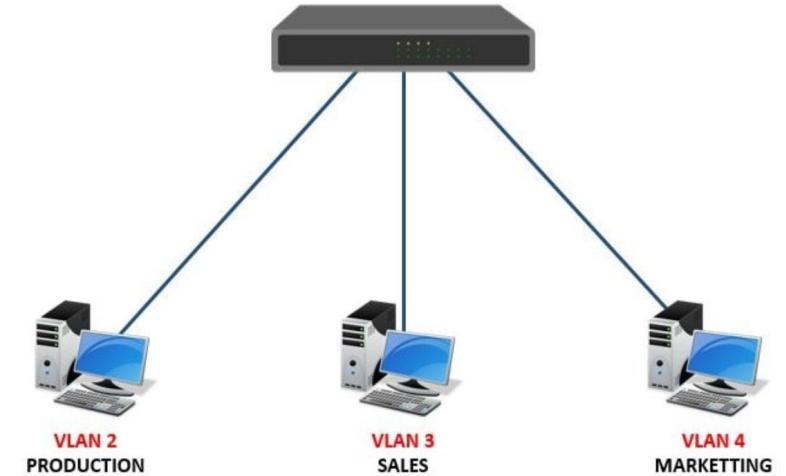
- Creates a secure tunnel to a private network over the internet
- Required to access resources in a LAN over the Internet
- Various protocols can be used; PPTP, L2TP, IPSec, OpenVPN, SSL-VPN





VLAN

- Virtual local area (VLAN) network is any network that is partitioned and isolated in a computer network at the data link layer or by switches.
- Carries a separate network address
- Separate network traffic





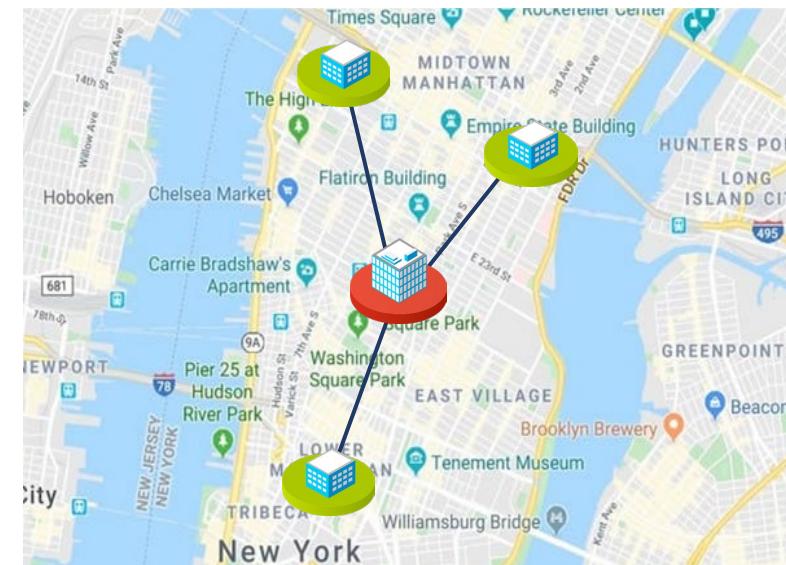
Networks

- **LANs (Local Area Networks)** are the private networks found in homes, offices, and schools. LANs can vary in size from a single room to an entire building.
 - SOHO Network
 - Enterprise/Corporate Networks
- **WLAN (Wireless Local Area Networks)** can exist within a LAN or on their own



MAN (Metropolitan Area Network)

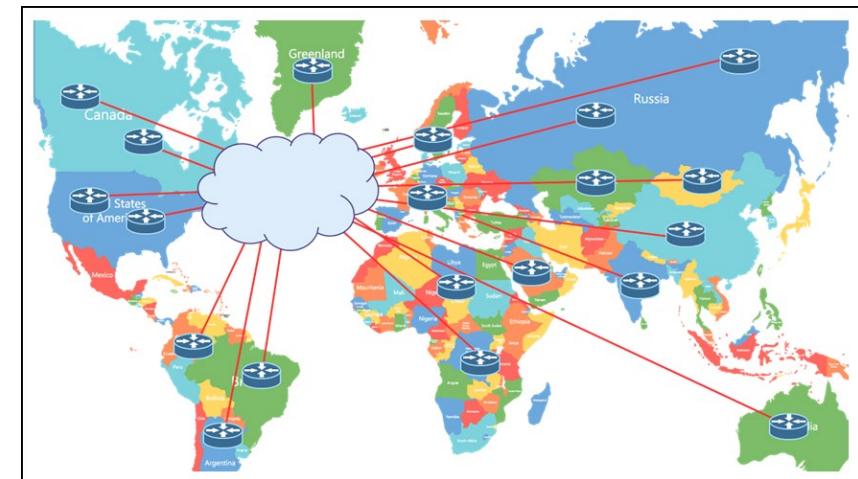
- **MANs (Metropolitan Area Networks) spread across a single city.**
 - Connections between the sites are often **privately owned** and managed by the organizations that use them.





WAN (Wide Area Network)

- **WANs (Wide Area Networks):** When an organization needs to connect their office on one side of the world to the other, they connect through a WAN.
 - The Internet is the public WAN that anyone can get access to.
 - Site-to-Site connections are used by large organizations to connect their different locations over private WAN links.

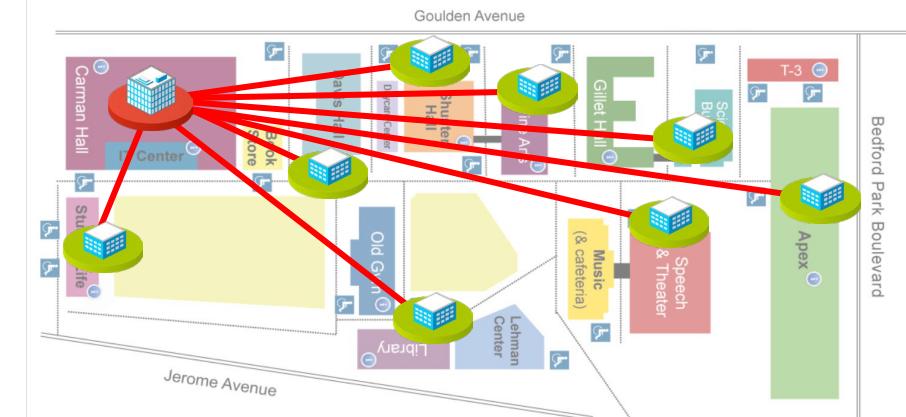


The Internet



CAN (Campus Area Network)

- **CANs (Campus Area Networks)** spread across a limited geographical distance like a college/corporate/military campus.
 - It is privately owned and managed.





PAN (Personal Area Network)

- **Personal Area Networks (PANs)** are small networks usually made up of two devices.
 - These devices can be connected over **wired** connections (Ethernet or USB) or **wireless** connections (Wi-Fi, Bluetooth, Infrared).



PC to a PC over a **wired** connection



PC to a smartphone over a **wireless** connection



PC to a PC over a **wireless** connection

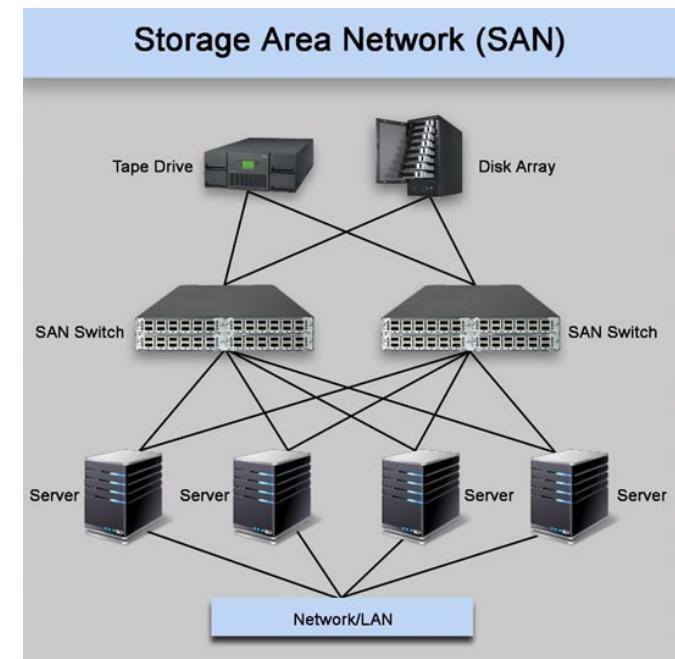


PC to a printer over a **wireless** connection



Other Network Types

- **SANs (Storage Area Networks)** are specifically built to store data.
 - The network consists of high-speed fiber links and large storage servers.





Internet Connection Types

- **DSL (Digital Service Line)**
 - DSL is a broadband service that operates over the PSTN(Public Switched Telephone Network)
 - Requirements
 - DSL modem
 - **DSL filter/splitter** must be used to prevent noise when connecting a telephone to a DSL line
- **Cable**
 - Uses the **DOCSIS** (Data Over Cable Service Interface Specification) standard to deliver Internet over coax
 - Described as an **FTTN (Fiber to the Node)** service
 - Requirements
 - Cable modem
- **Fiber:** Internet over fiber optic cable.
 - Fiber services like FIOS are **FTTP (Fiber to the Premise)**
 - Fastest service but also the most expensive
 - Requirements
 - **ONT(Optical Network Transceiver)** converts the fiber cable from the provider to twisted pair to connect to a router



Wireless Internet Connection Types

- **Satellite**

- Satellite internet is widely available and might be the only option for those in rural areas
- Requirements
 - Satellite dish connected to a satellite receiver via coax
 - A clear view into space
- Satellite suffers from **high latency** which makes it unusable for the following services
 - VoIP, video streaming, online gaming

- **Cellular**

- Cellular internet has gained usage as coverage has grown quickly
- Requirements
 - Within the 4G/LTE or 5G coverage area
 - Mobile device with a cellular radio installed

- **WISP (Wireless Internet Service Provider)**

- WISP provides Internet to smaller municipalities where cable or fiber services aren't available
- Providers use wireless access points deployed and at customer sites
- Requirements
 - Must be within the limited coverage area



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Crimper

- **Crimper** is used to terminate RJ45 and RJ11 heads to twisted-pair cables



Crimper



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Stripper

- **Cable Stripper** is used to strip the jacket of a cable



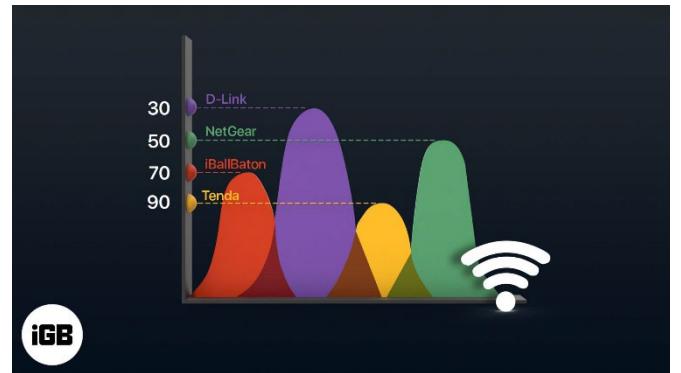
Cable Stripper



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WiFi Analyzer

- Application for your desktop or mobile phone that can analyze the type and strengths of wireless networks.
- Useful to understand where to place access points





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Toner Probe

- **Toner probe** is used to identify the other end of a twisted-pair cable
 - Tone generator sends a signal through the known end of the cable
 - The probe is used to locate the other end of the cable



Toner Probe



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Punch-Down

- **Punch-Down Tool** used to terminate twisted-pair to a 110 or 66 block



Punch-Down Tool



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Cable Tester

- **Cable Tester** is a simple tool that is used to test twisted pair terminations.
 - One end of the cable is plugged into the main unit and the other end to the remote
 - Lights should go off in sequence on both ends



Cable Tester



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Loopback Plugs

- **Loopback Plugs** are used to test if a network port can communicate to itself.
 - These are available for copper and fiber interfaces.



RJ45 Loopback plug



LC Loopback plug



Network Tap

- **Network taps** are used to monitor network traffic



Network Tap



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Hardware



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Network cables

- **Transmission Speeds**
 - **Copper cables** achieve speeds of up to 40 Gigabits
 - **Fiber cables** achieve speeds above 100 Gigabits
- **Transmission Distance**
 - **Copper cables** can reach distances of 1,100 meters (3,609 feet)
 - **Fiber cables** can reach distances of 40 kilometers (25 miles)



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Network cables

- **Attenuation** is the loss of signal strength in networking cables or connections
- **Noise Immunity**
 - **EMI(Electro-Magnetic Interference)** is a condition when signals from a device or cable leak out and disrupt signals of another device or cable
 - **Copper cables** are highly susceptible to interference
 - Use **shielded cables** to protect against EMI
 - **Fiber cables** are NOT susceptible to EMI since it is not copper



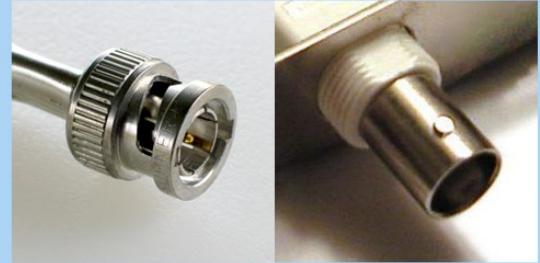
Coaxial Cable

- **Coaxial Cable (Coax)** is a round cable often used for cable in and satellite television connections. Its thick outer jacket makes it ideal for outdoor use.
 - **RG-6** is the most common type of coax cable.
- **Advantage**
 - Shielding protects against EMI
 - Long transmission distance (1100 meters)
 - More affordable than fiber optic cables
- **Disadvantage**
 - More expensive than twisted pair cable
 - Copper core can snap if mishandled



Coax Connectors

BNC Connector



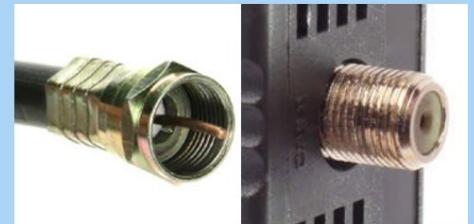
Connector

Port

Secure locking connector

Commonly used in the old bus and ring networks.

