# Networking and Internet Services

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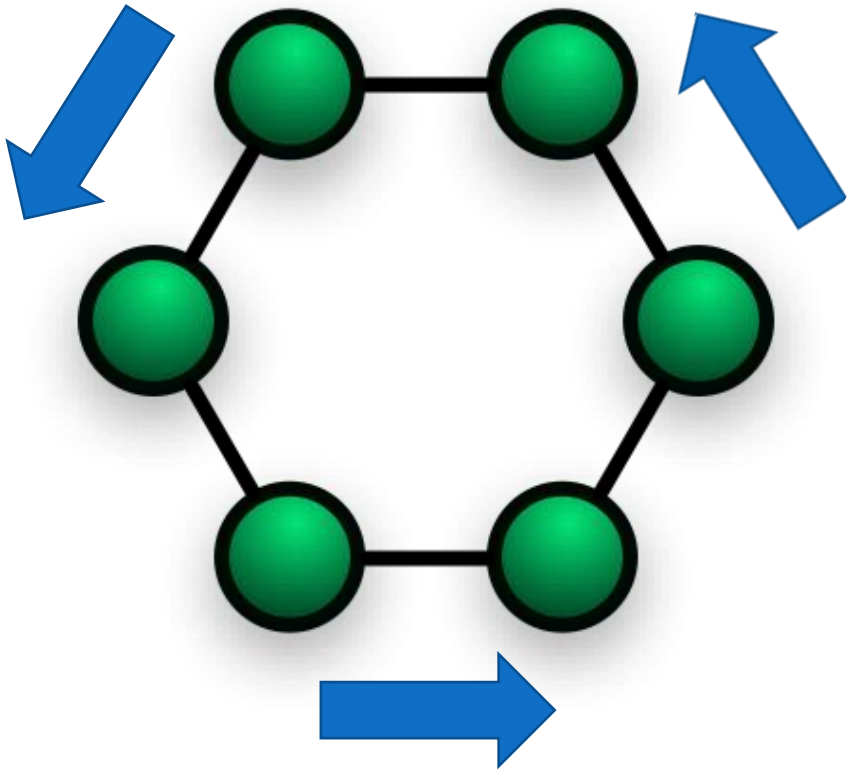
# Topologies

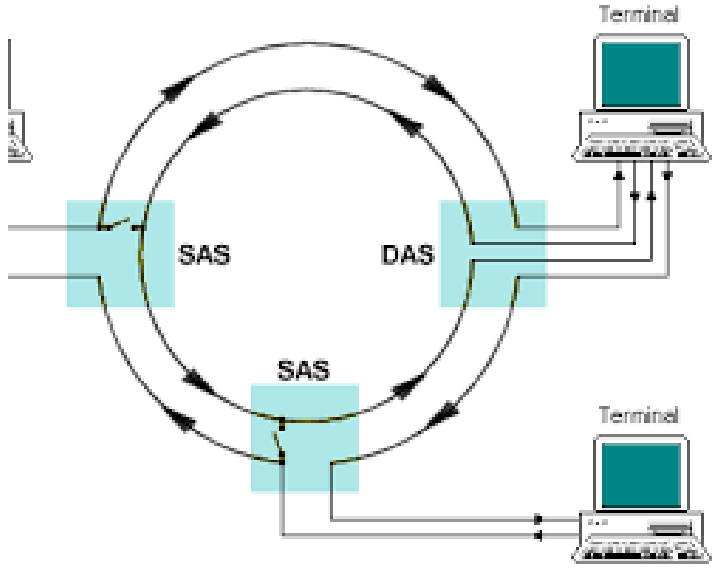
- Bus and Ring
- Star
- HyBrid
- Mesh
- Point to Multipoint
- Point to Point

# Ring Topology

- Data flows around in a unidirectional way
- No termination necessary
- Flaw:  Break in the physical network breaks the entire network.



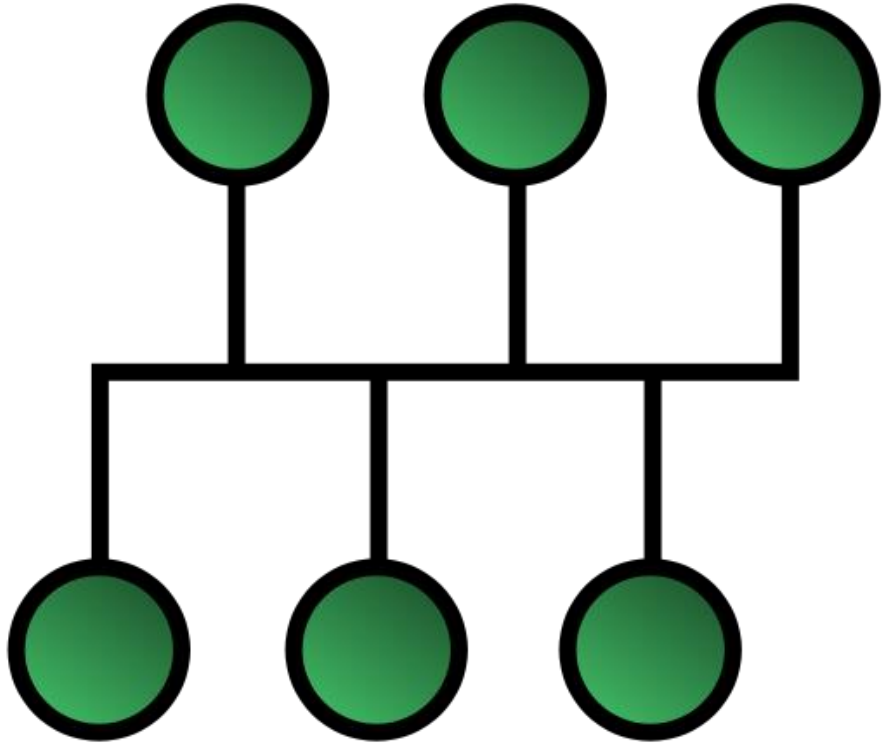
# Fiber Distributed Data Interface (FDDI)




- FDDI is a high-speed network technology that uses a ring topology. FDDI networks are typically used in enterprise networks and data centers.

# Bus Topology

- Ends of the bus are terminated
- Missing or defective termination causes unexpected results, and can bring the network down.
- Flaw:  Break in the physical network breaks the entire network.



# Bus Topology

Terminator

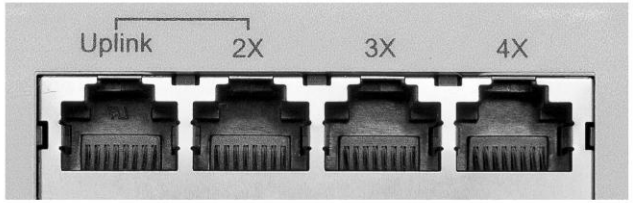
T-Connector

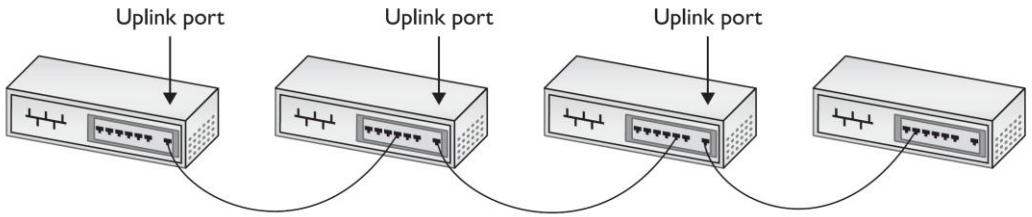
Coaxial Cable

# Devices:

- Coupler:  F to F adapter allowing you to make a network wire longer.
- Hub: A device that splits signals from 1:n signals.
  - Hubs can be chained via an "uplink" port.


