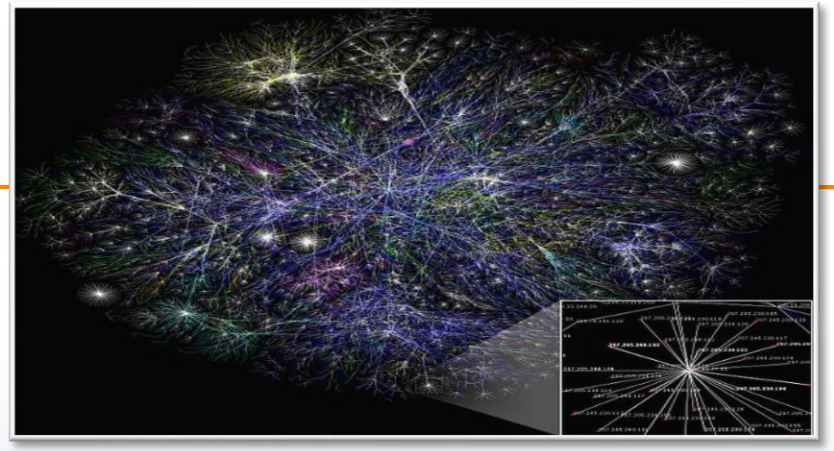
NETWORK TECHNOLOGIES 1



Outline

- Computer Network
- Network Models
  - Client Server
  - Peer to Peer
- Network Topology
  - Mesh
  - Ring
  - Star
  - Hybrid
- Network Interface Card
- Twisted Pair Cables
  - Connectors
  - Wiring Standards

Outline

- PVC Cable
- Plenum Cable
- Coaxial Cable
  - RG-58/59
  - RG-8
  - RG-6
  - BNC Connector
  - F Connector
- Fiber Optic Cables
  - Connector ST
  - Connector SC
  - Connector LC

Outline

- Network Devices
  - Hub
  - Switch
  - Router
  - Bridge
  - Access Point
  - Modem
- Network Attached Storage
- TCP/IP
  - Application Layer
  - Transport Layer
  - Internet Layer
  - Link Layer

Outline

- Decimal to Binary Conversion
  - Convert 7 to Binary
  - Convert 35 to Binary
  - Convert 148 to Binary
- IPv4
- Subnet Mask
  - Classful Based Sub Masks
- IP Address Classes
- Classless Inter-Domain Routing
- IP Address Schemes
- Network Address Translation (NAT)
- Demilitarized Zone (DMZ)

- Automatic Private IP Addressing (APIPA)
- Static vs. Dynamic IP Address
- TCP/IP Network Ports
- TCP Ports
- User Datagram Protocol Ports
- Common Ports
- Dynamic Host Control Protocol (DHCP)
- Domain Name System (DNS)
- Lightweight Directory Access Protocol (LDAP)
- Simple Network Management Protocol (SNMP)
- Server Message Block (SMB)
- Secure Shell (SSH)

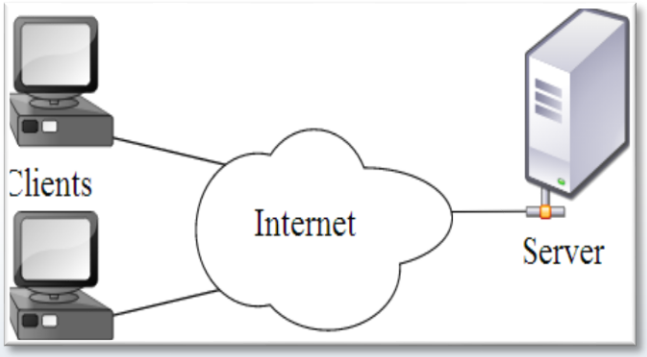
- Secure File Transfer Protocol (SFTP)
- IPv6
- Address Format
- Gateway
- Default Gateway

- Connected computers that exchange and share computing resources such as data, files, storage devices, compute nodes, servers, databases, network connections, input, output, and media devices.