F Connector



Connector

Port

Twisting hand screw commonly found on cable modems

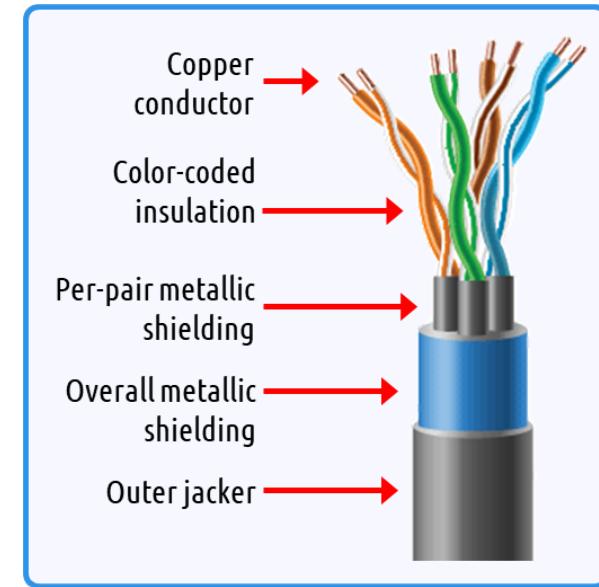


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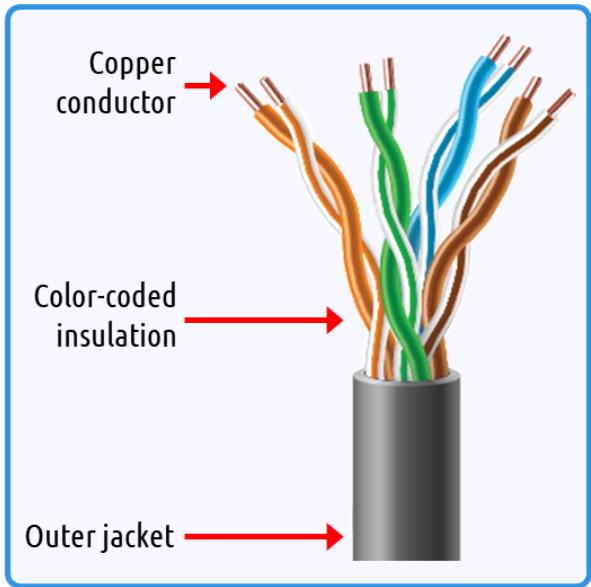
Twisted Pair cables

- Twisted Pair cables consist of **eight wires** that are twisted into **four pairs**.
 - This is the most used networking cable in homes and offices.
 - **Twisted Pair Types**
 - **STP (Shield Twisted Pair)**: Has shielding to protect against EMI
 - **Direct-burial cable** is a special type of electrical wiring or cable that is designed to be buried in a trench underground
 - **UTP (Unshielded Twisted Pair)**: Does NOT have shielding to protect against EMI

Twisted Pair cables



STP (Shield Twisted Pair)



UTP (Unshielded Twisted Pair)



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Twisted Pair Connector

RJ11 Connector



Connector

Port

RJ45 Connector



Connector

Port

- 4 pin connector
- Found on dial-up modems and analog telephones

- 8 pin connector
- Found on Computer networks



Twisted Pair Categories

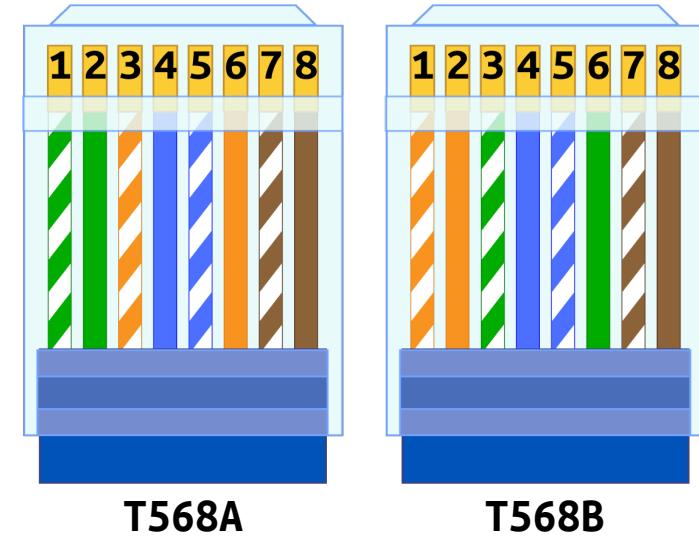
Category	Speed	Distance	Note
Cat 5	100 Mbps	100 meters	<ul style="list-style-type: none">Used in older networks
Cat 5e	1,000 Mbps / 1 Gbps	100 meters	<ul style="list-style-type: none">More twist per foot allows it to handle disturbances to achieve faster speeds
Cat 6	10,000 Mbps / 10 Gbps 1,000 Mbps / 1 Gbps	55 meters 100 meters	<ul style="list-style-type: none">Includes a piece of plastic to separate the 4 wire pairs which minimizes crosstalk
Cat 6a	10,000 Mbps / 10Gbps	100 meters	<ul style="list-style-type: none">Thicker wires to carry a more powerful signal for longer distance



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Wiring Standards

- There are two standard RJ45 pinouts for the individual arrangement of the wire connections to the RJ45 connectors within an Ethernet cable: **T568A** and **T568B** standards.

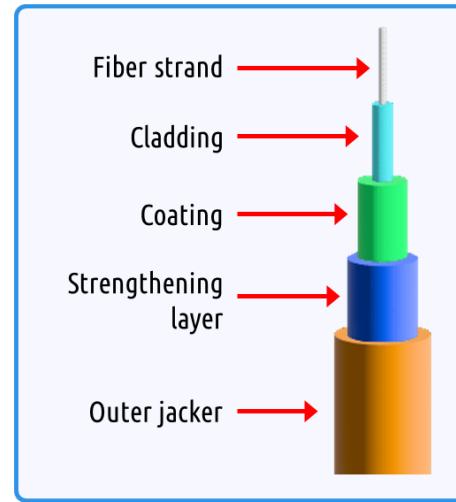


- The **blue** and **brown** pairs are always in the same location
- Only the **orange** and **green** pairs transpose their position



Fiber Optic cables

- Fiber optic cables transmit data using light over flexible glass or plastic.
 - Commonly used by WAN carriers and service providers' networks because of their needs for long-distance connections.
 - Some enterprises also them for high-speed long-range connections in their LANs



Fiber Optic Cable



Fiber Optic Cable

■ Advantage

- NOT susceptible to EMI
- Longest transmission distance up to 40km
- Fastest speeds up to 255 Tbps

■ Disadvantage

- Most expensive cable
- Most difficult to install
- Difficult to troubleshoot issues
- Expensive tools needed for installation and troubleshooting
- Can't easily repair cables in the field



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Fiber Optic Connector

ST Connector



Connector

- ST (straight tip)
- BNC style connector from the late 1980s and 1990s
- Used in SMF installations

LC Connector



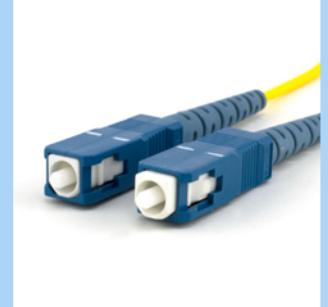
Connector

- LC (Lucent connection / local connection / little connector)
- Snaps-in style connector
- Small form-factor connector
- Used in SMF and MMF installations



Fiber Optic Connector

SC Connector



Connector

- SC (standard connector / subscriber connector / square connector)
- Snaps-in style connector
- Used in SMF and MMF installations

Dual LC Connector



Connector

- Dual LC
- Snaps-in style connector
- Small form-factor connector
- Used in SMF and MMF installations



Network Cable Specs

Cable	Connector	EMI Protection	Max Speed	Max Distance	Conductor	Cost
Coax	BNC and F	Shielding	1 Gigabit	1100 meters	Copper	\$\$\$
STP	RJ-45 & RJ-11	Shielding	10 Gigabits	100 meters	Copper	\$\$
UTP	RJ-45 & RJ-11	None	10 Gigabits	100 meters	Copper	\$
Single-Mode Fiber	ST, SC, & LC	Not susceptible	> 100 Gigabits	40 kilometers	Glass	\$\$\$\$\$
Multimode Fiber	SC, LC	Not susceptible	> 100 Gigabits	500 meters	Glass	\$\$\$\$\$



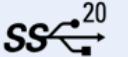
USB (Universal Serial Bus)

- **USB (Universal Serial Bus)**
 - Supports keyboards, mouse, storage devices, printers, scanners, webcams, gamepads, ethernet, WiFi, displays, audio devices, touchscreens.
 - **127 devices** can be plugged into USB





USB (Universal Serial Bus)

USB Version	Speed	Color	
USB 1.0	Low Speed	1.5 Mbps	White 
USB 1.1	Full Speed	12 Mbps	White 
USB 2.0	Hi-Speed	480 Mbps	Black 
USB 3.0	SuperSpeed	5 Gbps	Blue  ⁵
USB 3.1	SuperSpeed+	10 Gbps	Teal  ¹⁰
USB 3.2	SuperSpeed++	20 Gbps	N/A  ²⁰
USB 4	SuperSpeed+++	40 Gbps	N/A  ⁴⁰



USB Connector

Type A
USB 1.0 – 2.0 Type B
USB 1.0 – 2.0 Mini B
USB 1.0 – 2.0 Micro B
USB 1.0 – 2.0



Type A
USB 3.0 – 3.1 Type B
USB 3.0 – 3.1 Micro B
USB 3.0 – 3.1 Type C
USB 2.0 – 4

Type A (host port)

Computer connector

Type B (guest port)

Device connector

Type C (host and guest port)

Computer & device connector

Reversible



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Thunderbolt

- **Thunderbolt**

- Fastest and most capable connector
- Compatible with DisplayPort and USB devices
- Supports storage devices, displays, audio, networking, and adapters
- 6 thunderbolt devices can be daisy chained using a single thunderbolt port



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Thunderbolt

Thunderbolt Versions	Speed	Port Type
Version 1	10 Gbps	Mini Display Port
Version 2	20 Gbps	Mini Display Port
Version 3	40 Gbps	USB Type C
Version 4	80 Gbps	USB Type C



Mini Display Port



USB Type-C



Serial Port/RS-232/DB9

- **Serial Port** is one of the oldest ports still in use but for very few occasions
 - Most computer do NOT include a serial port, but one can be added via USB, PCI, or PCIe
 - Can be used to manage enterprise class network devices, program microcontrollers, or control robotic equipment



USB to Serial Adapter

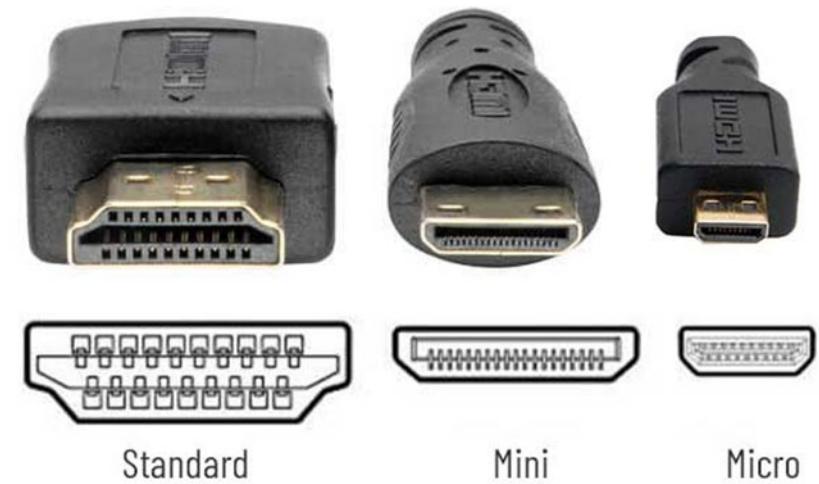


Rollover Cable (Console) / Serial to RJ-45



HDMI (High-Definition Multimedia Interface)

- HD and UHD audio and video
 - Most common connector for connecting computers to monitors and televisions
 - An active HDMI cable is required for connections longer than 25 feet
 - HDCP (High-Definition Copy Protection) support is required for some HD and UHD content like Blu-ray video and some streaming services

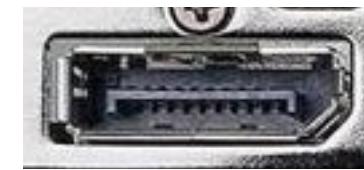




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DisplayPort

- HD and UHD audio and video
- Support HD digital video and audio signals.
- Popularized by Apple and commonly used by gamers to achieve very high refresh rates.
- Can be combined with USB and Thunderbolt ports



DisplayPort Cable



VGA (Video Graphics Array)

- SD and HD analog video
- 15pin D-SUB
- Normally colored blue



VGA Connector



VGA Port



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DVI (Digital Visual Interface)

- SD and HD analog and digital video
- Normally colored white



DVI Connector



DVI Port



Hard drive cables

SATA (Serial ATA) is a connector used to attach storage devices such as HDDs, SSDs, and optical drives

- Connector is ambidextrous; either end can connect to the motherboard or the drive
- All SATA types are compatible with each other
- Replaced the older PATA/IDE connector
- **Mini SATA (mSATA)** is a smaller version found in SFF systems

SATA Versions

Type	Max Speed
SATA 1	1.5 Gbps / 150 MB/s
SATA 2	3 Gbps / 300 MB/s
SATA 3	6 Gbps / 600 MB/s



SATA



SATA Cable



USB3.0 & eSATA drive



Older Drive Cables

- **SCSI**

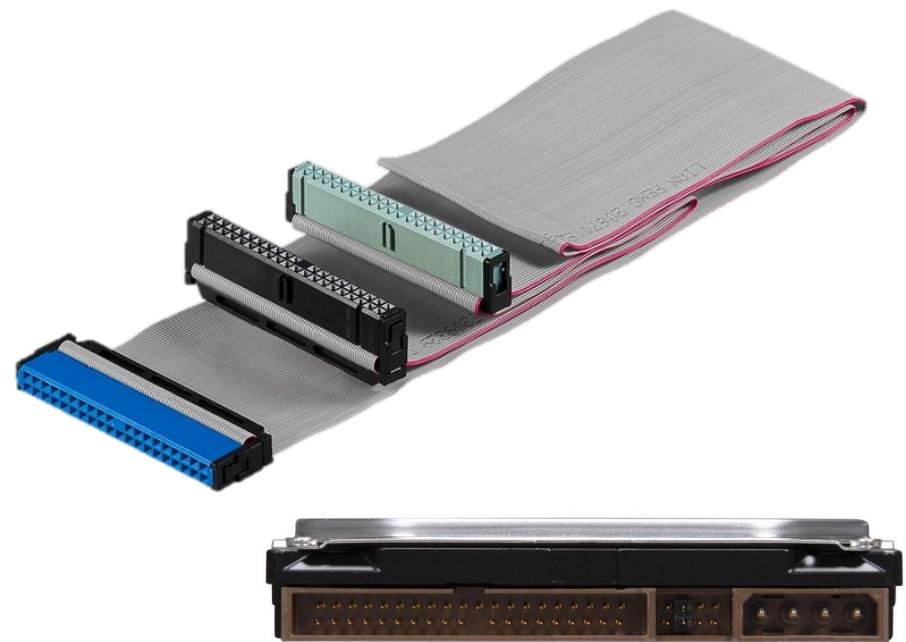
- 320 MB/s maximum data rate
- 80-pin ribbon connectors
- 1 connector supports many drives



Older Drive Cables

- **IDE/PATA**

- 166 MB/s maximum data rate
- 40-pin ribbon connector
- 1 connector supports 2 drives





Adapters

- **Video adapters** can be used to change a video connector from one type to another. They are simple devices so they cannot convert analog to digital or vice versa.





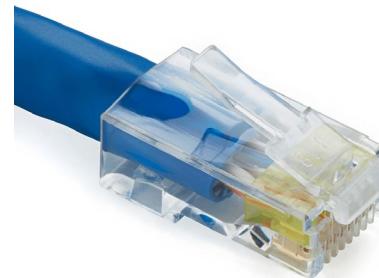
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Connector types

- RJ11



- RJ45



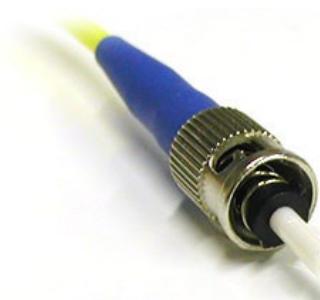


Connector types

- F type



- Straight tip (ST)



Connector types

- Subscriber connector (SC)



- Lucent connector (LC)





Connector types

- Punchdown block



- microUSB





Connector types

- miniUSB



- USB-C





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Connector types

- Molex



- Lightning port





Random Access Memory

- **RAM** is the most common type of system memory used by todays computing devices. All applications that are open on a system require some amount of memory, so the higher capacity of RAM the more applications that can be opened.
 - **SRAM: Static RAM** is memory that is often used as cache inside of CPUs, hard drives, LCDs and other components. It is soldered directly to the component, so it is NOT a serviceable part.
 - **DRAM: Dynamic RAM** is the memory that we install on the motherboard.
 - They vary in capacity from 2GB – 32GB commonly but are available in larger sizes



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Random Access Memory

- RAM is available in two packages, DIMMs and SODIMMs.
 - **DIMM (Dual Inline Memory Module)**
 - Commonly found in desktops and servers.



- **SODIMM (Small Outline Dual Inline Memory Module)**
 - Commonly found in notebooks and SFF systems.





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Random Access Memory

- **Double data rate (DDR)** is the advanced version of synchronous dynamic random-access memory
 - Difference between SDRAM and DDR is how much data is transported with each cycle
 - DDR RAM is available in various types (DDR, DDR2, DDR3, DDR4, DDR5)
 - Different types are NOT compatible with each other
 - A motherboard that supports one type of DDR will NOT work with any other type

Performance Rating

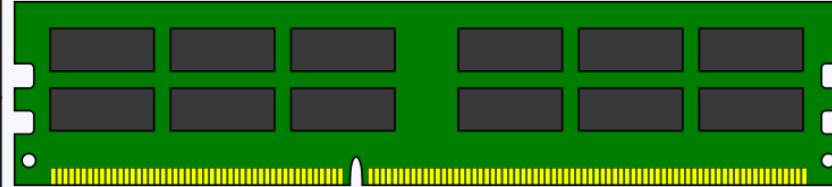
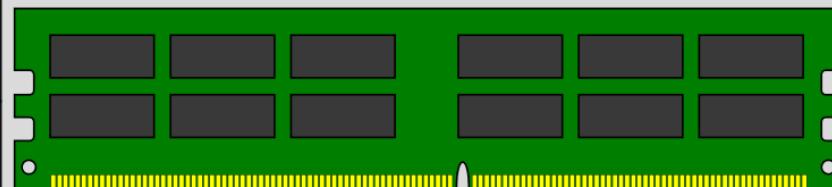
DDR-266 = PC-2100

266 × 8 = 2128

Transfer Bits Mbps
Rate



Double data rate (DDR)

Type	Min Speed	Max Speed	Pins	
DDR3	DDR3-800 / PC3-6400	DDR3-2133 / PC3-17000	DIMM: 240	
			SODIMM: 204	
DDR4	DDR4-1600 / PC4-12800	DDR4-3200 / PC4-25600	DIMM: 288	
			SODIMM: 260	
DDR5	DDR5-4800 / PC5-38000	DDR5-6600 / PC5-52800	DIMM: 288	
			SODIMM: 262	



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Memory Channeling

- Memory channeling allows a system to access more RAM simultaneously to improve performance

Channels	Configuration	Description
Single Channel	No requirements	System can access a single chip at a time
Dual Channel	Matching pairs	System can access two chips at once
Triple Channel	Matching threes	System can access three chips at once
Quad Channel	Matching fours	System can access four chips at once

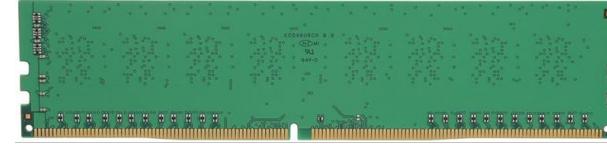


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Single-Sided vs Double-Sided DIMMs

- When **maxing out** RAM on a motherboard verify if it requires single-sided or double-sided memory. Single-sided memory can be more expensive at higher capacity with no performance benefit.