**Figure 4-19**
Typical uplink port



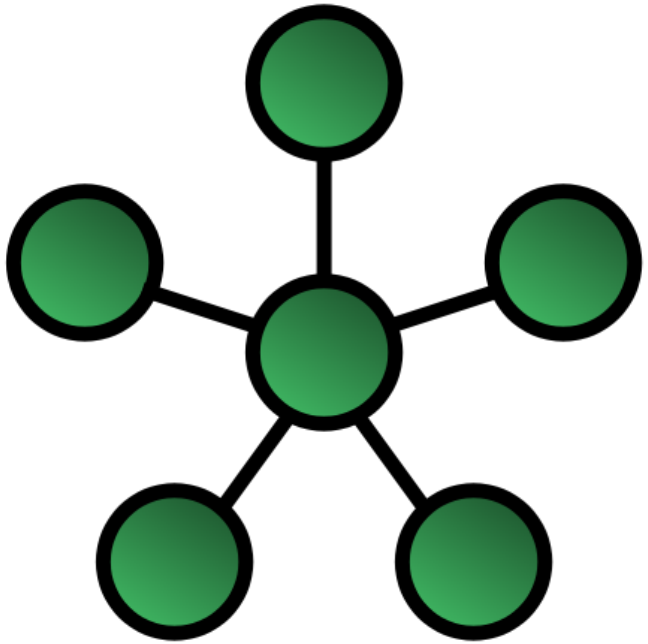



# Bridge

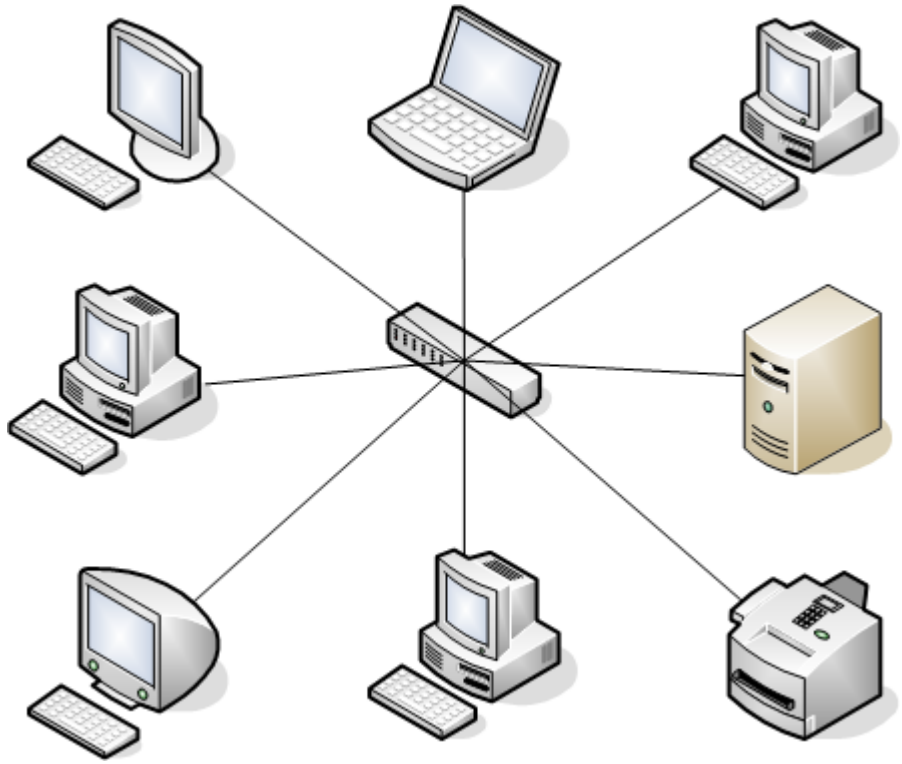
- Connects two networks together
- Like a hub but more intelligent (routes based on rules)
- A bridge isn't really programmable, it learns based on network traffic.
- It forwards and filters only what's necessary (A hub forwards everything).

# Star Topology

- Fault tolerant
- Requires a controller box
- More expensive to implement than BUS/RING



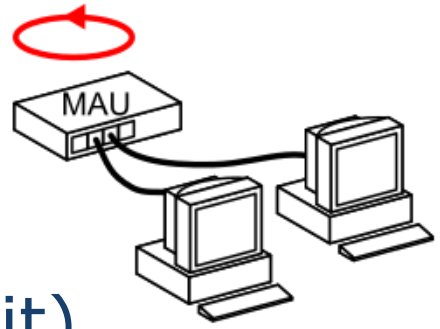
# Star



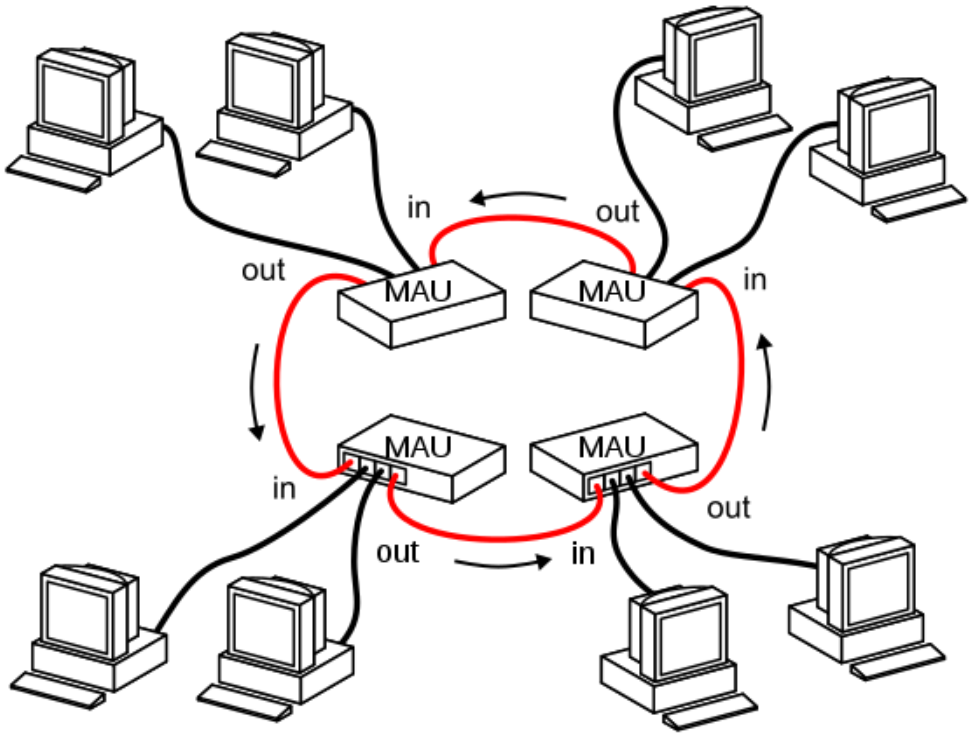
# Hybrid Topologies

- Token Ring
- Combination of
  - Ring
  - Star

MAU(Media Access Unit)