- Connection media includes
- Wired
- Wireless

- Devices (nodes) require a network interface device (NIC)

- Servers – provide network services and control
- of the network resources
- Client – use the network services provided
- by the server
- Allows computing resources: processing power, management, administrative, storage, and network capability can be concentrated where needed
- Very popular, many uses: Internet World Wide Web, Email, Windows network domain

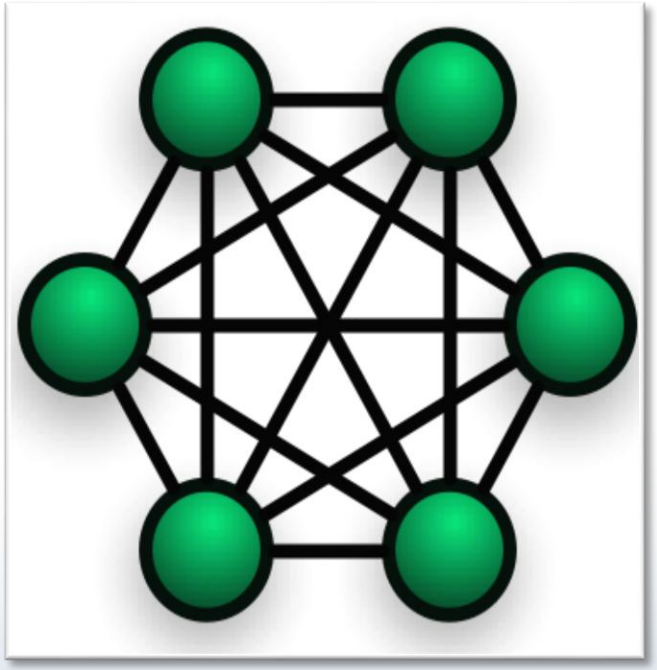


Network Models - Peer to Peer

- Computing resources are shared and decentralized
- Each peer has equal access to resources
- Authentication is done by each peer
- Easy and inexpensive to implement
- May have scaling issues (Windows workgroup < 10)
- Examples: Windows workgroup/homegroup, BitTorrent, BitCoin, wireless mesh networks

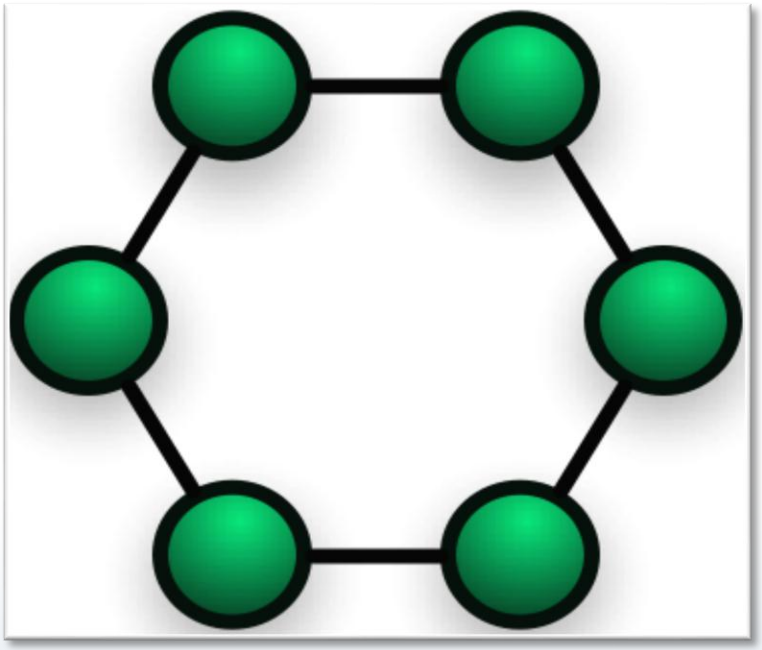
Network Topology - Mesh

- Each node is directly connected to every other node
- Little congestion
- Data travels very fast
- Very reliable
- Difficult to implement as the number of connections increase exponentially
- Generally for small networks



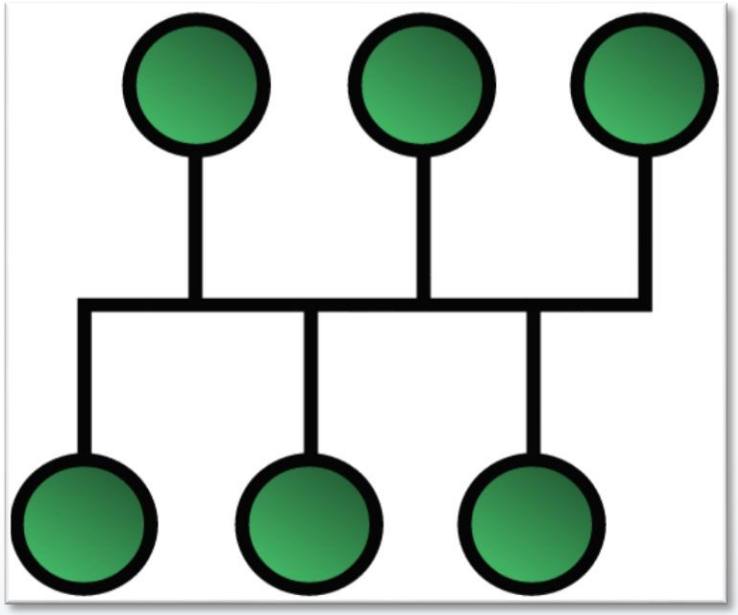
Network Topology - Ring

- Each node is connected to the nearest nodes
- Forms a ring
- Data travels in 1 direction
- All nodes either accept data or pass it along
- No centralized control