Single-Sided



Double-Sided





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RAM Variations

- **Latency** measures how **responsive** RAM is when data is being read from it
 - Reported as a **CAS** level or in **milliseconds**; lower is better for either
- **ECC (Error checking and correcting)** RAM can detect and fix errors in data on RAM
 - Makes a system **more stable** NOT faster
 - Commonly found in critical servers
- **Registered and Buffered Memory** includes extra chips to allow for more consistent communications between the memory controller and RAM
 - Only found in **high memory capacity** servers
 - **Unbuffered memory** is common for most desktop and portable systems



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RAM Considerations

- The CPU and chipset determines the features below, consider the following when acquiring RAM for an upgrade or replacement
 - Maximum capacity is predetermined.
 - RAM type is the most important since only one is supported.
 - DIMMs are found in desktop and server systems.
 - SODIMMs are found in laptops and SFF computers.
 - RAM Speed should match motherboard supported speed for best experience, but it is not a requirement for compatibility.
 - Number of slots will determine how many pieces of RAM can be installed.



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Storage Terminology

- **Capacity** defines how much data can be stored
 - Measured in MB(megabytes), GB(gigabytes), TB(terabytes)
- **Performance** defines how fast data can be read or written
 - Measured in bps (bits per second), Mbps (megabits per second), or Gbps (gigabits per second)
 - Also known as the throughput
- **Interface** is how the drive connects to the computer system
 - Internal interfaces; SATA or m.2
 - External interfaces; USB or Thunderbolt
 - Also known as the connector
- **Form factor** defines the dimensions of the disk



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Hard Disk Drive (HDD)

- **Hard Disk Drives** use a magnetic head to read/write data onto spinning metal or ceramic platters
 - Available in 2.5" and 3.5" form factors
 - Commonly connected to SATA interfaces
 - Also found in legacy interfaces such as IDE/PATA and SCSI
- **Advantages**
 - Affordable in large sizes up to 22TB
- **Disadvantages**
 - Not ideal for mobile since there are many moving parts
 - Vibrations can cause the drive head to crash into the platter damaging the drive
 - Slower at reading and writing data than an SSD



Hard Disk Drive (HDD)



Inside 3.5" drive



2.5" and 3.5" Drives



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Hard Disk Drive (HDD)

Platter Speeds	Common use	Sizes
5,400 RPMs	Laptop/Notebooks	2.5" and 3.5"
7,200 RPMs	Desktops	2.5" and 3.5"
10,000 RPMs	Gaming and servers	3.5"
15,000 RPMs	Enterprise and data centers	3.5"



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SATA

SATA (Serial ATA) is a connector used to attach storage devices such as HDDs, SSDs, and optical drives

- Connector is ambidextrous; either end can connect to the motherboard or the drive
- All SATA types are compatible with each other
- Replaced the older PATA/IDE connector
- **Mini SATA (mSATA)** is a smaller version found in SFF systems

SATA Versions

Type	Max Speed
SATA 1	1.5 Gbps / 150 MB/s
SATA 2	3 Gbps / 300 MB/s
SATA 3	6 Gbps / 600 MB/s



SATA



SATA Cable



USB3.0 & eSATA drive



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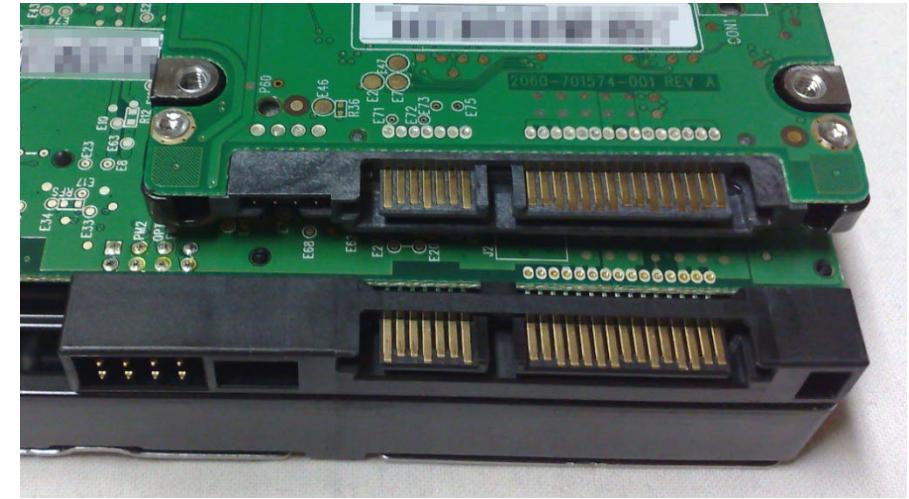
SATA

- **SATA Drive Form Factors**

- **3.5-inch drives**
 - **Large form factor** used in desktop and server systems
 - Drives up to 22TB
 - Available as an HDD or SSD
- **2.5-inch drives**
 - **Small form factor** used in portable, desktop, and server systems
 - Drives up to 5TB
 - Available as an HDD or SSD
- **mSATA drives**
 - **Small form factor** used in mobile, portable, and desktop systems
 - SSDs only



SATA



2.5" and 3.5" SATA Drives



mSATA Drive



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Solid State Drive (SSD)

- **Solid State Drives (SSD)** uses an array of flash chips to read and write data electrically
 - Available in SATA and M.2 form factors
 - **Advantages**
 - Ideal for mobile since there are no moving parts
 - Faster at reading/writing data
 - **Disadvantages**
 - **More expensive** than traditional HDDs
 - Price per gigabyte is how we determine the value of the drive
 - **Limited writes cycles**



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Solid State Drive (SSD)



SSD out of its shell



M.2/NVMe SSD drive



SSD Connector

- **M.2 connectors** have quickly become the preferred SSD form factor
 - Smallest drive form factor
 - Replaced the older mSATA standard
 - Supports SATA and NVMe solid state drives
 - Formerly NGFF (Next Generation Form Factor)
 - **M.2 slots are “keyed”** to identify what type of device or drive is supported

Key ID	Device Supported	Standard
B Key	SATA SSD	SATA
M Key	NVMe SSD	PCIe x2/x4
B+M Key	SATA or NVMe SSD	SATA or PCIe



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SSD Connector

- M.2 connectors



SATA

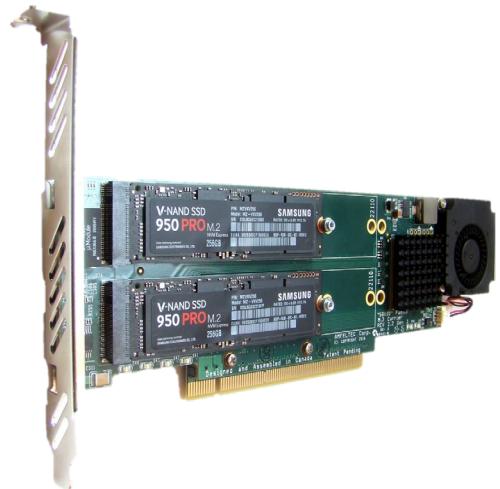


NVMe

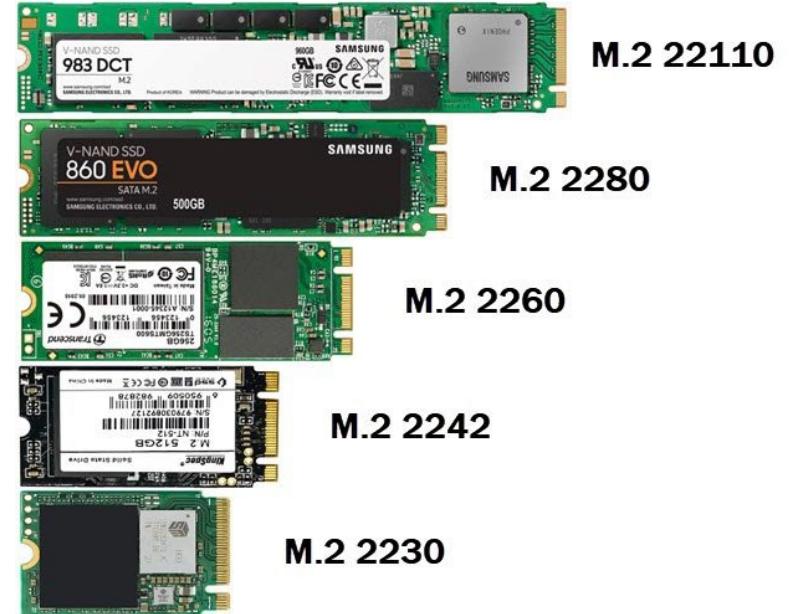


NVMe (Non-Volatile Memory express)

- PCIe based SSD drive which provides the best performance
- Fastest SSDs on the market
- Available in different lengths

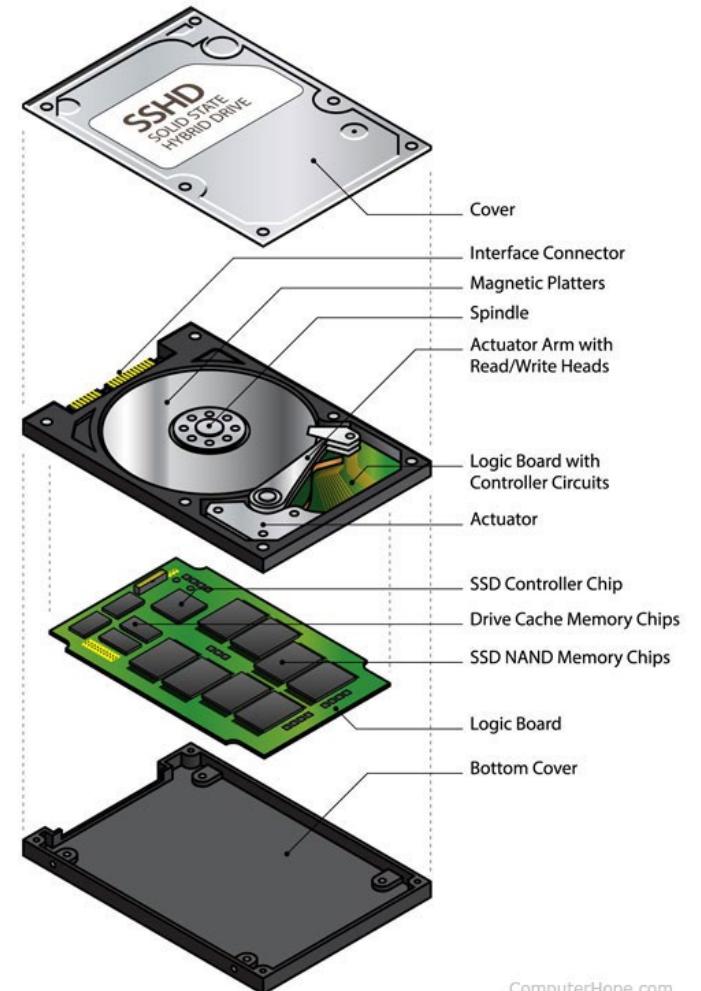


NVMe to PCIe Adapter





Solid State Hybrid Drive (SSHD)



ComputerHope.com



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External Drives

- **External Drives** are a convenient way to expand storage
 - Available in HDD or SSD formats
 - Available in various connector types
 - 3.5" drives require power from an AC outlet
 - 2.5" drives can be powered by some ports

Connector	Speeds	Power Portable Drives
eSATA	1.5Gbps - 6Gbps	No
USB	480Mbps - 40Gbps	Yes
Thunderbolt	10Gbps - 80Gbps	Yes



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Flash Memory Devices

- USB Thumb/Flash/Pen Drives
 - Faster, larger, and more durable than floppy disks or optical media
 - Meant to be used to transport data
 - Should NOT be used as persistent storage like a hard drive
- Memory Cards/Storage Cards
 - Used in portable devices like smartphones, cameras, tablets, and game consoles
 - Many formats exist; SD, miniSD, microSD, CompactFlash (CF)
- Card readers can be used to connect a storage card if support isn't included in a device



Flash Memory Devices



CompactFlash, SD, and microSD Cards



USB flash drive



USB card reader



Optical Drive Comparisons

Optical Drive	Laser	Read Only Media	Recordable Media	Rewriteable Media	Common Sizes
CD	• Red	• CD-ROM	• CD-R	• CD-RW	• 700MB
DVD	• Red	• DVD-ROM • DVD-Video	• DVD-R	• DVD-RW • DVD-RAM	• SS/SL: 4.7GB • SS/DL: 8.5GB
Bluray	• Blue	• BD-ROM • BD-Video	• BD-R	• BD-RE • BDXL	• 25GB • 50GB • 200GB (BDXL)





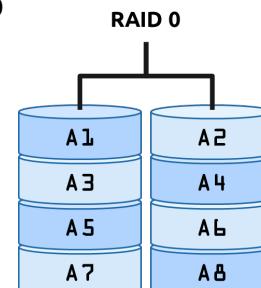
RAID

- **RAID (Redundant Array of Independent Disks)** combines identical hard drives to either increase storage capacity and performance, provide data protection or both.
 - RAID is not specific to any kind of drive
 - IDE, SATA, M.2, PCIe, USB, or Thunderbolt drives
 - **Hardware RAID**
 - Motherboard built-in RAID
 - PCI or PCIe RAID controller card
 - USB/Thunderbolt external RAID encloser
 - **Software RAID**
 - **Windows:** Dynamic Disk and Storage Spaces
 - **macOS:** Disk Utility can be used to create RAID arrays
 - **Linux:** Built-in to the Linux kernel as a standard
 - **JBOD (Just a Bunch of Disks)**



RAID 0

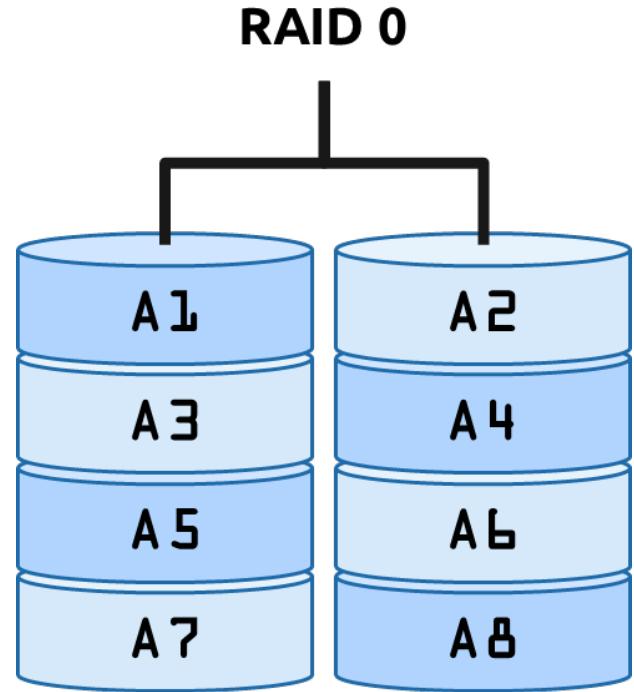
- RAID 0 uses disk striping to combine drives into one larger and faster logical drive
 - Disk Striping is a method of storage that spreads data bits across all disks in the array, increasing performance and capacity
 - Advantage
 - Faster read and write because of disk striping
 - Larger storage than any single disk
 - Only two disks are required, but more disks will increase capacity and performance
 - Disadvantage
 - NO Data Protection!
 - If one disk fails all data is lost without a backup
 - More disks you have the more data you can lose without a backup