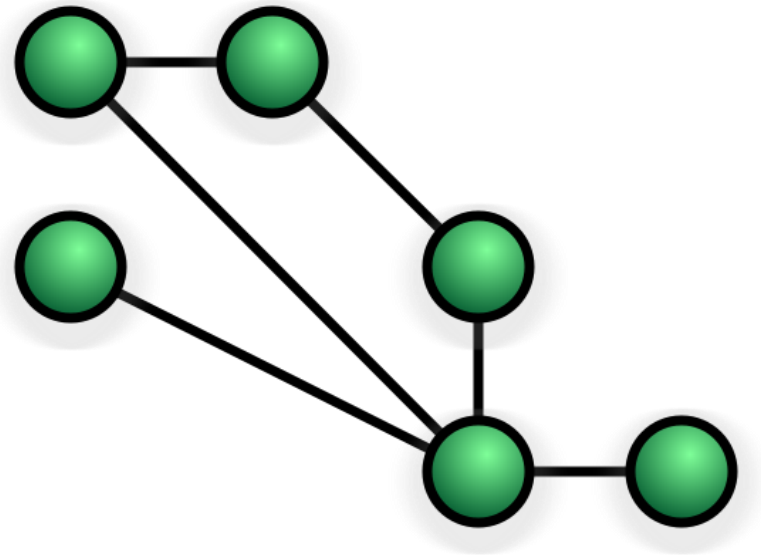

a)




b)

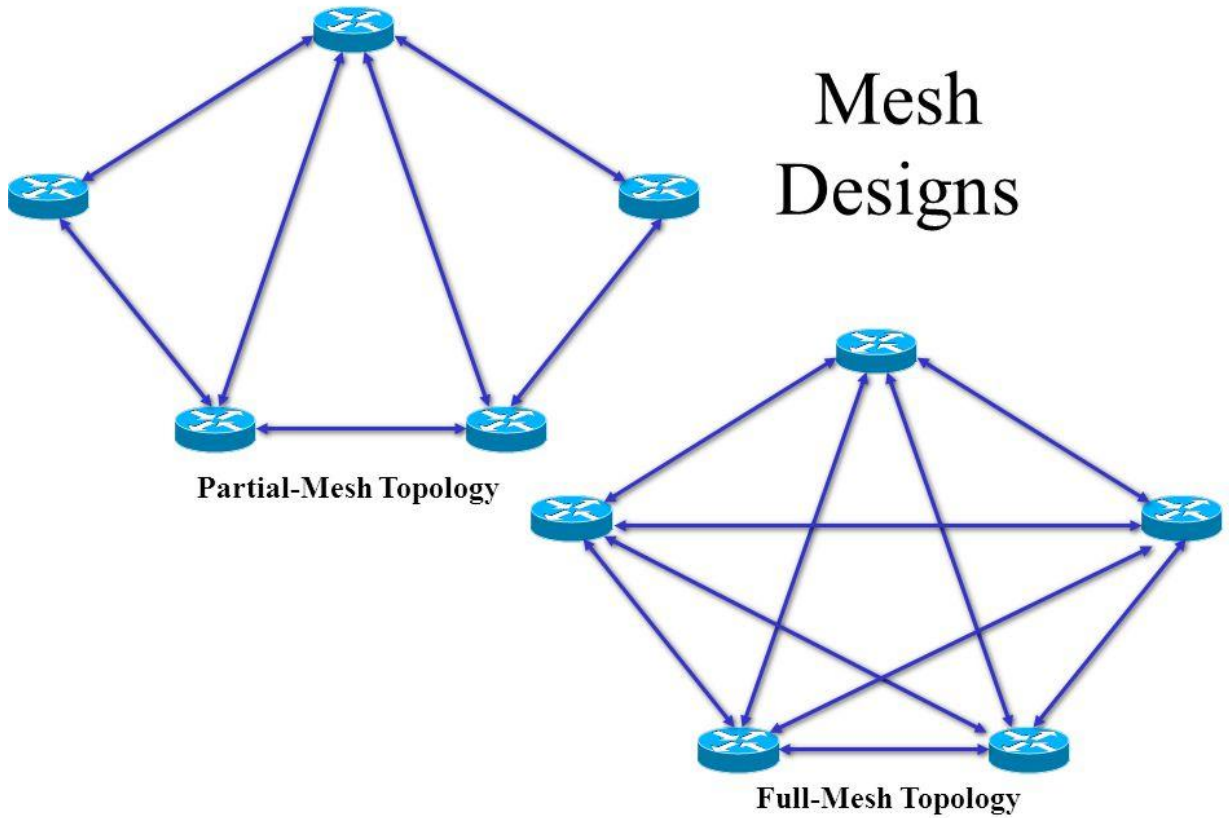
# Mesh Topology

- Computer-to-computer connections.
- Bidirectional (alternate routes).
- Message can pass over another computer to get to destination
- Used mainly in Wireless network technology



# Full vs. Partial Mesh

- Partial
  - At least 2 computers have redundant connections.
- Full
  - All computers interconnected.

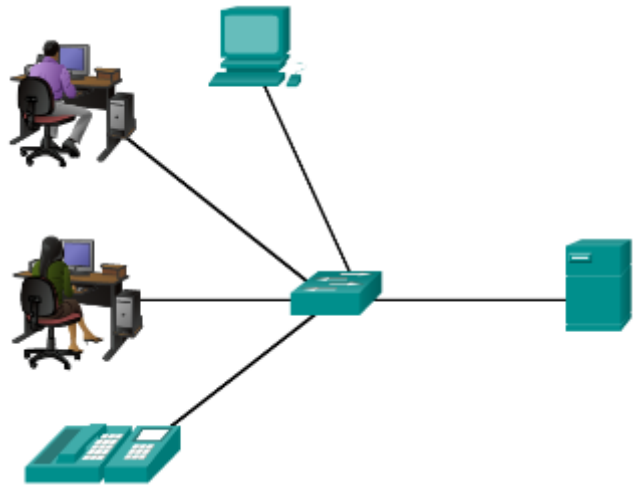


# Other types

- Point to Point
  - Like a telephone call
  - Two computers connected together.
  - Can be over USB/Network