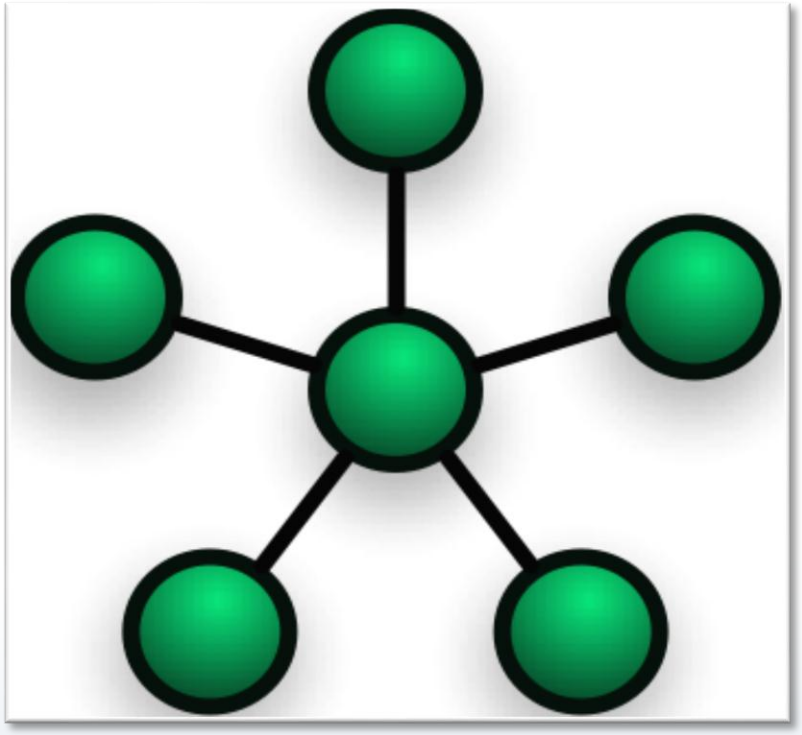
Network Topology - Ring

- Each node is connected to the same data path
- Every node receives all data at the same time
- Data flows in a single continuous stream
- Example PCI