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RAID 0





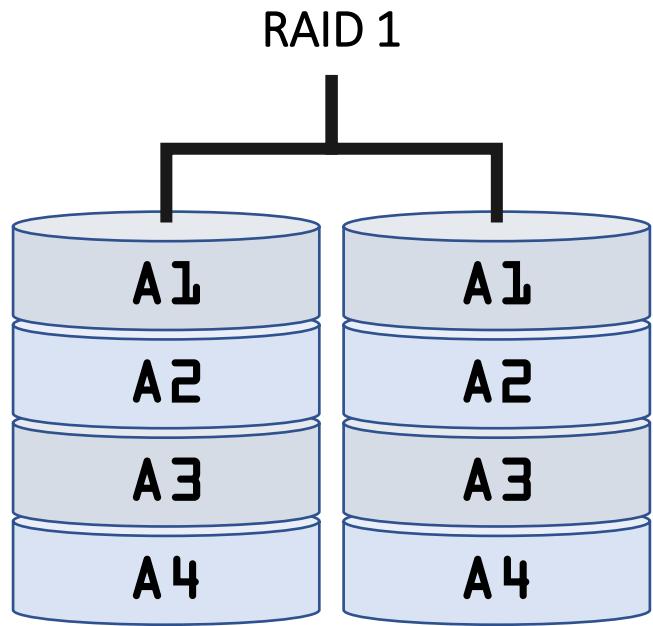
RAID 1

- RAID 1 provides data protection by mirroring data across two disk
 - Disk Mirroring actively duplicates bits across two disks to prevent data loss
 - Advantage
 - Data protection
 - If one disk fails, there is NO data loss
 - Only two disks are required, but more disks will increase protection but NOT capacity or performance
 - No performance lost if a disk fails
 - Fast recovery
 - Disadvantage
 - Maximum storage capacity is limited to the size of a single disk
 - One disk for storage and one for protection



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RAID 1





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RAID 5

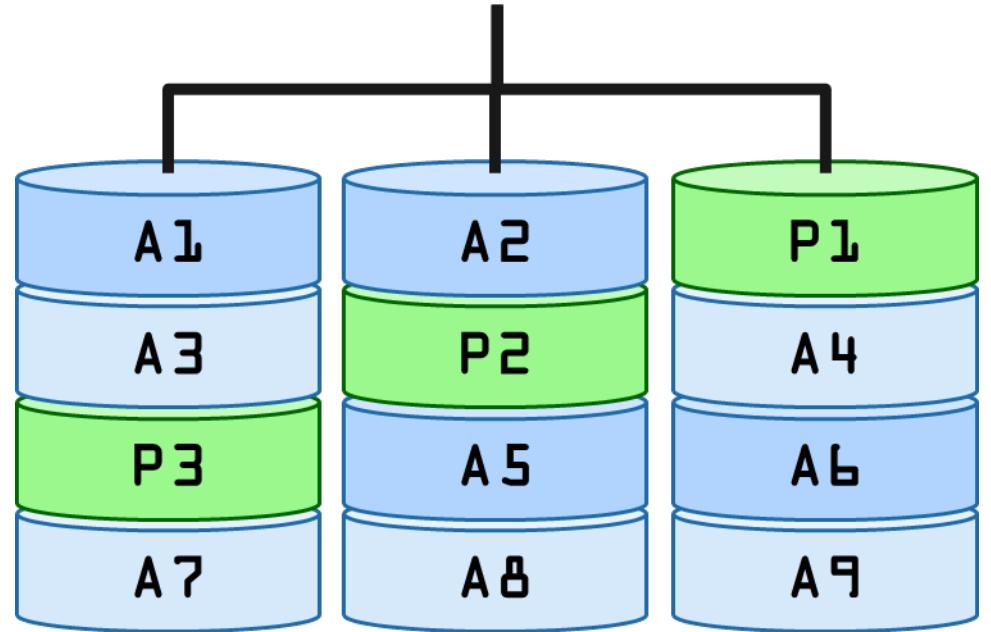
- RAID 5 uses disk striping to combine drives into one larger and faster logical drive and distributes parity across all disks in the array
 - **Parity data** is a smaller representative value that can be used to recreate data if data is lost
 - **Advantage**
 - Data protection
 - If one disk can fail, parity will be used to recreate the data
 - Larger storage than a single drive
 - **Disadvantage**
 - Three disks are required, but more disks will increase capacity NOT protection or performance
 - Parity is SLOW!
 - Makes working while a disk has failed slow
 - Makes rebuilding the array slow when replacing a degraded disk



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RAID 5

RAID 5





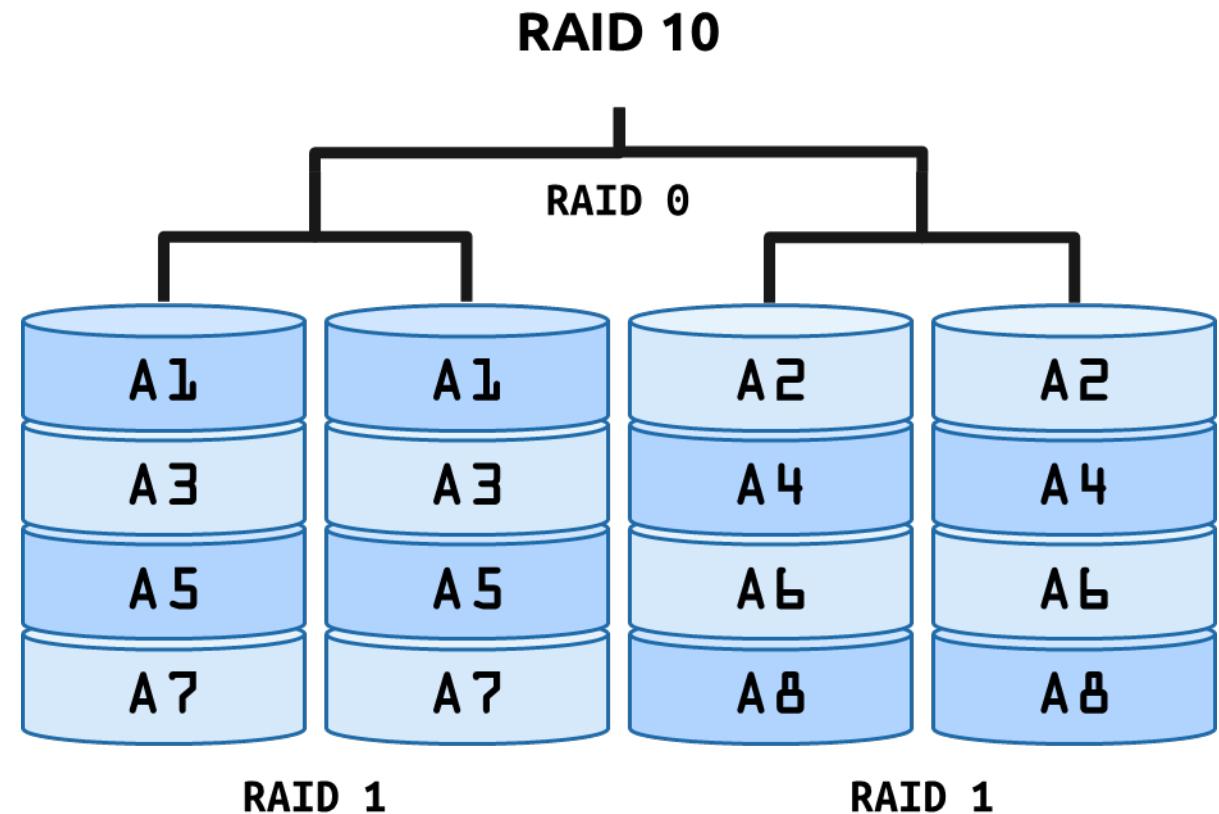
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RAID 10

- **RAID 10 (1+0)** combines disk into RAID 1 arrays and then combines those arrays into a RAID 0
 - **Advantage**
 - Faster read and write because of disk striping
 - Larger storage than any single disk
 - More disks will increase capacity, performance, and protection
 - No performance lost if a disk fails
 - Fast recovery
 - **Disadvantage**
 - Four disk minimum
 - If a RAID 1 array fails all data will be lost
 - That's two disks in a single RAID 1 failing



RAID 10

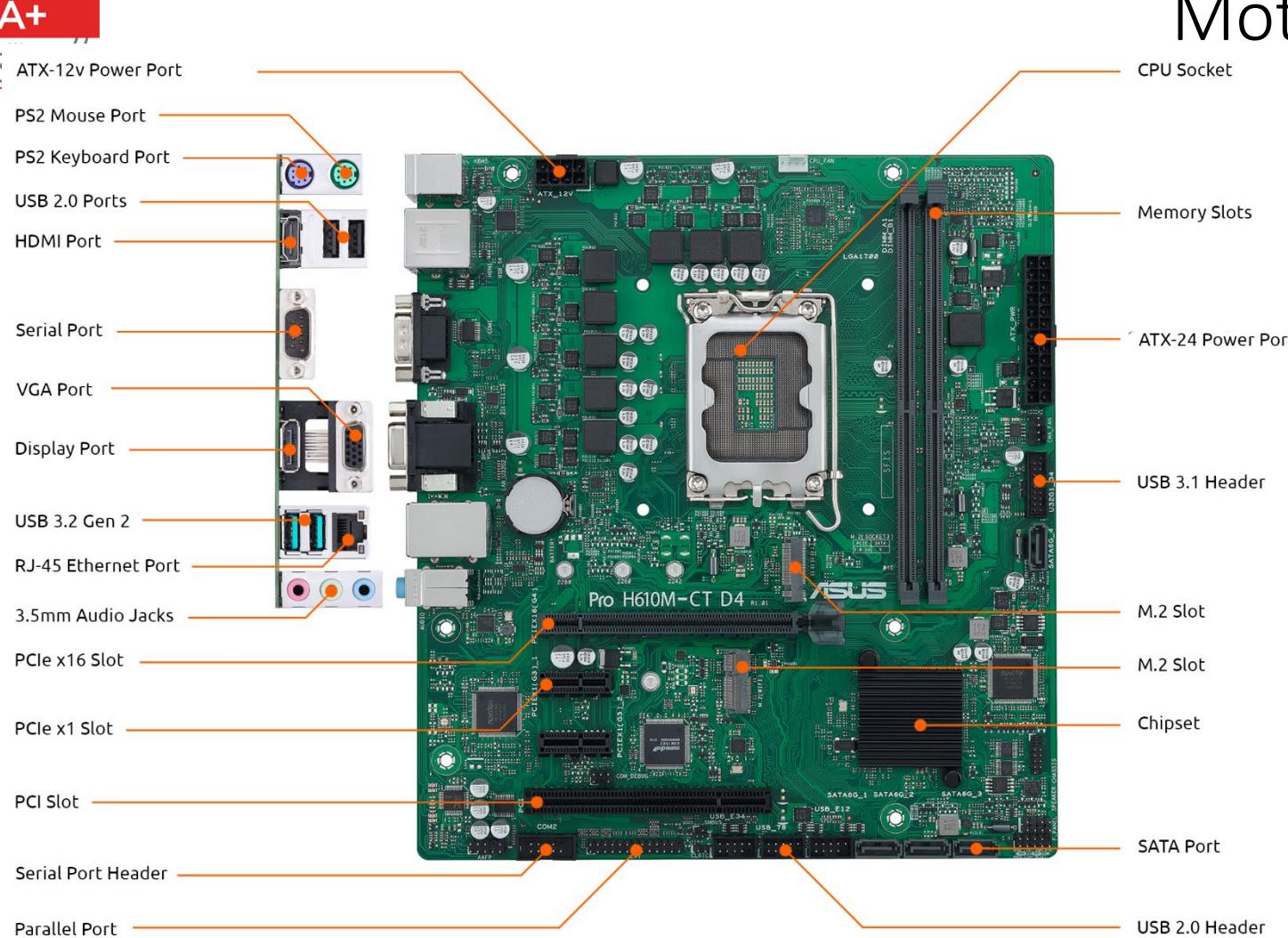




Motherboards and Chipsets

- **Motherboards** serve as the basis of the entire computer system.
 - All hardware will communicate through it via some connector or radio.
- A **Motherboard chipset** defines what features are supported such as;
 - CPU model and make
 - RAM type, capacity, and speed
 - Ports types (USB and Thunderbolt)
 - Storage features like drive type and RAID support
 - Expansion slot types like PCI or PCIe
 - Network connections (wired and wireless)

Motherboards and Chipsets





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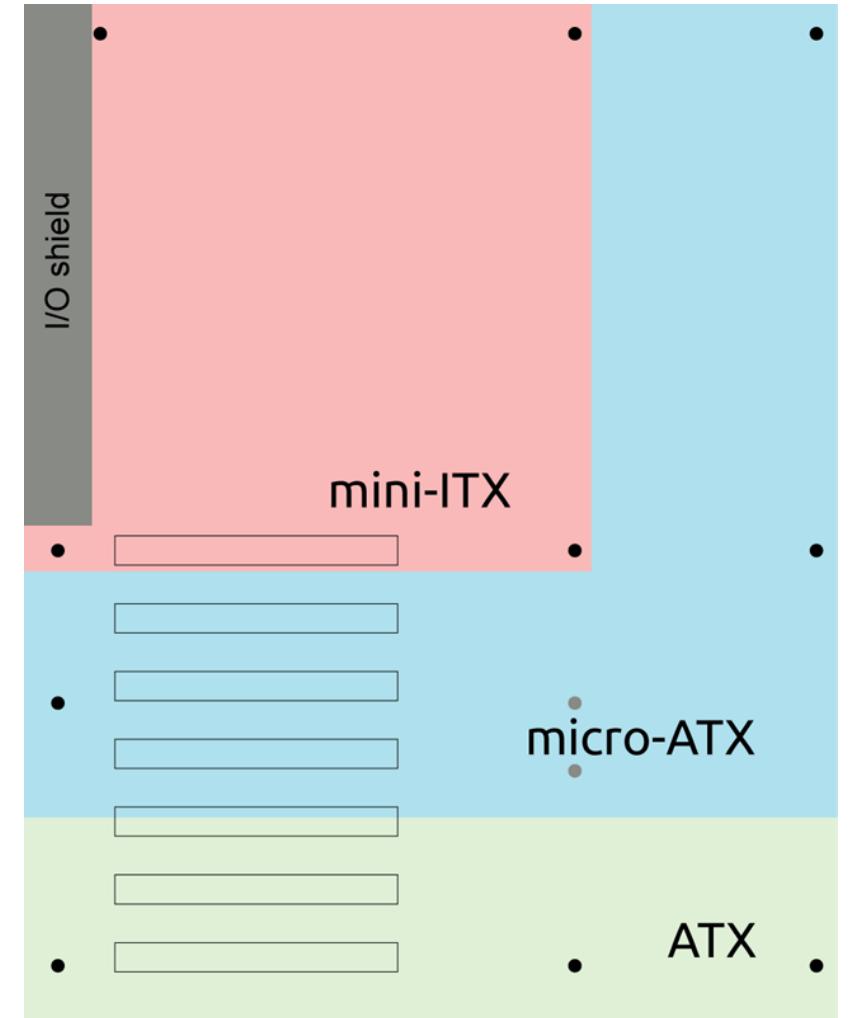
Motherboard Form Factors

- **Motherboard form factor** defines the size (width and height) of the board
 - Form factor will NOT directly affect performance but will affect the availability of ports and slots
- **Types of Form Factors**
 - **ATX (Advanced Technology eXtended)**
 - Biggest form factor
 - **micro-ATX (Micro Advanced Technology eXtended)**
 - Mid-sized form factor
 - **mini-ITX (Information Technology eXtended)**
 - Smallest form factor



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Motherboard Form Factors



Form Factor Size Differences



PCI (Peripheral Computer Interconnect)

- **PCI (Peripheral Computer Interconnect)** expansion slots are used to attach hardware devices to expand the capabilities of a computer system beyond what's integrated into the motherboard.
 - PCI slots are the **oldest and slowest slots** so should only be used for the sake of **compatibility**
 - 32-bit bus allows for 266 MB/s.
 - **Mini PCI** slots can be found in older mobile computers but are not common



PCI Slots on a Desktop



PCIe (Peripheral Computer Interconnect Express)

- **PCIe (Peripheral Computer Interconnect Express)** expansion slots are used to attach hardware devices to expand the capabilities of a computer system beyond what's integrated into the motherboard.
 - PCIe slots are the **latest and fastest slot**
 - Available in different sizes x1, x4, x8, x12, x16 and x32
 - Bigger slots offer more lanes to transfer data so offer increased performance over the smaller slots
 - Smaller cards will always work in a bigger slot
 - Bigger cards can sometimes work in a smaller slot
 - **Mini PCIe** is a common internal expansion for laptops and desktops
 - Mostly used for WiFi adapters and SSD storage