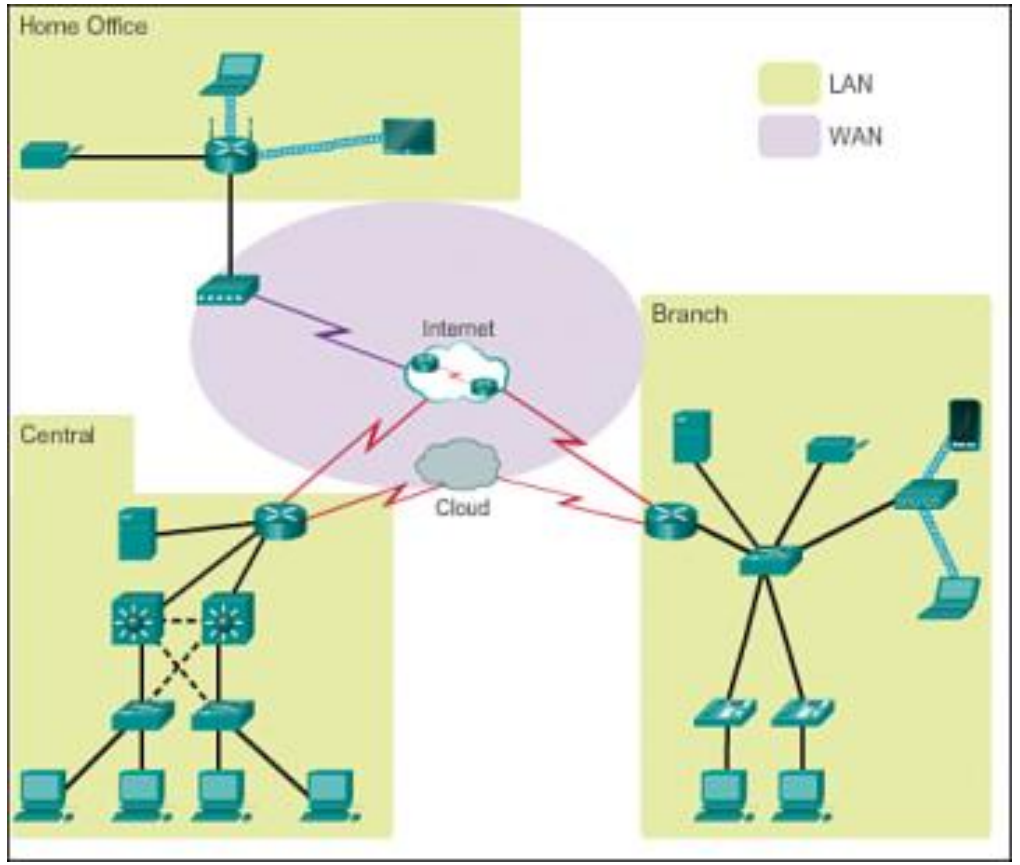
# Local Area Networks (LANs)

- Local Area Networks
  - Interconnects end devices in small geographical area such as a home, school, office building, or campus
  - Administrated by a single organization
  - Provides high speed bandwidth to internal devices



# Wide Area Networks (WANs)

- Wide Area Networks
  - Interconnect LANs over wide geographical areas such as **between cities**, states, provinces, **countries**, or continents
  - Administrated by multiple service providers
  - Speed links between LANs are generally slower

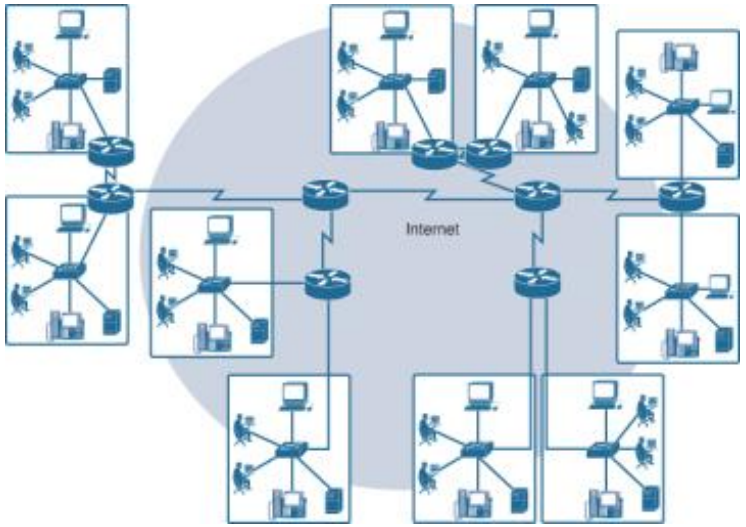


# Broadband vs. Baseband Network

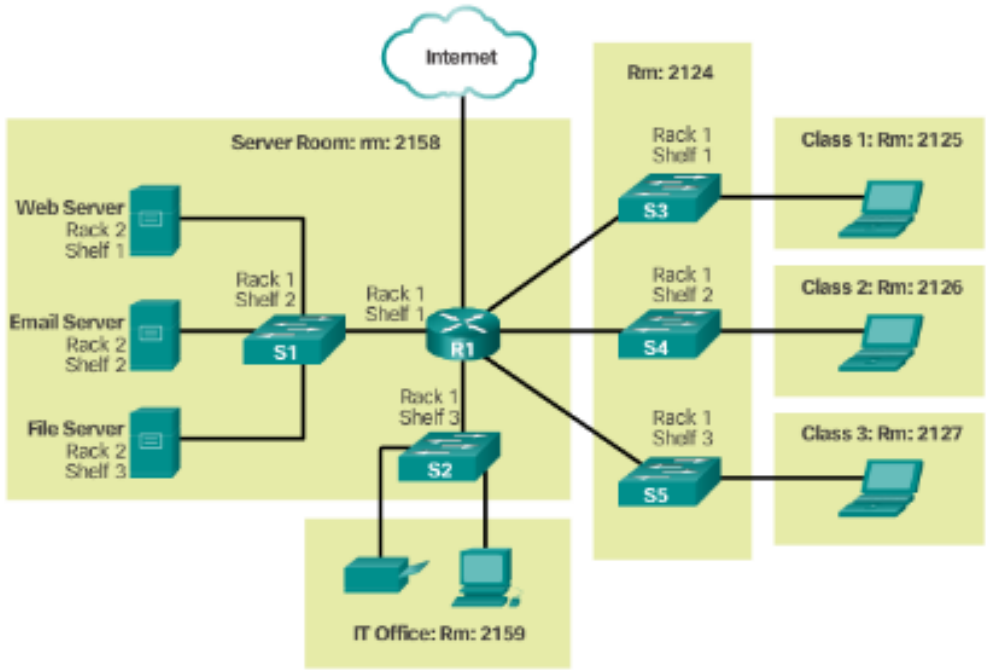
- To understand the basic differences between both technologies, consider the **baseband** as a **railway** track (only one train can go on a railway track) and the **broadband** as a **highway**.
- In the **baseband** transmission, **only one data signal** can be transmitted at a time.
- Unlike a railway track on a highway, multiple vehicles can go simultaneously. For example, on a 3-lane highway, 3 vehicles can go at the same time. Similar to a highway, in **broadband** transmission, **multiple data signals** can be transmitted at the same time.