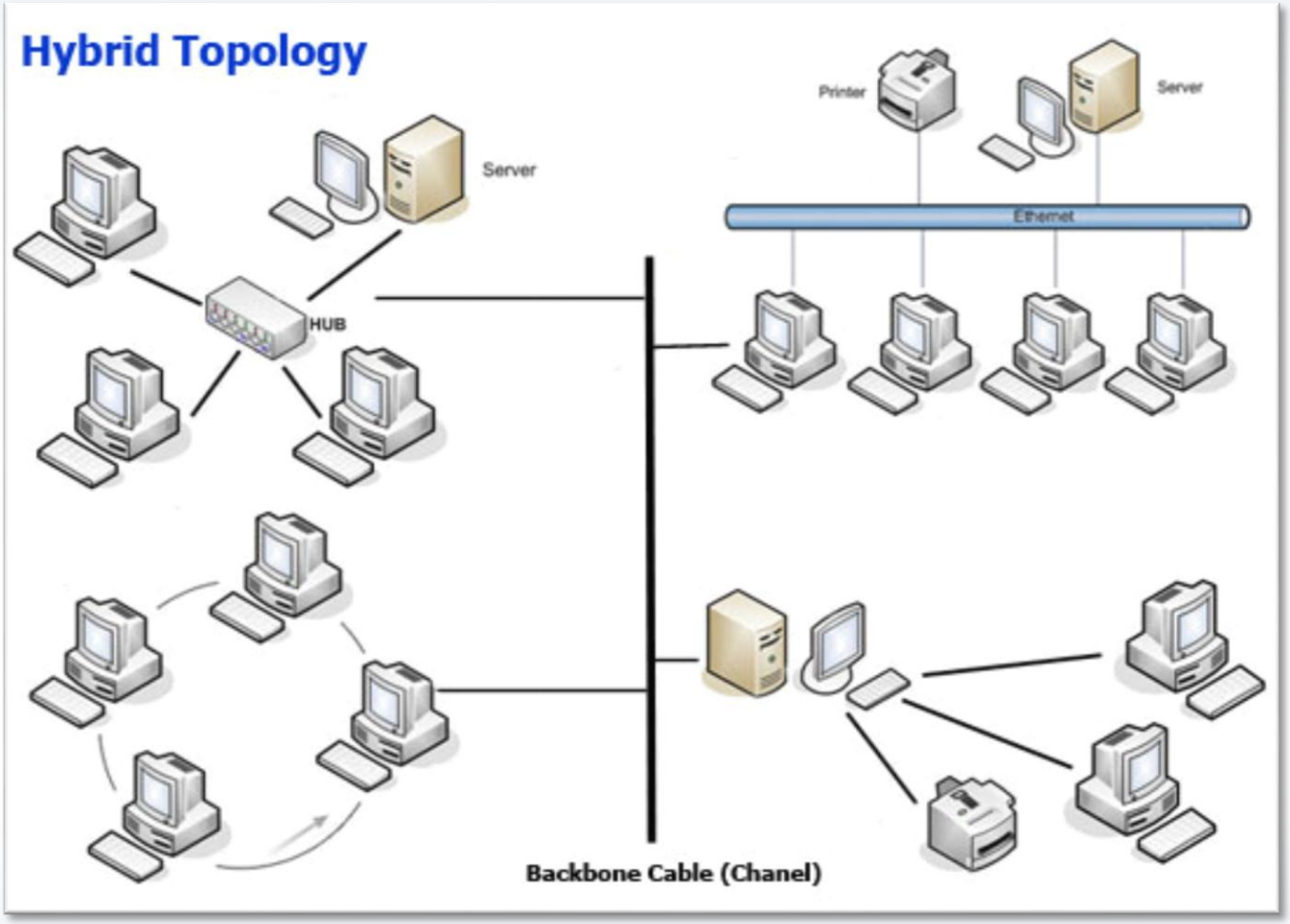


Network Topology - Star

- Involves a central connectivity device (i.e. hub, switch, router)
- All nodes make 1 connection to the central device
- The device can forward data from one node to another



Network Topology - Hybrid



Network Interface Card

- Ports: single, multiple
- Antennas
- MAC Address: Media Access Control Address
  - -Six bytes long, hexadecimal
  - -00:1A:99:BD:18:D3
  - -First 3 bytes are vendor specific
  - -Remaining bytes are unique to the NIC
- Status lights: Link active, transmit, receive, speed, color/flickering – activity, problems, collisions

Twisted Pair Cables

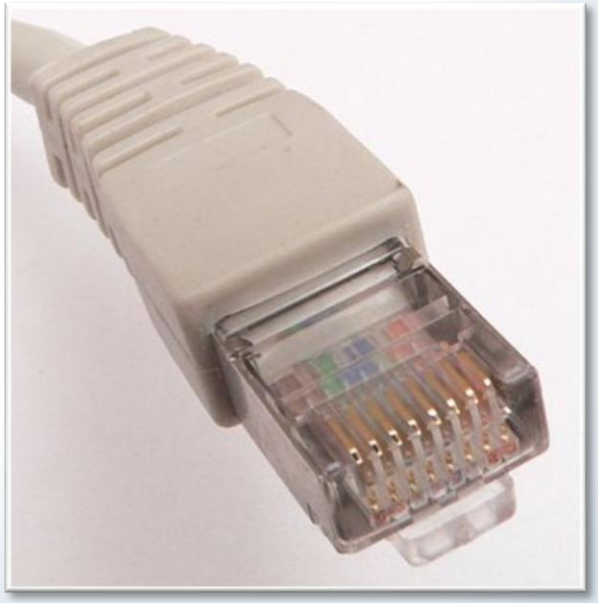
- Twisting minimizes interference
- UTP – unshielded twisted pair
- -No shielding
- -Less expensive
- -Most common
- STP – shielded twisted pair
- -Shielding (usually foil) present
- -Useful around electric equipment and cabling
- -More expensive