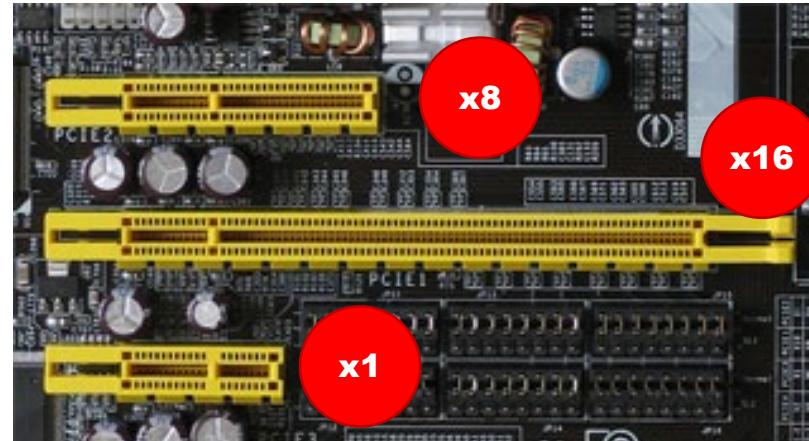
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PCIe (Peripheral Computer Interconnect Express)

Version Number	Year Released	Transfer Rate			
		x1	x4	x8	x16
1	2003	0.250 GB/s	1.000 GB/s	2.000 GB/s	4.000 GB/s
2	2007	0.500 GB/s	2.000 GB/s	4.000 GB/s	8.000 GB/s
3	2010	0.985 GB/s	3.938 GB/s	7.877 GB/s	15.754 GB/s
4	2017	1.969 GB/s	7.877 GB/s	15.754 GB/s	31.508 GB/s
5	2019	3.938 GB/s	15.754 GB/s	31.508 GB/s	63.015 GB/s



PCIe Slots on a Desktop



Mini PCIe Slots



Central Processing Unit (CPU)

- The **CPU (Central Processing Unit)** is a core component of all computing devices
 - Processes instructions for the operating system, applications, and other components
 - Motherboard chipset and socket define CPU compatibility



Central Processing Unit (CPU)

- CPU Architecture
 - x86/x64
 - Designed with **desktop** and **server** systems in mind
 - **Intel** and **AMD** dominate this market space
 - Consumes **lots of power** and generates **lots of heat**
 - **Large library of compatible software**
 - ARM
 - Designed with **mobile** and portable computers in mind
 - Qualcomm, Samsung, Nvidia, Apple, and many others compete in this space
 - **Power efficient** and generates **less heat**
 - **Limited software compatibility** but growing quickly



Desktop and Server CPU

- **PGA (Pin Grid Array) Socket**
 - Connector with **holes** to receive the pins from the bottom of the CPU
 - Older style still used by **AMD** for some Ryzen CPUs
- **LGA (Land Grid Array) Socket**
 - Connector with **pins** that contact the pads on the bottom of the CPU
 - **Intel** created and exclusively uses LGA sockets
 - Used by **AMD** for their Ryzen Threadripper and EYPC CPUs



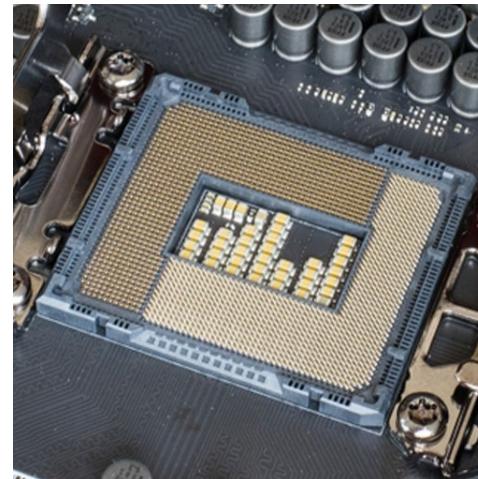
Desktop and Server CPU



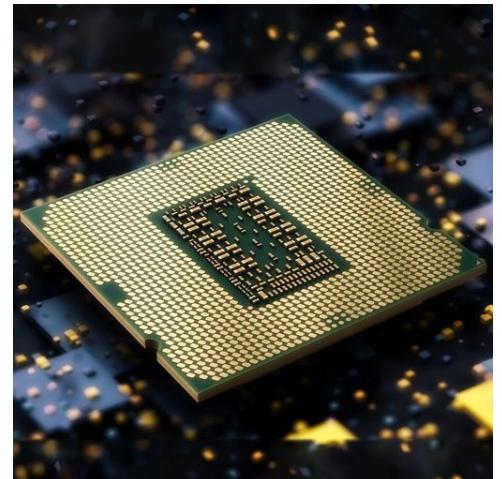
AM4 PGA Socket



AMD Ryzen CPU



LGA1700 Socket



Intel Core i-Series CPU

Technical Institute of America



Server CPU Sockets

- **Multi-Socket Motherboards**
 - Some server motherboards have multiple CPU sockets to provide **high performance**
 - Can be either **LGA or PGA** socket types but never both



Quad LGA CPU Motherboard



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Sockets and Processors

Socket	Generation	Intel CPUs
LGA 1155	2 nd & 3 rd	Core i3/i5/i7/i9, Pentium, Celeron, Xeon
LGA 1150	4 th	
LGA 2011	3 rd , 4 th , & 5 th	
LGA 1151	6 th , 7 th , 8 th , & 9 th	
LGA 1200	10 th & 11 th	
LGA 1700	12 th	

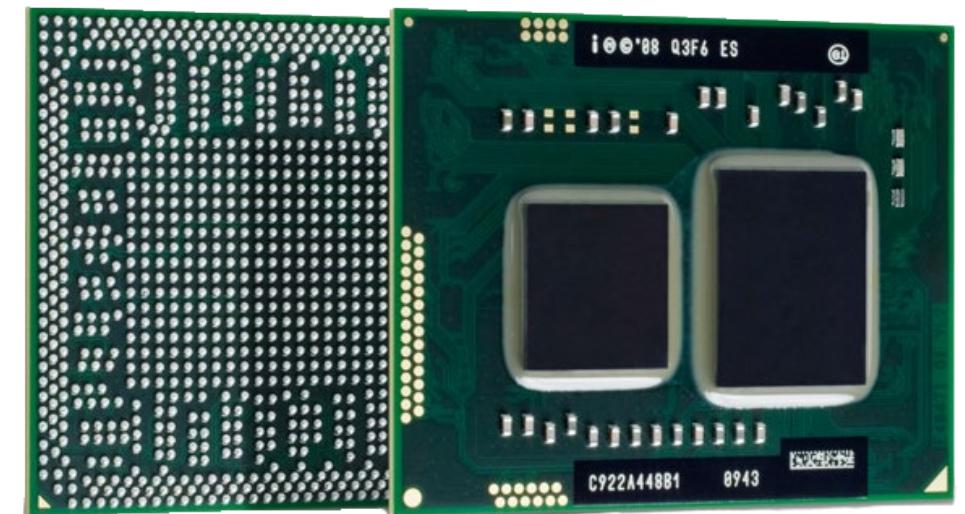
Socket	Pins	Style	AMD CPUs
AM3+	942	PGA	FX Vishera, FX Zambezi
FM2	904	PGA	A-Series
FM2+	906	PGA	A-Series
AM4	1331	PGA	Ryzen, Athlon, A-Series
TR4	4094	LGA	Ryzen Threadripper
sTRX4	4094	LGA	Ryzen Threadripper

	High-Performance CPUs	Mainstream CPUs	Budget CPUs	Server CPUs
Intel	Core i9	Core i5 and i7	Core i3, Pentium and Celeron	Xeon
AMD	Ryzen Threadripper	Ryzen	Athlon and A-Series	EYPC



Mobile CPU Sockets

- **Mobile CPUs** are designed to be smaller and more power efficient than desktop CPUs to better fit the use of mobile users
- **BGA (Ball Grid Array) Socket**
 - There is **no connector**, instead balls of solder are used to attach the CPU to the board
 - **Intel** and **AMD** use them for their mobile CPUs



BGA Style Intel Core i7-5500U



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32-bits vs 64-bits and Clock Speed

- **32-bit and 64-bit** refer to how many bits a CPU can address per cycle.
 - The 64-bit architecture handles large amounts of RAM more effectively than a 32-bit system.
- **Clock speed** is an indicator of performance and how fast a CPU can process data.
 - Higher frequency suggests better performance
 - 1000MHz = 1GHz

	32 Bit CPU	64 Bit CPU
x86 / 32-bit Software	✓	✓
x64 / 64-bit Software	✗	✓
Maximum RAM	4 Gigabytes	16 Terabytes
Windows 10	✓	✓
Windows 11	✗	✓
macOS	✗	✓
Linux	✓	✓



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Multithreading and Multicore

- **Hyper-Threading** is an Intel based technology which allows a CPU core to process multiple instructions simultaneously
 - Referred to as **Simultaneous multithreading (SMT)** by other manufacturers like AMD
- A **multicore** processor is a single chip that has two or more processor cores attached
 - Provides enhanced performance and reduced power consumption
 - Enables more efficient simultaneous processing of multiple tasks
 - Dual-Core, Quad-Core, Hexa-Core and Octa-Core processor are common in all computing devices



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Multithreading and Multicore

Single core
1GHz CPU



Multithreading

Dual core
1GHz CPU



Multicore

Dual core
1GHz CPU

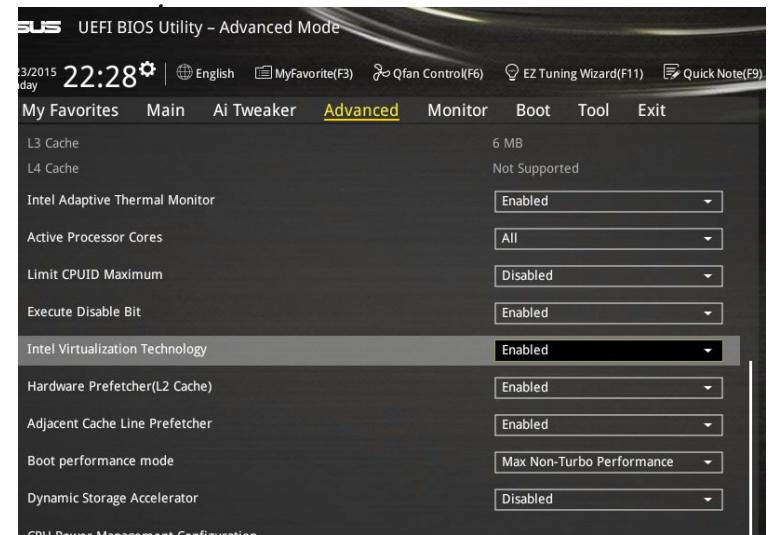


Multicore with
Multithreading



CPU Technology

- **Virtualization Support** allows for a system to host virtual machines (VMs)
 - NOT all CPUs support this feature, check manufacturers' documentation
 - Can be enabled or disabled in the BIOS/UEFI utility
 - **Intel Virtualization Technology (Intel VT)**
 - Also known as **Intel VT-d** in a BIOS/UEFI menu
 - **AMD Virtualization Technology (AMD-V)**
 - Also known as **Secure Virtual Machine** in a





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Throttling and Overclocking

- **Throttling** a CPU is done to **reduce power consumption** and so the **CPU generates less heat**. Modern CPUs will reduce their clock speed if they become too hot.
 - Intel calls its throttling technology “**SpeedStep**”
 - AMD calls their throttling technology “**Cool’n’Quiet**”
- **Overclocking** a CPU will increase the CPU frequency by increasing the multiplier to get better performance.
 - Supplying a better cooling solution is a must when overclocking; liquid cooling is recommended.
 - Only recommended for gamers.
- **Clock Multipliers** are used to change the ratio of the base clock and the external clock often modified to overclock a CPU.
 - CPU clock x Clock multiplier = CPU frequency.
 - $150 \text{ MHz} \times 10 = 1,500 \text{ MHz}/1.5 \text{ GHz}$



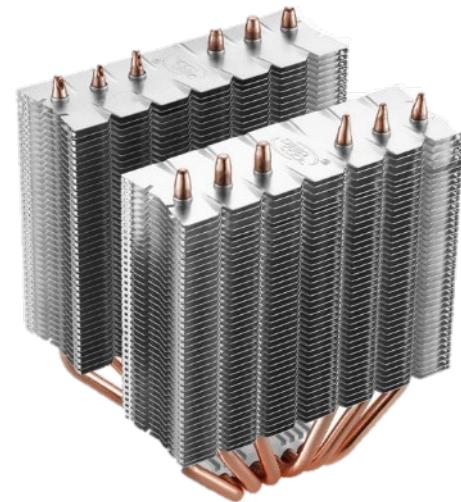
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Passive Cooling

- **Passive Cooling** techniques do NOT use any moving parts
 - **Thermal Compounds** are a paste or grease that's applied to the top of a chip to assist in moving the heat away from a chip
 - Fills in the microscopic imperfections in the CPU aluminum lid
 - Conducts heat away from the CPU and into the heat sink
 - Must be replaced if it becomes dry and brittle
 - **Thermal pads** are soft rubber pads that are an alternative to thermal compounds
 - Last longer than thermal compound but not as good at transferring heat
 - Commonly used on memory chips
 - NOT commonly used with CPUs
 - **Heat Sinks** are blocks of metal that absorb the heat from the chip they sit on
 - Commonly used with CPUs, memory, SSDs, GPUs, and chipsets
 - Before you install a heat sink, you must always apply thermal compound



Passive Cooling





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Active Cooling

- **Active Cooling**
 - CPU Fan/CPU Cooler
 - Includes a heatsink with a fan mounted on it
 - If a system is overheating, consider replacing the stock cooler with a more efficient one
 - **Compatibility** is based on the **CPU socket type**
 - Case Fan
 - Intake fans pull in cool air
 - Exhaust fans push out the hot air



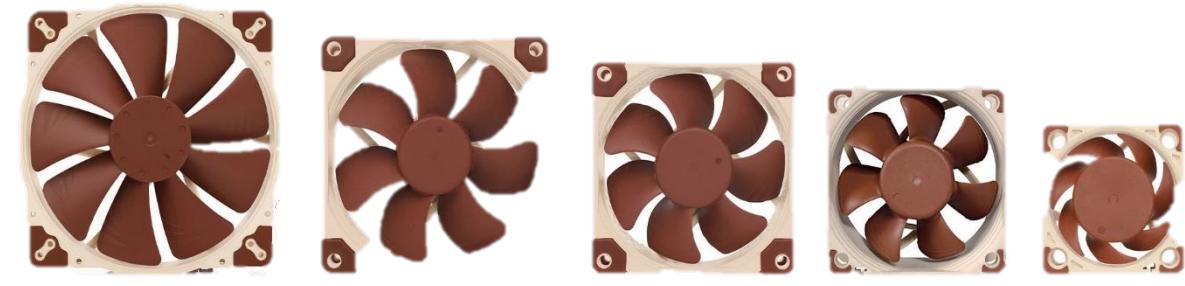
Active Cooling



Intel LGA 1700
stock cooler



AMD AM4
stock cooler



200mm 92mm 80mm 60mm 40mm
Case Fans from 200mm – 40mm



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Advanced CPU Cooling

Liquid Cooling uses either water or coolant to transfer heat as quickly as possible

- Can be very dangerous because the risk of a leak
- Liquid cooling kits can be more efficient but require regular maintenance
- All-in-one coolers do NOT require regular maintenance but may not be as efficient
- Only recommended if overclocking or gaming