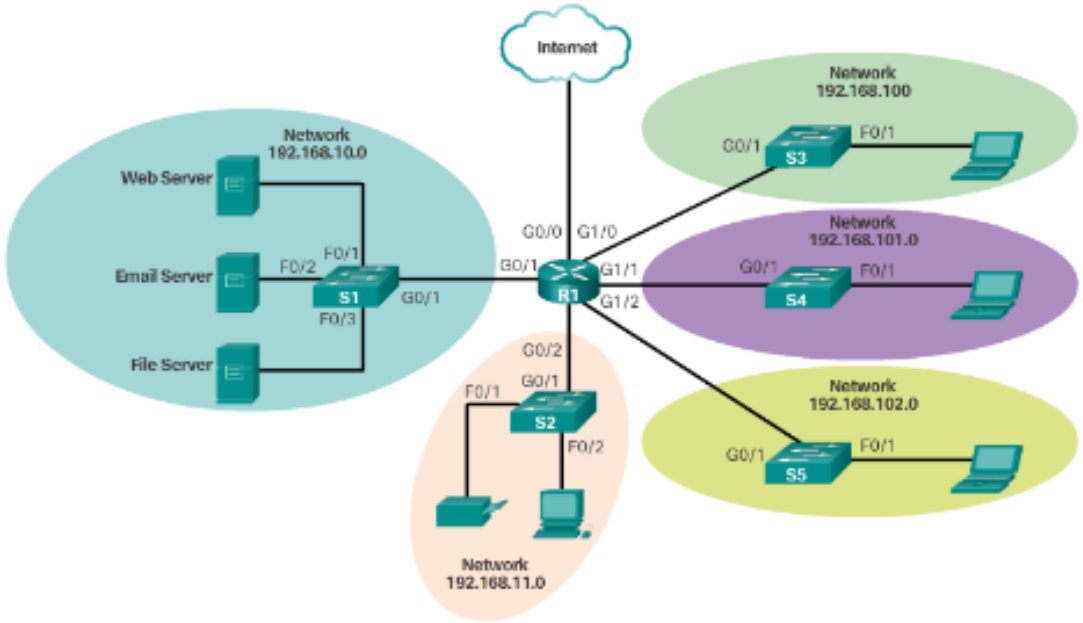
# The Internet

- The Internet
  - Worldwide collection of interconnected LANs and WANs
  - Not owned by any individual or group



# Physical vs Logical Topology



# Broadband vs. Baseband

- **Baseband:**
  - Digital signals are used
  - Frequency Division Multiplexing(**FDM**) is not possible
  - Baseband is **bi-directional** transmission
  - Short-distance signal travelling

  The entire bandwidth of the cable is consumed by a single signal in a baseband transmission.

  **Broadband:**
  - Analog signals are used
  - Transmission of data is unidirectional
  - Signal travelling distance is long
  - Frequency Division Multiplexing(**FDM**) is possible
  - The signals are sent on multiple frequencies and allow all the multiple signals to be sent simultaneously in broadband transmission.

# More details on (Broad|Base)band

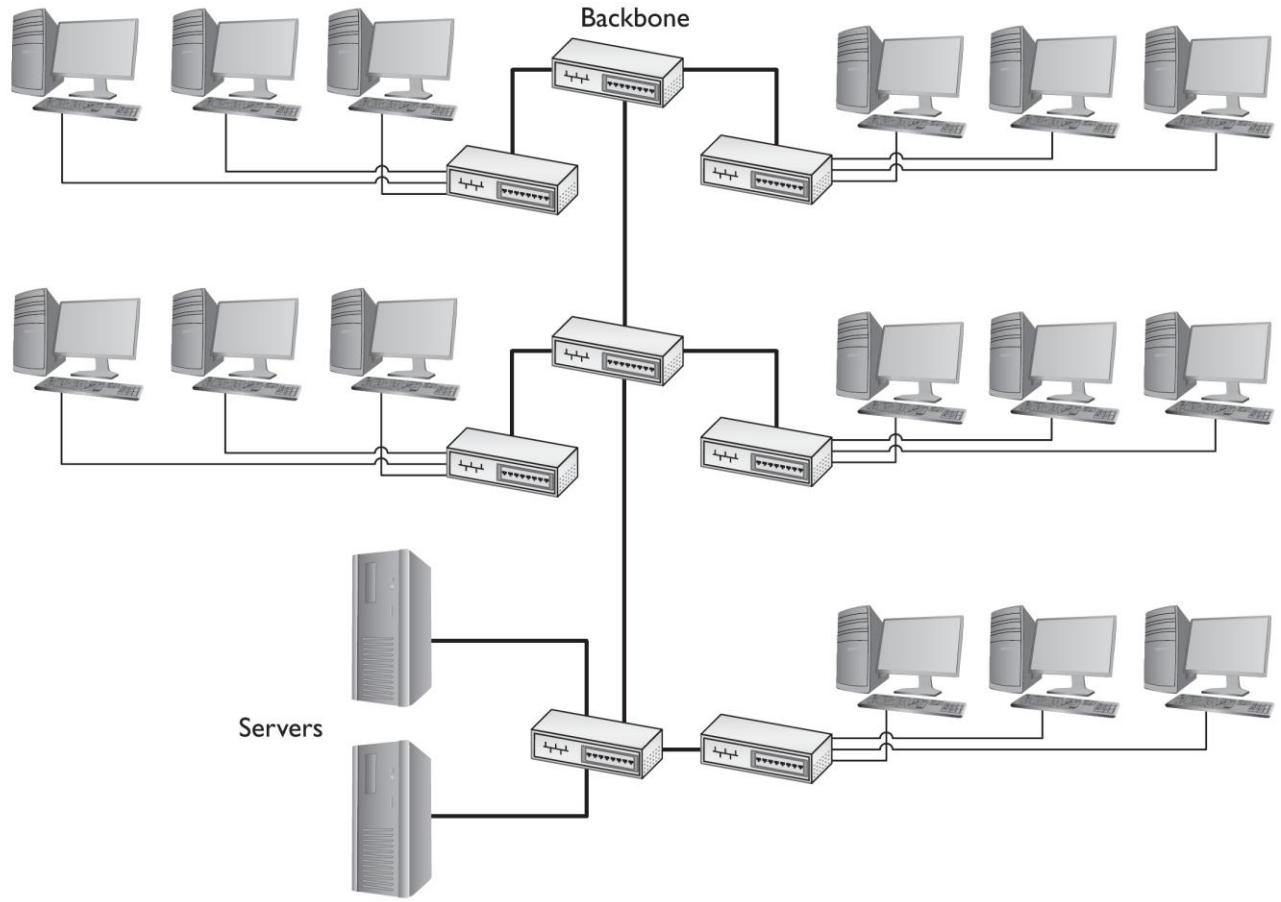
https://www.computernetworkingnotes.com/networking-tutorials/differences-between-baseband-and-broadband-explained.html

# Give examples of Broadband vs. Baseband?

- Broadband
  - ISP’s signal to your street
  - Wifi signal is **not typically** considered broadband, but it kind of is in a way.
- Baseband
  - An ethernet cable
  - Sharing TV and Internet on a Cable (in the home)

# Backbones (of the Network)

- A backbone connects all the different physical servers all together.
- Usually just a series of switches.
- It’s better to make these REDUNDANT.



# Backbone Definition

- It's the series of high speed switches that form the structure of the network before it gets to it's destination.
- Usually hidden away in server rooms and pipes in the walls.

- Backbones should be considerably **faster** than the regular office.