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Expansion cards

- Sound card
 - Used to add more sound options





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Expansion cards

- Video card
 - Enhance graphics, usually a PCIe Card

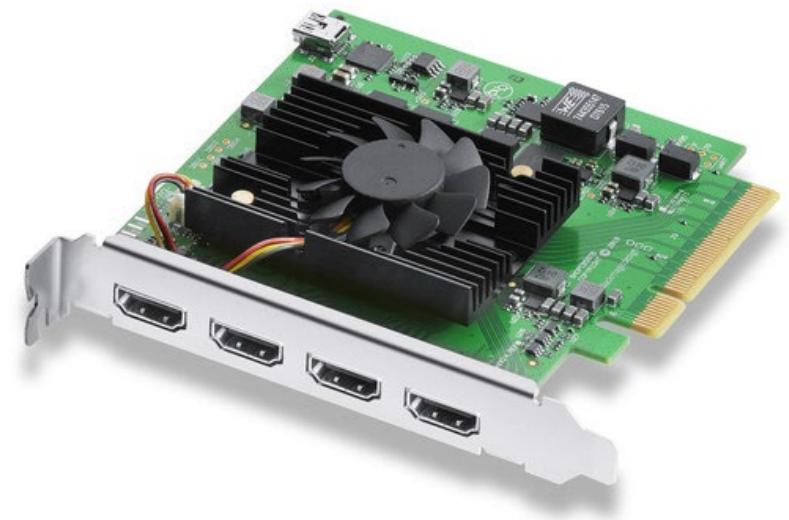




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Expansion cards

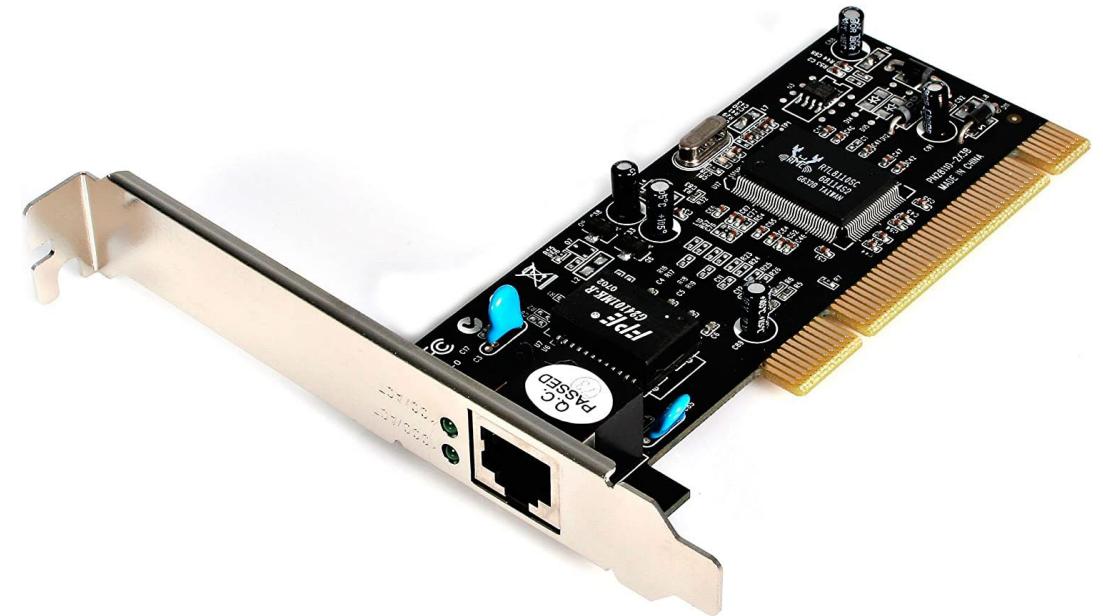
- Capture card
 - Use to capture video from a device such as a camera





Expansion cards

- NIC
 - Use to connect to a network, both wired or wireless





Computer Firmware

- A **BIOS (Basic Input Output System)** or a **UEFI (Unified Extensible Firmware)** is included on every motherboard to initiate the boot process and to manage integrated hardware.
 - **ROM (read-only memory)** chip is used to store the BIOS/UEFI
 - **UEFI Only features**
 - **Secure boot:** Blocks untrusted code from running at boot up
 - **Faster startup:** Loads an operating system faster than a BIOS
 - **Mouse and keyboard interaction:** BIOS only supports keyboard interactions





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CMOS (Complementary Metal–Oxide–Semiconductor)

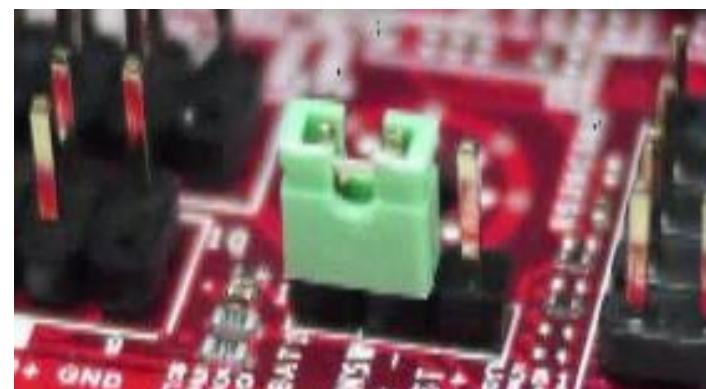
- The **CMOS** is used to store configuration changes done to the BIOS/UEFI
 - **CMOS Setup Utility** can be accessed by pressing “Delete” or “F2” during boot, but it does vary by system
 - Also known as **BIOS Setup Utility, UEFI Setup Utility**
 - **RTC (Real-Time Clock)** is part of the CMOS and is used to provide the time to the computer system
 - A **boot time password** can be configured to be required before the operating system loads
 - **CMOS** is physically located on volatile memory
 - **volatile memory** requires power to store information
 - **CR2032** coin batteries keep power to the CMOS
 - If the **battery dies** or is removed the CMOS will reset back to its **default settings**



CMOS (Complementary Metal–Oxide–Semiconductor)



CR2032 battery



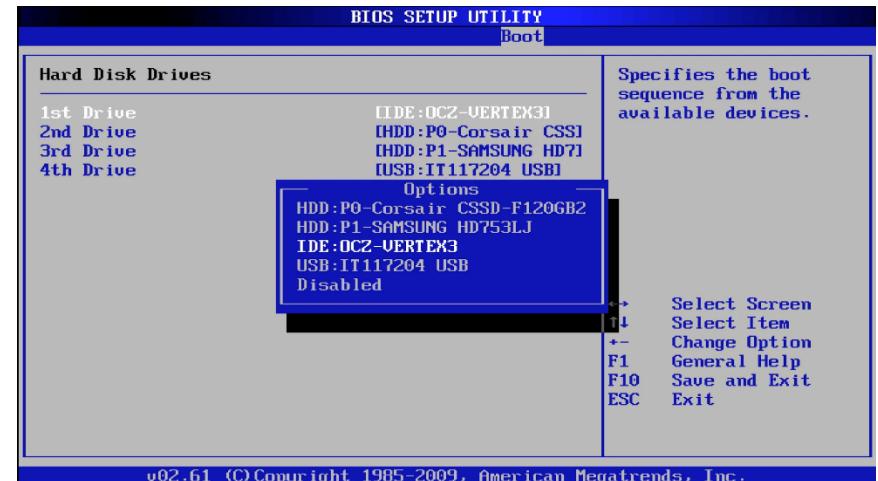
Clear CMOS Jumper



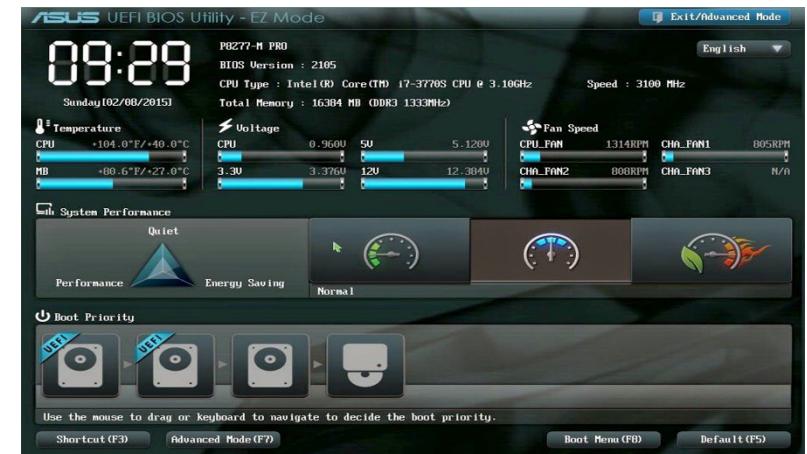
Clear CMOS Switch



CMOS



AMI BIOS Setup Utility



ASUS UEFI BIOS Utility



CMOS

- Common CMOS settings
 - Manage Integrated Features
 - Boot Device Priority
 - Control which storage device the computer will first boot from
 - Boot Time Passwords
 - Enable/Disable access to ports
 - USB, Thunderbolt, Serial, and Network interfaces
 - Wake-on-LAN (WoL)
 - Virtualization Support
 - CPU multipliers and voltages
 - RAM timing and voltages.



Encryption

- Trusted Platform Module (TPM)
 - Hardware encryption
 - Stores cryptographic key generally for hard drive encryption
- HSM
 - Hardware security module
 - Used to generate, store and process cryptographic keys.
 - Usually an external appliance or add on card





Power Supplies

- A **Power supply unit (PSU)** is a critical component since they provide power to the motherboard and all other components attached to it.
 - **Watts** identify the total amount of power a PSU can deliver
 - 500 watts is what CompTIA recommends as a standard PSU
 - Match the wattage when replacing a PSU or get one with a higher wattage, never lower
 - **Non-Modular PSUs** have all the cables permanently attached
 - Can take up space and reduce airflow
 - **Modular PSUs** don't have any cables attached, just connectors
 - Only need to attach the cables that are needed
 - **Redundant Power Supplies**



Power Supplies



Non-Modular PSU



Fully Modular PSU



PSU Form Factors

- **ATX vs SFX**

- ATX PSUs are used in computer cases that support ATX and Micro-ATX motherboards.
- SFX PSUs are used in computer cases that support Mini-ITX or smaller form factors.



SFX and ATX PSUs



Molex, SATA, and PCIe

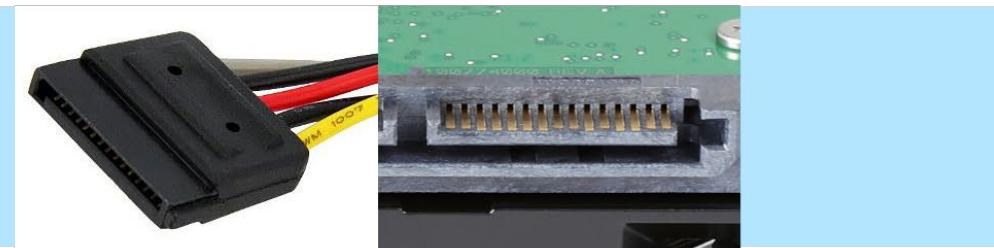
Molex Power Connector

- Supplies 5v and 12v
- Used by IDE drives, case fans, and other devices
- Also known as the Standard connector



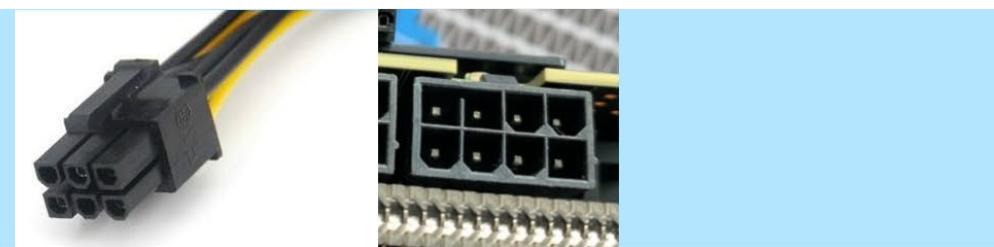
SATA Drive Power Connector

- Supplies 5v, 12v and 3.3v
- Used on SATA drives only



PCIe power connector

- Used to give additional power to PCIe video cards
- 6 pin supplies 3 rails of 12v
- 8 pin supplies 4 rails of 12v





ATX and ATX12v

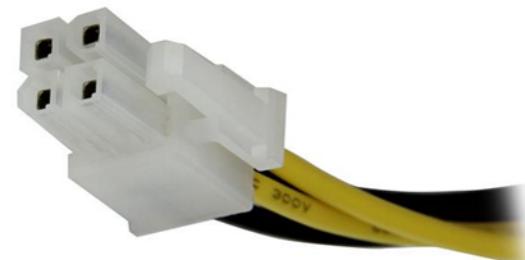
ATX Connector

- Supplies 5v, 12v and 3.3v
- Gives power to the motherboard
- Comes in a 20 pin and 24 pin version



ATX12v

- 4 pin connector also known the P4 connector
- Connects to the motherboard to give power to the CPU





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Printer and Multifunction Devices

- **Printers** are the oldest output devices and are still in use in homes and businesses.
 - Most printers are really **Multifunction Devices (MFD)**
 - They can include functions like **printing, faxing, scanning, and coping** all in one.
- **CMYK (Cyan, Magenta, Yellow, Key/Black)** is the four-color printing process used by color printers. It can produce thousands of distinct colors.
- **Common Interfaces:** USB, WiFi, Bluetooth, Ethernet or NFC.





Properly unboxing a device

- Ensure you have the right amount of space
- Correct power
- Correct internet connection
 - Wired or wireless
- Follow all instructions in the manual
- Usually configured on it's interface or with a web interface





Printer Control Language (PCL) vs. PostScript

- **PCL and PostScript is that they're both Page Description Languages (PDL)**
- PCL is trademarked by HP
 - Most used
- PostScript developed by Adobe
 - Mostly used in industrial printers like plotter.



Device connectivity

- USB
- Ethernet
- Wireless



Public/shared devices

- Printer share
 - Computer on the network that is sharing its printer
 - Computer has to be on
- Print server
 - A dedicated computer used to share printers.
 - Can be a server in the network or can be done on a large multifunction device



Configuration settings

- Duplex
- Orientation
- Tray settings
- Quality



Security

- User authentication
 - Used to allow only specific individuals or groups to use the printer
- Badging
 - If supported some devices will require to scan a badge in order to print to the device
- Audit logs
 - Can display who used it and when
 - Shows any errors both software and hardware issues
- Secured prints
 - If supported will require to input a code to be able to print



Multifunction Devices

- Automatic document feeder (ADF)/flatbed scanner





Finishers

- **Finishers** take care of the busy work that happens after printing.
 - **Duplexers** enable automatic 2-sided printing
 - **Collator/Separator** properly orders the pages in a print job and separates each print job
 - **Stapler** can staple all the pages in a print job
 - **Binder** can print booklets usually with a spiral binding
 - **Paper trays** allow a printer to hold more paper and different sizes of paper





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Laser Printers

Laser printers fuse powered ink onto paper by using very high heat to melt toner on to the page.

- **Advantage**
 - Fastest printer
 - Lowest cost per-page (cpp) for black and white printing.
- **Disadvantage**
 - Highest cost per-page for color printing.
- **Maintenance**
 - Replace toner, apply maintenance kit, calibrate, clean





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Toner, Imaging Drum, Transfer Belt, and Erase Lamp

- **Toner** the powered ink used by laser printers
 - When working with toner make sure to avoid inhaling toner.
- **Imaging Drum** is a photosensitive drum that the laser/led write to
 - If the drum gets scratched it will leave visible marks on the print outs
- **Transfer Belt and rollers**
 - keeps the colors aligned in a laser color printer
- **Erase Lamp** clears the imaging drum
 - If the erase lamp fails it will leave part of the previous print job on the drum which will show up on the next print job, this is called “Ghosting”



Toner Tube



Toner Cartridge



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Toner, Imaging Drum, Transfer Belt, and Erase Lamp

- Pickup Rollers
 - Pickups paper from the tray
 - Can be cleaned or replaced if needed
- Separation Pads
 - Separate paper to ensure the printer doesn't pickup more than one sheet
- Duplexing Assembly
 - Used to print on two sides on the page



Pickup Rollers



Separation Pad



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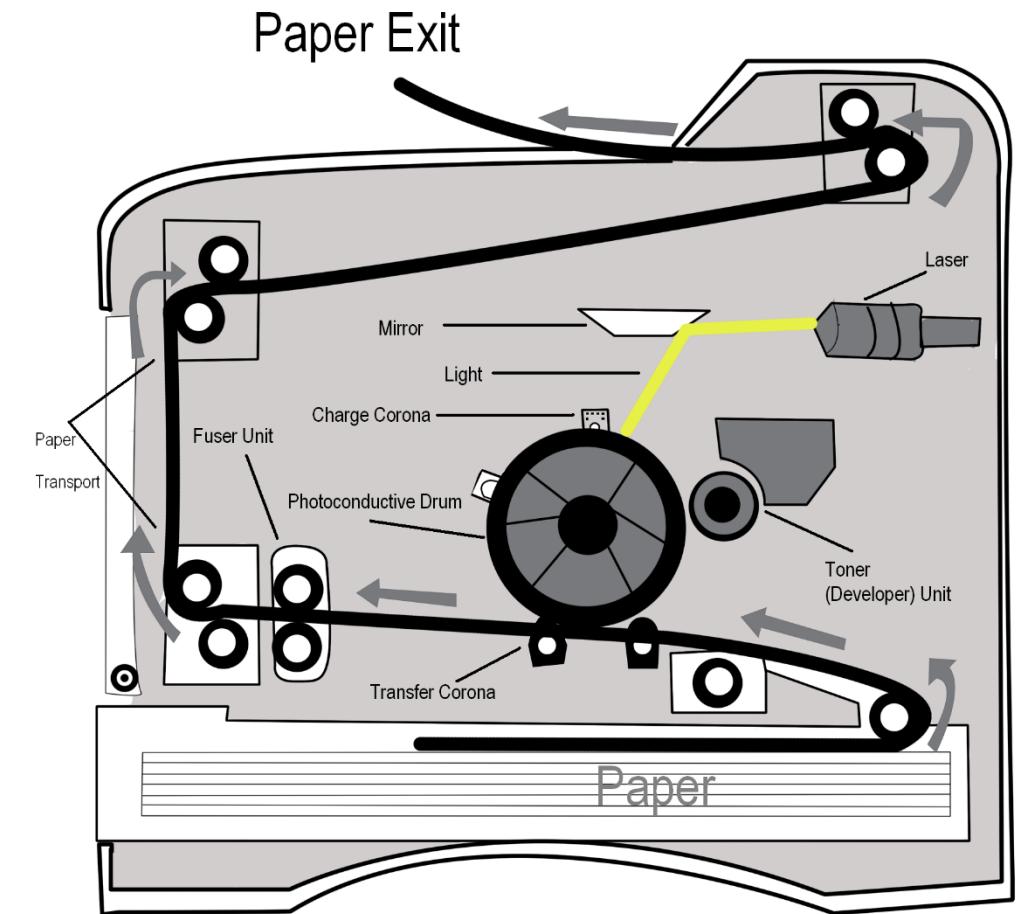
Primary Corona, Transfer Corona, Laser, and Fuser

- **Primary Corona** Wire charges the imaging drum.
 - If the primary corona wire fails, it may cause the printer to output blank pages or black pages.
- **Transfer Corona** Wire/Roller pulls the toner onto the paper from the drum
 - If the transfer corona wire fails, it will cause the printer to output blank pages.
- **Laser writes** to the imaging drum
- **Fuser melts** the toner onto the paper
 - If the fuser fails, it will lead to the toner being able to be rubbed off the page.



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Primary Corona, Transfer Corona, Laser, and Fuser



Laser Printing Process



Laser Print Process

1. Processing

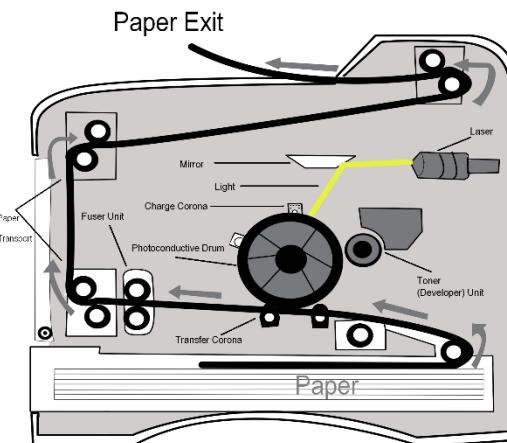
- The printer receives and processes the image and stores the page in memory.

2. Charging

- Places a -600VDC charge on the photosensitive drum using the charging corona.

3. Exposing

- The laser writes an image onto the photosensitive drum, by lowing voltage (-100VDC).



Laser Printing Process



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Laser Print Process

4. Developing

- The developing roller has a negative charge and the toner stuck to it. As the rolls the toner toward the photosensitive drum, the toner is attracted to it.

5. Transferring

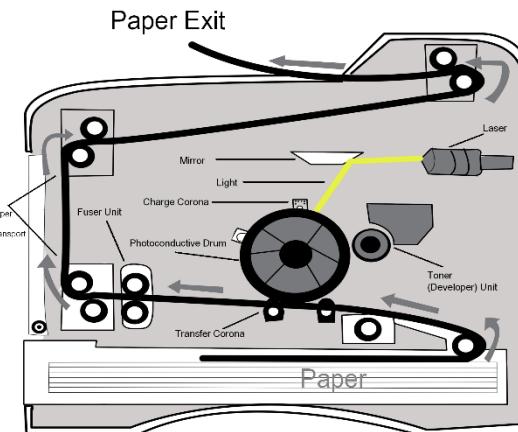
- The image is then transferred from the drum to the paper.

6. Fusing

- The fuser, with a fuser roller and the pressure roller make the image permanent. The paper then exits the printer.

7. Cleaning

- The printer then uses a rubber scraper to clean the photosensitive drum.





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Laser Printer Maintenance Kit

- When a printer prints a certain amount of pages you will need to replace many parts
- A maintenance kit usually replaces:
 - Fuser Unit
 - Transfer Roller
 - Paper Feed Roller / Separation Roller
 - Pickup Roller





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Clean and Calibrate

- When a new toner or maintenance kit is applied you will need to calibrate it within the printer software
- Clean the printer according the manufactured specifications



Inkjet Printer

- **Inkjet Printer** uses ink in the form of **ink cartridges**, it prints by spraying the ink onto the page.
 - **Advantage**
 - Most affordable color printer
 - **Disadvantage**
 - **Ink cartridges** are expensive and dry up if you don't use them.
 - Every time you install a new ink cartridge you must **recalibrate** the printer which consumes ink and paper
- **Inkjet Printer Components**
 - Ink cartridge, print head, roller, feeder, duplexing assembly, carriage belt
- **Maintenance**
 - Clean heads, replace cartridges, calibrate, clear jams



Inkjet Printer





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Impact Printer

- **Impact Printers** use ink in the form of an **ink ribbon** and print by some mechanism striking the ribbon to transfer an image to the page.
 - **Dot matrix** and **Daisy wheel** printers are the most common impact printers.
 - **Advantage**
 - Can print on carbon backed paper.
 - **Disadvantage**
 - Slow and loud
 - The tractor feed paper would often jam the printer.
 - **Impact Printer Components**
 - Print head, ribbon, tractor feed
 - Impact paper
 - **Maintenance**
 - Replace ribbon, replace print head, replace paper



Impact Printer





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Thermal Printers

- **Thermal printers** are the only printer that does not use ink to print. It prints on heat sensitive paper.
 - The **heat sensitive paper** is easy to identify because it has a **shiny** or waxy look
 - Printouts are meant to be **disposable**, so if you want to keep the information for a long time you can make a **photocopy or scan** the printout.
 - **Thermal Printer Components**
 - Feed assembly, heating element
 - Special thermal paper
 - **Maintenance**
 - Replace paper, clean heating element, remove debris



Thermal Printers





3D Printers

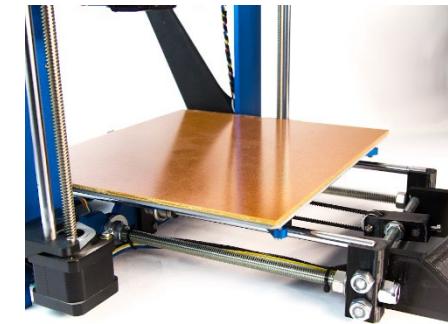
3D printers provide a convenient way to produce prototypes of physical objects without having to go through a complex manufacturing process.

Type	Consumable	Resolution	Printing Element	Description
FDM	Filament	.1mm - .3mm	Extruder (Hot-end)	The filament is feed into an extruder which will create the 3D object a single layer at a time.
SLA	Resin	.025mm - .3mm	Light (Laser or LCD screen)	A platform is lifted out of the resin as a light hardens the resin into plastic.



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3D Printers



Print Bed



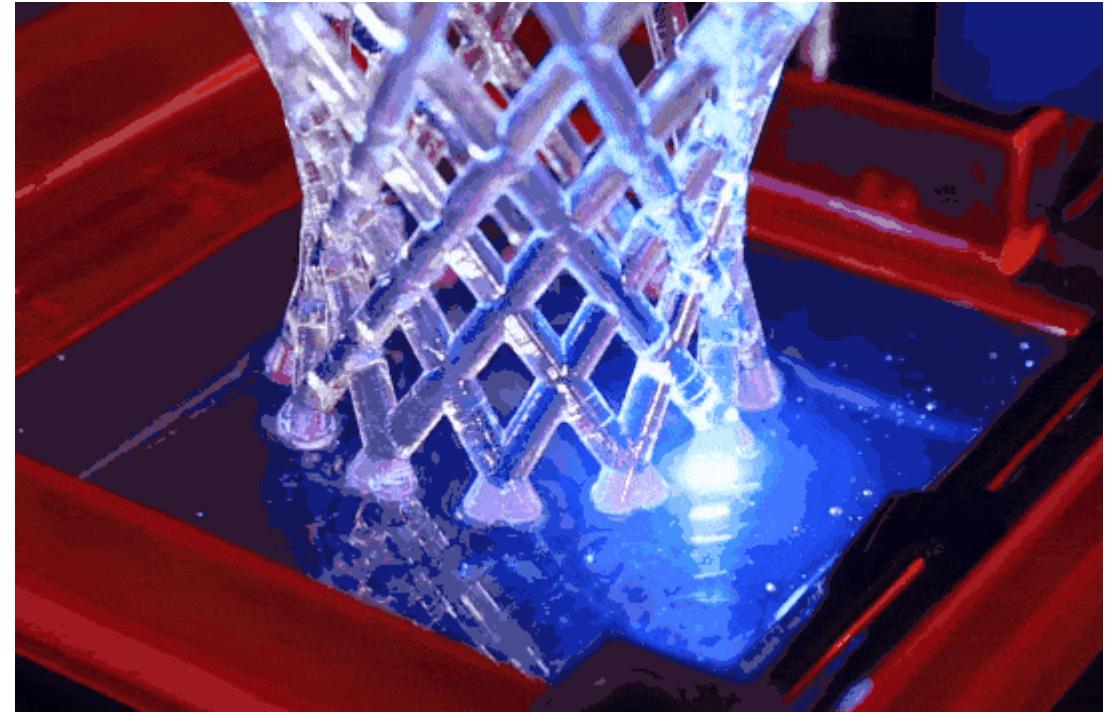
Resin



Filament



FDM (Fused Deposition Modeling) vs SLA (Stereolithography)

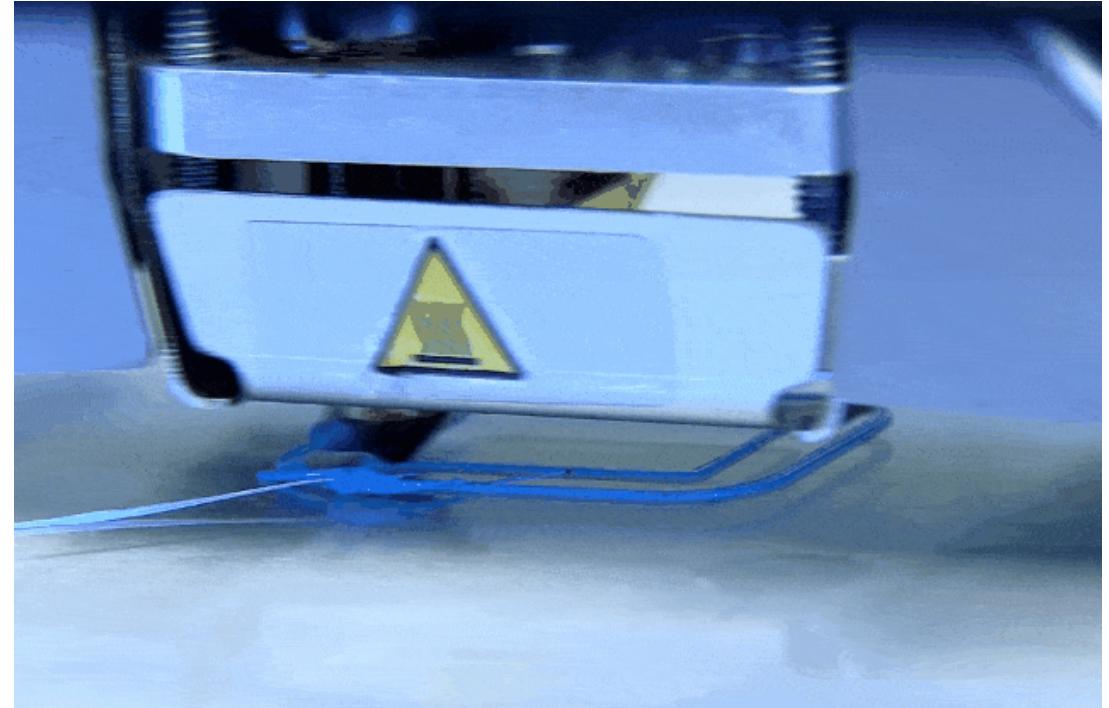


SLA (Stereolithography)

- Liquid resin is hardened by light as the object is attached to a rising print bed



FDM (Fused Deposition Modeling) vs SLA (Stereolithography)



FDM (Fused Deposition Modeling)

- Plastic filament is melted out of an extruder (hot end) onto a print bed



Virtualization

- **Virtualization** uses a hypervisor to allow multiple operating systems to work simultaneously in one physical computer system
 - Benefits
 - Power saving
 - Less physical hardware will less power
 - Hardware consolidation
 - Fewer devices means less hardware to manage
 - System management and security
 - Virtual machines (VMs) are sandboxed environments
 - VMs are easier to backup and replicate



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Hardware Support and Resource Requirements

- **RAM**

- Each virtual machine will require the same resources as an actual physical machine. Windows 10 requires 2GB of RAM minimum to install on physical hardware, so it'll require 2GB to install in a virtual machine.

- **VM Storage Types**

- **Virtual hard drives** exist as a single file on a physical hard drive.
 - Easy to replicate and transport.
- **Physical hard drives** can be attached exclusively to a virtual machine, so it is unusable by another VM or the host OS.



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Virtualization

- **Desktop Virtualization**
 - Virtual desktop infrastructure (VDI) is a technology that is used to provide virtual machines to be used as virtual desktops by remote users
 - Provides simplified centrally managed user systems
 - Can be done on-premise or in the cloud
- **Client-Side Virtualization**
 - Sandbox
 - Test development
 - Application virtualization
 - Legacy software/OS
 - Cross-platform virtualization



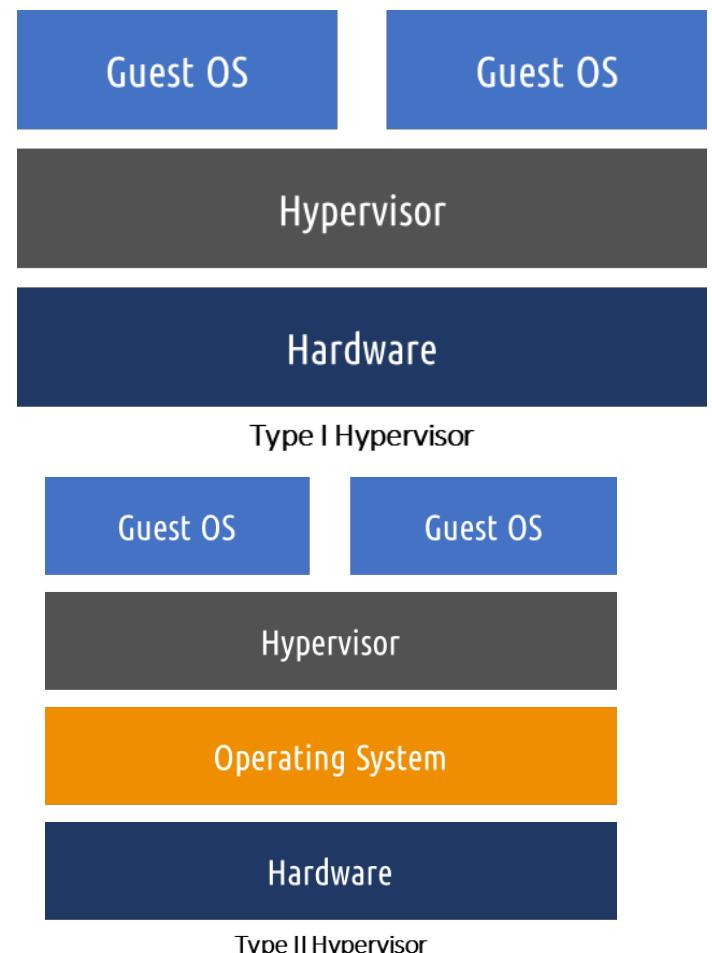
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Virtual Networking Components

- **Hypervisor:** The software that is used to create, run, and manage the VMs is the hypervisor
 - Type I hypervisors run directly on the hardware **without an operating system**
 - Prioritizes resources for the VMs
 - Also known as bare metal virtualization
 - Type II hypervisors run within an operating system
 - Share resources between the host and the VMs



Virtual Networking Components





Cloud Characteristics

- **Shared resources**

- Hardware resources can provide services to devices beyond their physical boundaries
- This provides more flexibility and scalability with resiliency

- **Metered utilization**

- The cloud is a pay-as-you-go service, you pay for what you use
- This helps optimize cost when using the cloud

- **Rapid elasticity**

- Resources can be allocated and reallocated as required to optimize resources usage and cost

- **High availability**

- A hardware failure should have little to no effect on cloud services

- **File synchronization**

- Makes files available from anywhere you can access the cloud



Cloud Deployment Models

- **Public cloud**

- A third-party hosts the equipment for anyone to make use of their service.
- Examples of public clouds include Amazon Elastic Compute Cloud (EC2), IBM's Blue Cloud, Sun Cloud, Google AppEngine, and Windows Azure Services Platform.