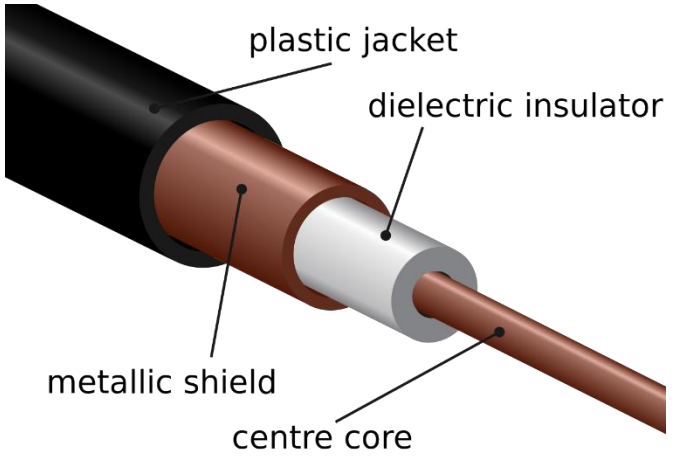
- Often in large companies backbones are fiber-based and your local baseband is twisted pair.

- Backbone can be baseband or broadband, but usually it’s **BASEBAND**.

# Cabling

# COAX cable

- Made of copper wire.
- High electromagnetic interference (EMI) shielding
- Used with older bus and star networks using BNC connectors
- Used by cable providers now to deliver internet and cable to homes.  (See photo right)
- Uses an F connector (right)
- Radio Grade of **RG**-6 used today
- Wire rated at 75 ohms impedance
- Can be split




# Impedance, Capacitance and Inductance

- Impedance is a measure of how much a circuit opposes the flow of current. It is similar to resistance, but it also takes into account the effects of capacitance and inductance. Impedance is measured in ohms.

- Capacitance is the ability of a material or device to store electric charge. It is measured by the charge in response to a difference in electric potential.

- Inductance is the property of a conductor to oppose a change in the electric current flowing through it. The flow of electric current creates a magnetic field around the conductor. The field strength depends on the magnitude of the current and follows any changes in the current.

- Inductance is measured by the size of the electromotive force, or voltage, induced in it, compared with the rate of change of the electric current that produces the voltage.

# Coax Cable

- Can easily be split.
- Can be extended with adapters.


# Twisted Pair

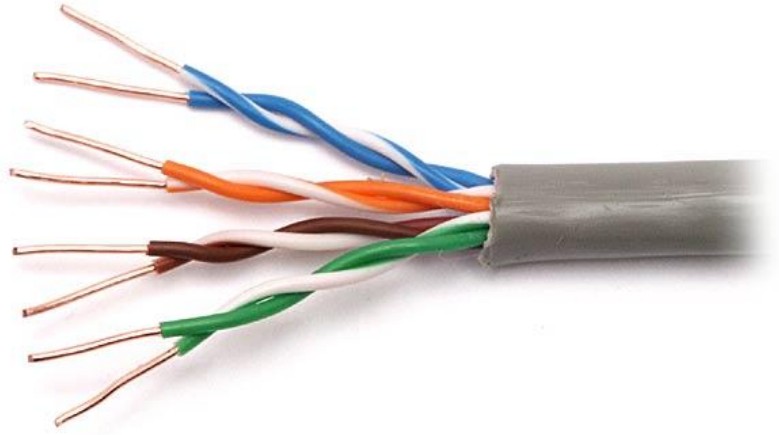
- The most common type of cabling used in networks consists of twisted pairs of cables bundled together into a common jacket.
- Twisted-pair cabling for networks is composed of multiple pairs of wires twisted around each other at specific intervals.
- The twists reduce interference, called crosstalk: the more twists, the less crosstalk. Networks use two types of twisted-pair cabling: shielded twisted pair and unshielded twisted pair.

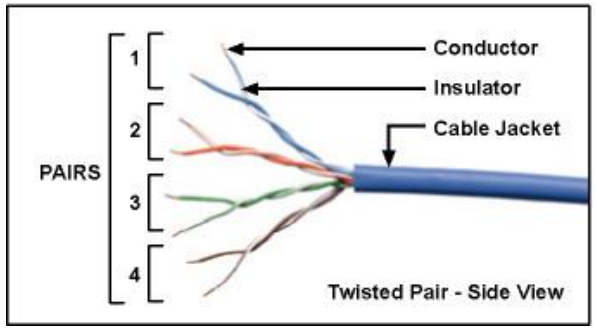
# Crosstalk

- Crosstalk is a phenomenon that occurs when a signal **transmitted on one cable interferes** with a signal transmitted **on another cable** in close proximity. Crosstalk is caused by electromagnetic interference between unshielded twisted pairs (UTP). It can occur when wires run too closely together.

# Twisted Pair

- Types:
  - Shielded
  - Unshielded
  - Solid (For permanent installations)
  - Stranded (For patch cables)
- Rated in MHz





# Hertz

- Hertz (Hz) is the unit of measurement for frequency. **One hertz is equal to one cycle per second**.
- Frequency is the number of times an event occurs in a given length of time. For example, a frequency measured at 20 Hz is travelling at 20 cycles (or waves) per second.
- Hertz is used to measure the frequency of vibrations and waves, such as sound waves and electromagnetic waves. It is named after German physicist Heinrich Hertz (1857-1894).
- The hertz is a derived SI unit. In base SI units, one hertz is equal to one per second (1/s). One thousand hertz is referred to as a kilohertz (kHz), 1 million hertz as a megahertz (MHz), and 1 billion hertz as a gigahertz (GHz).