Cloud Deployment Models

- **Private Cloud**

- A third-party host the equipment for a single client to have exclusive use of the resources.
- Private clouds are driven by concerns around security and compliance and keeping assets within the firewall.



Cloud Deployment Models

- **Community cloud**

- A community cloud is a multi-tenant platform that allows several companies to work on the same platform, given that they have similar needs and concerns.



Cloud Deployment Models

- **Hybrid cloud**

- By using a Hybrid approach, companies can maintain control of an internally managed private cloud while relying on the public cloud as needed.



Cloud Computing Service Models

- Software as a Service
 - Software as a service vendors host the applications, making them available to users via the internet. Metered utilization
- Platform as a Service
 - Platform as a service offers developers a platform for software development and deployment over the internet, enabling them to access up-to-date tools.
- Infrastructure as a Service
 - Infrastructure as a service is used by companies that don't want to maintain their own on-premises data centers.



Cloud Computing Service Models

	SaaS Software as a Service	PaaS Platform as a Service	IaaS Infrastructure as a Service
User	Customer	Customer	Customer
Application	Provider	Customer	Customer
Operating System	Provider	Provider	Customer
Hardware	Provider	Provider	Provider
Network	Provider	Provider	Provider
Facility	Provider	Provider	Provider
Regulatory Compliance	Customer	Customer	Customer
	<ul style="list-style-type: none">The software does NOT require installation instead is accessed via a web browserThe customer only manages user access	<ul style="list-style-type: none">Customers can develop their own applications and services without the need to manage any infrastructure or operating systems	<ul style="list-style-type: none">Customers manage the operating system, the applications installed, and the access to it



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CompTIA Troubleshooting Steps

- 1. Identify the problem
 - Gather information from the user, identify user changes, and, if applicable, perform backups before making changes
 - Inquire regarding environmental or infrastructure changes
- 2. Establish a theory of probable cause (question the obvious)
 - If necessary, conduct external or internal research based on symptoms
- 3. Test the theory to determine the cause
 - Once the theory is confirmed, determine the next steps to resolve the problem
 - If the theory is not confirmed, re-establish a new theory or escalate



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CompTIA Troubleshooting Steps

- 4. Establish a plan of action to resolve the problem and implement the solution
 - Refer to the vendor's instructions for guidance
- 5. Verify full system functionality and, if applicable, implement preventive measures
- 6. Document the findings, actions, and outcomes



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Problems related to motherboards, RAM, CPU, and power

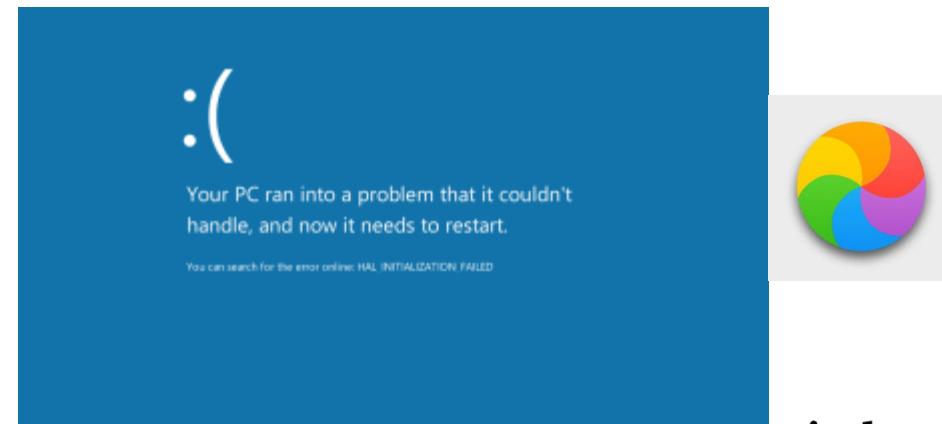
- Power-on self-test (POST) beeps
 - checks a computer's internal hardware for compatibility and connection before starting the remainder of the boot process
 - If the computer passes the POST, the computer may give a single beep
 - If the computer fails the POST, the computer may generate a beep code telling the user the source of the problem.
- Use this link to see what the beeps mean
 - https://en.wikipedia.org/wiki/Power-on_self-test



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Problems related to motherboards, RAM, CPU, and power

- Proprietary crash screens (blue screen of death [BSOD]/pinwheel)
 - Could be something with the hardware or operating system or application
 - Hardware issues could be:
 - Bad RAM or RAM going bad
 - Failing HD
 - Wrong video card drivers
 - Software
 - Operating system is corrupt
 - Application generates an error and windows doesn't know how the response





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Problems related to motherboards, RAM, CPU, and power

- **Black screen**
 - No display on the screen
 - Check the following:
 - Monitor is getting power
 - Plug in both power and video cable
 - Plug into the computer
 - Plug into the correct video port on the computer
 - Surge is turned on
 - Monitor is set to the correct display type such as HDMI



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Problems related to motherboards, RAM, CPU, and power

- **No Power**

- When you press the power button nothing happens
- Check the following:
 - You are pressing the correct power button and not the reset button
 - Computer is plugin
 - Surge is turned on
 - Surge actually works
 - Power supply switch is set to on
 - Jumpers are plugged into the motherboard correctly
 - Ensure the power supply is correctly plugged into the motherboard
 - Replace the power supply with a known working one



A+

Problems related to motherboards, RAM, CPU, and power

- **Sluggish performance**

- Computer is running slow
- Can happen for a large number of reasons including:
 - Not enough memory
 - Slow hard drive
 - Slow processor
 - Corrupt application
 - Corrupt operating system
 - Virus or malware on the system
 - Not using the correct drivers



A+

Problems related to motherboards, RAM, CPU, and power

- **Overheating**

- Computer gets too hot and shuts off or reboot
- Generally happens because of poor ventilation
- Check the following:
 - All fans in the case are working
 - Heatsink on the processor is working
 - May need to remove the processor heatsink and replace the thermal paste
 - If overclocking get liquid cooling



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Problems related to motherboards, RAM, CPU, and power

- **Burning smell**

- Something in the case is melting or caught on fire
- Shut off the computer right away and unplug from the wall
- Mostly like the power supply has burned out
- Check the following:
 - Try to smell inside the case to see it is coming from, smell the power supply
 - Look at the motherboard to see if you see any black spots



A+

Problems related to motherboards, RAM, CPU, and power

- **Intermittent shutdown**

- Computer shuts down randomly
- Can happen because of heat issues
- Can happen for a large number of reasons including:
 - Operating system is corrupt
 - Memory is failing



A+

Problems related to motherboards, RAM, CPU, and power

- **Application crashes**

- Applications are stopping or freezing randomly
- Usually can happen because of corruption of the application or the operating system
- Can happen for a large number of reasons including:
 - Operating system is corrupt
 - Application is corrupt
 - Memory is failing
 - Event viewer



A+

Problems related to motherboards, RAM, CPU, and power

- **Grinding noise**

- Only fans or hard drives make noise in a computer case
- Could be a fan having issues
- Could be hard drive failing



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Problems related to motherboards, RAM, CPU, and power

- **Capacitor swelling**
 - Failing capacitor
 - Generally will have to replace the motherboard





A+

Problems related to motherboards, RAM, CPU, and power

- **Inaccurate system date/time**
 - Generally the BIOS battery is dead and will need to be replaced.



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Problems with storage drives and RAID arrays.

- **Light-emitting diode (LED) status indicators**
 - Use to help you diagnose issues
 - Can tell you if drives are functioning
 - On most RAID systems the lights should be a blinking green, if it is amber it may be a dead drive.



A+

Problems with storage drives and RAID arrays.

- **Grinding Noises and Clicking Sounds**

- Drive is either dead or dying
- Backup data right away if the drive can still be used



A+

Problems with storage drives and RAID arrays.

- **Bootable device not found**

- System could be set to boot to the wrong drive in the BIOS
- Drive is dead
- Operating system could be corrupt



A+

Problems with storage drives and RAID arrays.

- **Data loss/corruption**

- Restore from backup if data is loss or corrupt



A+

Problems with storage drives and RAID arrays.

- **RAID failure**

- Depending on the RAID you may need to:
 - Replace a failed drive and let the RAID rebuild (RAID 1,5,10)
 - Replace the failed drive and restore all data from backup (RAID 0)



A+

Problems with storage drives and RAID arrays.

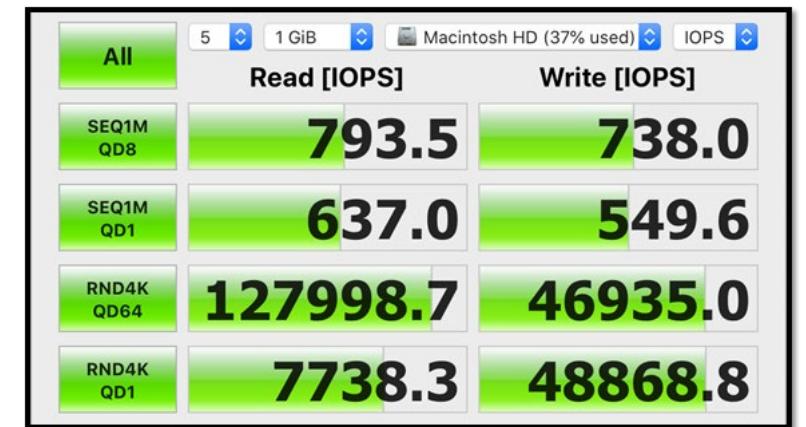
- **Self-monitoring, Analysis, and Reporting Technology (S.M.A.R.T.) failure**
 - monitoring system included in computer hard disk drives (HDDs) and solid-state drives (SSDs)
 - Function is to detect and report various indicators of drive reliability with the intent of anticipating imminent hardware failures
 - Software that could tell you of imminent drive failure



A+

Problems with storage drives and RAID arrays.

- **Extended read/write times and Input/output operations per second (IOPS)**
 - Looks at how fast drives are working
 - Can describe





A+

Problems with storage drives and RAID arrays.

- **Missing drives in OS**

- BIOS not set to the correct drive
- Drive is dead
- OS is corrupt



A+

Video, Projector, and Display Issues.

- **Incorrect data source**
 - Check the cable is plugged into the correct port
 - Monitor is set to the correct source



A+

Video, Projector, and Display Issues.

- **Physical cabling issues**

- If you think it's a bad cable, replace with a known working cable
- Discard bad cables



A+

Video, Projector, and Display Issues.

- **Burned-out bulb**

- Project bulbs last only a certain amount of hours.
- Replace all burned bulb



A+

Video, Projector, and Display Issues.

- **Fuzzy image**
 - Check the cables
 - Ensure the computer is set the correct resolution (native resolution)



A+

Video, Projector, and Display Issues.

- **Display burn-in**

- Able to see the last image on the monitor.
- May happen with an image is left on display for a long period of time
- Try leaving a display of white image for a long period of time



A+

Video, Projector, and Display Issues.

- **Dead pixels**
 - Black dot on the screen
 - After a certain number of dead pixels the manufacturer may replace the display if under warranty



A+

Video, Projector, and Display Issues.

- **Flashing screen**
 - Check the cable is plugged into the correct port



Video, Projector, and Display Issues.

- **Incorrect color display**
 - Adjust color setting on monitor, On screen display.



A+

Video, Projector, and Display Issues.

- **Audio issues**

- Check the cable is plugged into the correct port
- Check if the volume is turned up
- Check if the speakers are plugged in
- Check if the speakers have power



A+

Video, Projector, and Display Issues.

- **Dim image**

- Check the brightness setting is up on the monitor
- Might have to replace the monitor if the backlight is dead



A+

Video, Projector, and Display Issues.

- **Intermittent projector shutdown**

- Could be a heating issue
- Could be set to ECO mode and shuts off when the image is not moving for a long time



A+

Common issues with mobile devices.

- **Poor battery health**

- Battery is dying, replace the battery if possible
- Have too many application open
- Running the phone in high performance mode



A+

Common issues with mobile devices.

- **Swollen battery**
 - Shut down right away
 - Replace the battery if possible



A+

Common issues with mobile devices.

- **Broken screen**
 - Replace the screen if possible
 - For laptop ensure the wireless antennae are set back correctly



A+

Common issues with mobile devices.

- **Improper charging**

- Charging port is damage or battery is not holding the charge
- Fix the charging port if possible or replace the battery
- Check the cable to ensure you are using the correct cable



A+

Common issues with mobile devices.

- **Poor/no connectivity**

- Ensure you have joined the correct wireless network
- Ensure you are within a short distance of the access point
- Ensure the area has enough cell towers



A+

Common issues with mobile devices.

- **Liquid damage**

- Depending on the liquid. It may or may not dry
- Don't use the phone for a day or two
- Let it dry



A+

Common issues with mobile devices.

- **Overheating**

- Have too many application open
- Running the phone in high performance mode
- Have it next to heater



A+

Common issues with mobile devices.

- **Digitizer issues**

- Touch screen not working
- Replace the digitizer if possible or the entire screen unit



A+

Common issues with mobile devices.

- **Physically damaged ports**
 - Might be possible to remove and solder on a new port.
 - Might have to replace the motherboard



A+

Common issues with mobile devices.

- **Malware**

- Run antimalware on the device
- Factory reset the device



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Common issues with mobile devices.

- **Cursor drift/touch calibration**
 - Will need to recalibrate the device in its software



Printer issues.

- **Lines down the printed pages**
 - Replace the drum on laser
 - Inspect the print heads on inject



A+

Printer issues.

- **Garbled print**
 - Usually using the wrong driver language
 - Inspect the print heads on inject



A+

Printer issues.

- **Toner not fusing to paper**
 - Issue with fusing assembly/roller
 - Replace the fusing assembly /roller



A+

Printer issues.

- **Paper jams**

- Check all rollers and replace wormed ones
- Use a Maintenance kits
- Ensure to use the right type of paper, not all printer can handle all thinness of paper



A+

Printer issues.

- **Faded print**
 - Replace ink or toner



A+

Printer issues.

- **Incorrect paper size**

- Check the printer to see what size it supports
- Ensure application knows what size paper it is printing on
- Ensure the trays have the right paper size



A+

Printer issues.

- **Paper not feeding or Multipage misfeed**
 - Replace pickup roller
 - Check paper wight



A+

Printer issues.

- **Multiple prints pending in queue**
 - Print spooler service is jam and needs to restart
 - Either restart the PC or the service



A+

Printer issues.

- **Double/echo images on the print**
 - Ghosting on page
 - Drum is not getting clean after a print cycle
 - Replace the toner cartridge generally fixes this



A+

Printer issues.

- **Incorrect color settings**

- Check if the correct ink is used
 - 3rd party ink may give a slightly different color
- Make sure ink cartridge is in the correct slot, blue is in blue
- Check application
- Calibrate the printer



A+

Printer issues.

- **Finishing issues**
 - Staple jams
 - Inspect the stapling mechanism
 - Hole punch
 - Inspect the Hole punch mechanism



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Printer issues.

- **Incorrect page orientation**
 - Application or printer is set to the incorrect orientation



A+

Problems with networks

- **Intermittent wireless connectivity**
 - Reboot the phone
 - Reboot the access point
 - Check if you are within the correct area



A+

Problems with networks

- **Slow network speeds**
 - Make sure you are within the correct distance
 - Application running



A+

Problems with networks

- **Limited connectivity**

- They might be able to access the lan but not internet
- Check configuration of IP setting



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Problems with networks

- **Jitter**

- High jitter is when data comes at unexpected rates or inconstant
- Low is the opposite
- Ensure the company has QoS setup



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Problems with networks

- **Poor Voice over Internet Protocol (VoIP) quality / Jitter**
 - High jitter is when data comes at unexpected rates or inconstant
 - Low is the opposite
 - Ensure the company has QoS setup
 - Low bandwidth
 - Drop packets



A+

Problems with networks

- **Port flapping**
 - Interface is going up and down
 - Physical problem like a pin is bent on the connector or cable
 - Replace the cable if needed



A+

Problems with networks

- **High latency**
 - Slow speeds
 - Might affect VOIP calls
 - Implement QoS



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Problems with networks

- **External interference**
 - If the onboard NIC card is not working replace with an external USB NIC.