# Twisted Pair Stats

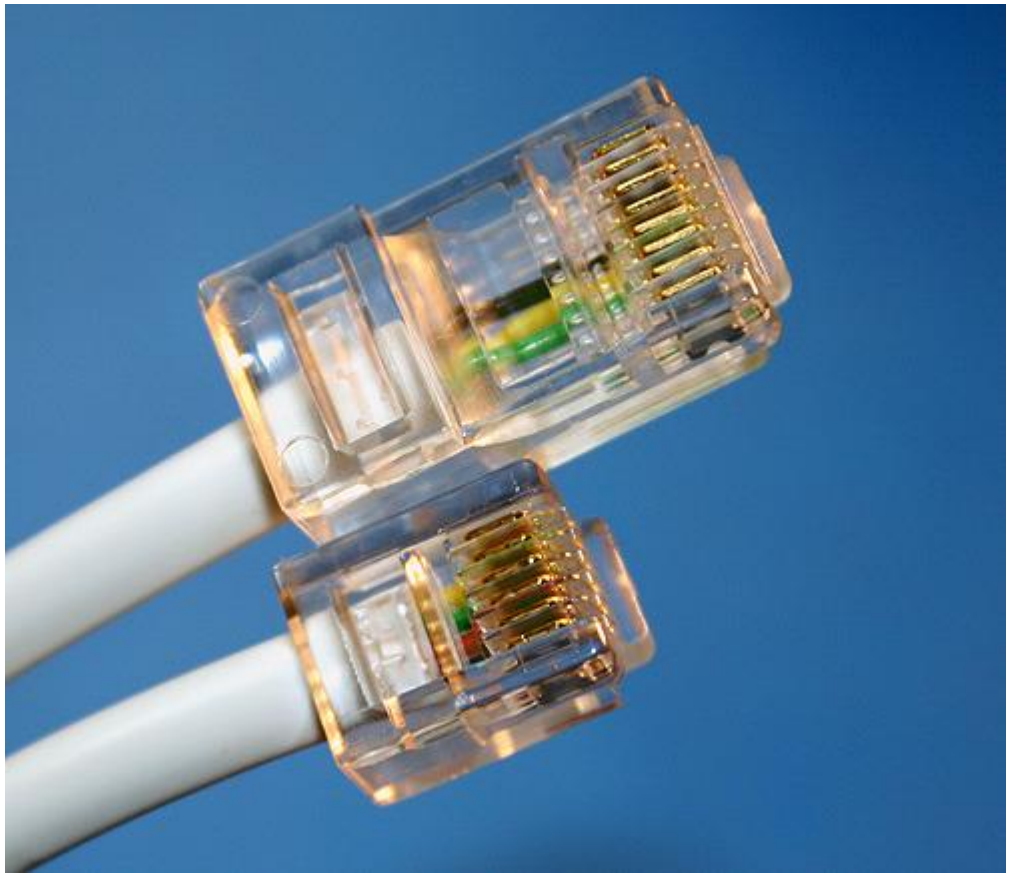
| CAT Rating | Max. Frequency | Max Bandwidth | Status with TIA/EIA |
|---|---|---|---|
| CAT 1 | <1 MHz | Analog Phone Lines | |
| CAT 2 | 4 MHz | 4 Mbps | |
| CAT 3 | 16 MHz | 16 Mbps | Recognized |
| CAT 4 | 20 MHz | 20 Mbps | |
| CAT 5 | 100 MHz | 100 Mbps | |
| CAT 5e | 100 MHz | 1000 Mbps | Recognized |
| CAT 6 | 250 MHz | 10000 Mbps | Recognized |
| CAT 6a | 500 MHz | 10000 Mbps | Recognized |

# Clock Cycles

- Generally, each Hertz (cycle per second) translates into one bit of data per second.
- Therefore 10Mhz = 10Mbps
- Faster speeds like 1000Mbps (Cat 5e) can go through a 100Mhz connection due to compression techniques.

# Connectors

- Telephone = RJ11
- Network cable = RJ45



# Fiber-Optic

- Not subject to electromagnetic interference (EMI)
- Very fast
- Using LED's = MMF (Multimode Fiber)
  - Slightly cheaper than SMF
- Using laser = SMF (Single Mode Fiber)
  - SMF is more effective over long distances

# IEEE Certifications

| IEEE Specialization | Architecture |
|---|---|
| 802.1 | Higher Layer LAN Protocols (Bridging) |
| 802.2 | LLC |
| 802.3 | Ethernet |
| 802.5 | Token Ring |
| 802.11 | Wireless LAN |
| 802.15 | Wireless PAN (Wireless Personal Area Network) |
| 802.16 | WIMAX (Worldwide Interoperability for Microwave Access) |
| 802.22 | Wireless Regional Area Network |

# 100BaseT

- Called "Fast Ethernet"
- Uses 2 pairs of wires (from 4 total)
- Auto-sensing
  - The computer supports 10/100/1000
  - Switch supports 10/100
  - Connection established at 10/100
  - Almost all modern NICs are auto-sensing
- There is no way to visually see the speed of a NIC.
  - By software
  - By model#

# 100BaseT Specs

- Uses 4 pairs of wires (from 4 total).

**100BaseTX (100BaseT) Summary**

- **Speed** 100 Mbps
- **Signal type** Baseband
- **Distance** 100 meters between the hub/switch and the node
- **Node limit** No more than 1024 nodes per hub/switch
- **Topology** Star-bus topology: physical star, logical bus
- **Cable type** CAT 5 or better UTP or STP cabling with RJ-45 connectors

# 100BaseFX

- Fiber-Optic equivalent of 100BaseT

**100BaseFX Summary**

- **Speed** 100 Mbps
- **Signal type** Baseband
- **Distance** Two kilometers between the hub/switch and the node
- **Node limit** No more than 1024 nodes per hub/switch
- **Topology** Star-bus topology: physical star, logical bus
- **Cable type** Multimode fiber-optic cabling with ST or SC connectors

# Full Duplex and Half Duplex?

- Half
  - Can send data or receive data, but one at a time.
- Full
  - Can send and receive data both at the same time
  - Doubles bandwidth
- Duplex can be set in the internet connection of your NIC controller (Windows).
- Questions:
  - What is a phone call?
  - What is a modern home Internet connection?

# Gigabit Ethernet (1000BaseT)

- IEEE *802.3ab* standard
- Called *1000BaseT*
- *Recall the types of cable (Cat 5e Cat 6)*

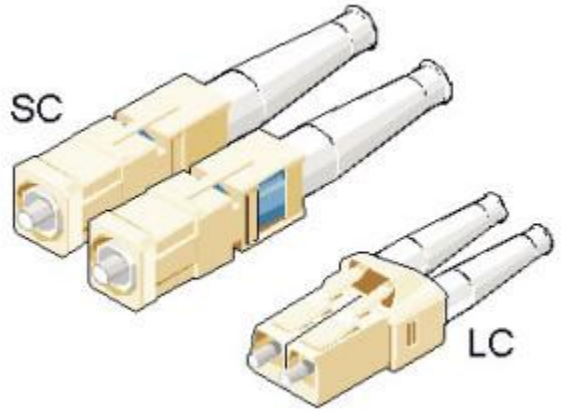
# Some Gigabit standards to Remember

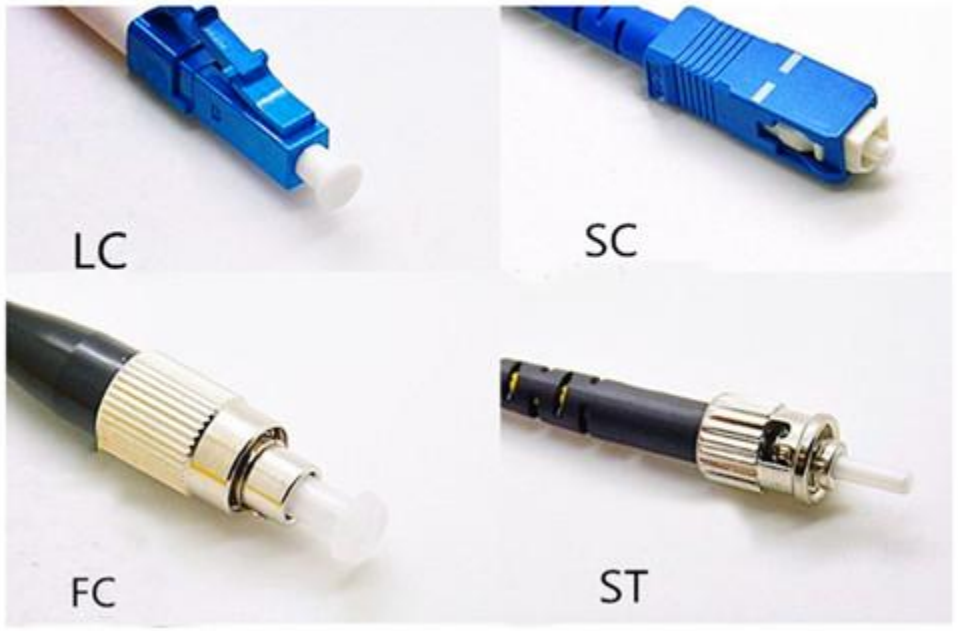
- 1000BaseCX
  - Twinaxial cable
  - Only 25 meters
  - Not common
- 1000BaseSX
  - Multimode
  - 220-500 meters
  - LC connector

- 1000BaseLX
  - Long distance Gigabit
  - Single Mode
  - 5 Kilometer range
  - With repeaters – 70 Kilometers

# Connector Types

- Connector Types:
  - ST: Straight Tip
  - SC: Square Connector
  - FC: Ferrule Connector
  - LC: Lucent Connector



# ST

- ST stands for "**straight tip**" and is a type of fiber-optic connector. ST connectors are used in fiber-optic cables and use a bayonet-style plug and socket. They have a 2.5mm diameter ferrule and a bayonet twist locking mechanism.
- ST connectors were developed by AT&T and were popular in the 1980s and 1990s. They are now the de facto standard for commercial wiring.
- ST connectors can be used with both single-mode and multimode fiber-optic cabling. They are used in data centers, short to medium range network links, and military and security applications.
- ST connectors can be mixed and matched with FC, SC, FDDI, and ESON connectors using a hybrid adaptor.

# SC

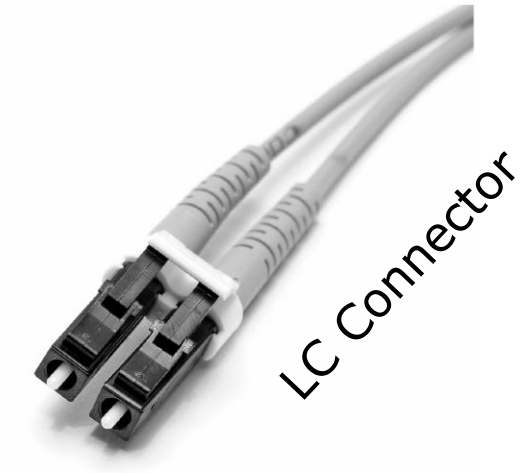
- SC stands for "**Square Connector**" or "Subscriber Connector". It's the most common type of fiber optic connector used today. SC connectors are used to connect fiber-optic cabling to networking devices. They are often used in datacoms and telecom applications, such as point-to-point and passive optical networking. SC connectors are popular because they are low-cost, durable, and easy to install. They use a push-pull design with a locking tab to secure the cable. The name "Square Connector" comes from the shape of the connector body, which is actually rectangular. SC connectors are also known as Standard Connectors or Subscriber Connectors.

# FC

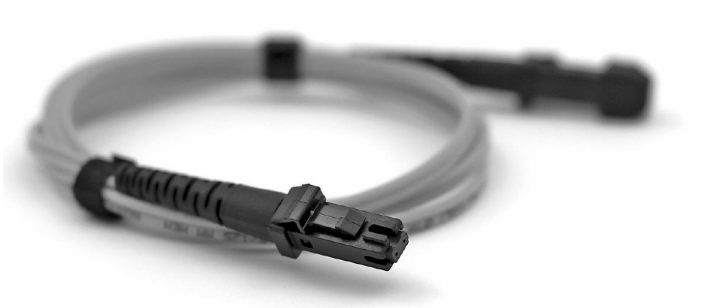
- The FC fiber connector stands for "**Ferrule Connector**" or "Fiber Channel". The FC connector was originally called a "Field Assembly Connector" by its inventors. It was developed by NEC (Nippon Electric Co.) for use in high-vibration environments.

- The FC connector has a 2.5 mm ferrule and a threaded metal coupling nut. It was the first optical fiber connector to use a ceramic ferrule. The FC connector has a round screw-type fitment made from nickel-plated or stainless steel.

- New type of connector called Small Form Factor (SFF) fiber connector became more common.
- LC and MT-R are the most common.




MT-R Connector



# LC Connector

- **LC** stands for **Lucent Connector**, a type of fibre optic connector. It was developed by **Lucent Technologies** in the 1990s for telecommunication applications.

- LC is one of the **smallest fibre optic connectors** and is half the size of the most commonly used Square Connector (SC). LC connectors are also known as "little connectors"

# MT-RJ Connector

- **MT-RJ** stands for **Mechanical Transfer Registered Jack**. MT-RJ fibre connectors are designed to support high-density connections. They are **similar in design to the standard RJ45** connector used in Ethernet.

- MT-RJ connectors are known for their **compact size** and **high performance**

# Gigabit Ethernet Summary

| Standard | Cabling | Cable Details | Connectors | Length |
|---|---|---|---|---|
| 1000BaseCX | Copper | Twinax | Twinax | 25 m |
| 1000BaseSX | Multimode fiber | 850 nm | Variable, commonly LC | 220–500 m |
| 1000BaseLX | Single-mode fiber | 1300 nm | Variable, commonly LC and SC | 5 km |
| 1000BaseT | CAT 5e/6 UTP | Four-pair/full-duplex | RJ-45 | 100 m |

**Table 5-1** Gigabit Ethernet Summary

# 10Gbe Connections

- Can use alternate transmission format called SONET
- Standard Naming convention
- 10G Base{x|y}
- X = S/L  (Short Long)
- Y = R/W (R-Lan / W-SONET-Wan)

| Standard | Fiber Type | Wavelength | Physical Layer Signaling | Maximum Signal Length |
|---|---|---|---|---|
| 10GBaseSR | Multimode | 850 nm | LAN | 26–300 m |
| 10GBaseSW | Multimode | 850 nm | SONET/WAN | 26–300 m |

| Standard | Fiber Type | Wavelength | Physical Layer Signaling | Maximum Signal Length |
|---|---|---|---|---|
| 10GBaseLR | Single-mode | 1310 nm | LAN | 10 km |
| 10GBaseLW | Single-mode | 1310 nm | SONET/WAN | 10 km |

| Standard | Fiber Type | Wavelength | Physical Layer Signaling | Maximum Signal Length |
|---|---|---|---|---|
| 10GBaseER | Single-mode | 1550 nm | LAN | 40 km |
| 10GBaseEW | Single-mode | 1550 nm | SONET/WAN | 40 km |

# 10GBaseT

- Home based 10GB Ethernet.
- Runs on CAT-6 Cabling
- 55 Meter maximum

| Standard | Cabling | Wavelength/ Cable Details | Connectors | Length |
|---|---|---|---|---|
| 10GBaseSR/SW | Multimode fiber | 850 nm | Not defined | 26–300 m |
| 10GBaseLR/LW | Single-mode fiber | 1310 nm | Variable, commonly LC | 10 km |
| 10GBaseER/EW | Single-mode fiber | 1550 nm | Variable, commonly LC and SC | 40 km |
| 10GBaseT | CAT 6/6a UTP | Four-pair/full-duplex | RJ-45 | 55/100 m |

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