Twisted Pair Category

Category	Network	Bandwidth Signaling	Application	Max Speed	Notes
CAT 3	Phone Computer	16 Mhz	10BASE-T	10 Mbps	Mainly phone
CAT 5	Computer UTP	100 Mhz	100BASE-T	100 Mbps	Most common
CAT 5e	Computer UTP	100 Mhz	100BASE-T 1000BASE-T	1 Gbps	Most common
CAT 6	Computer UTP	250 Mhz	100BASE-T 1000BASE-T 1GBASE-T 10GBASE-T	10 Gbps	
CAT 6a	Computer UTP	500 Mhz	1000BASE-T 1GBASE-T 10GBASE-T	10+ Gbps	
CAT F/7	Computer STP Phone CATV	600 Mhz	1000BASE-T 1GBASE-T 10GBASE-T	10+ Gbps	Individual wire shielding

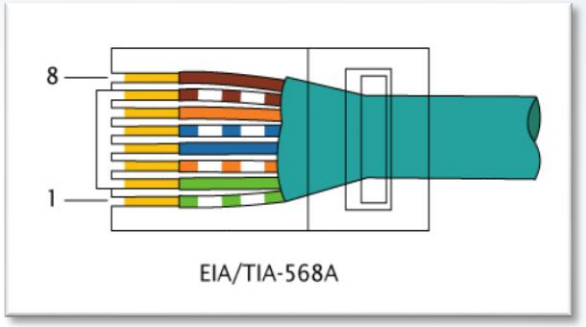
Twisted Pair Connectors

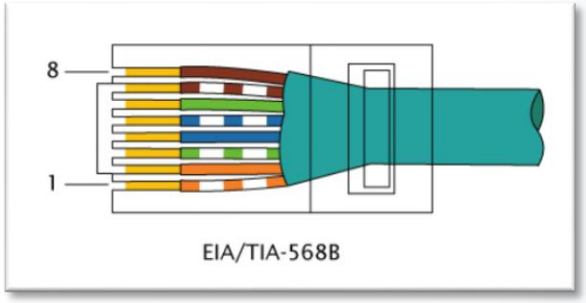
- RJ-11 – 6 position, 2 conductor (6P2C)
- -Looks similar to RJ-45
- -Suitable for phone systems
- -RJ 14 - 6P4C
- -NOT SUITABLE FOR COMPUTER NETWORK
- RJ-45 – 8 position, 8 conductor (8P8C)
- -Most common connector for twisted pair
- network cable



Twisted Pair Wiring Standards

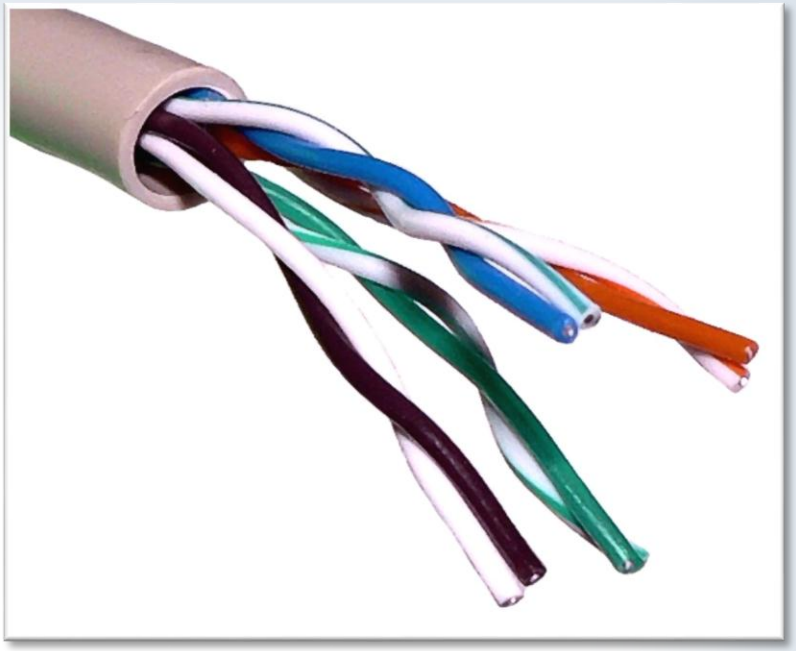
- TIA – Telecommunications Industry Association
- EIA – Electronic Industries Alliance
- T568A -
- -Older legacy
- -Network, voice, video
- T568B – standards for
- -100 ohm twisted pair
- -STP – shielded twisted pair
- -Optical fiber
- T586C – newest designed for commercial building





PVC Cable

- Polyvinyl chloride
- -Inexpensive
- -Physically flexible
- -Rubber like plastic polyurethane
- jacket
- -Emits noxious fumes when burned
- -Used outside of walls and ceilings



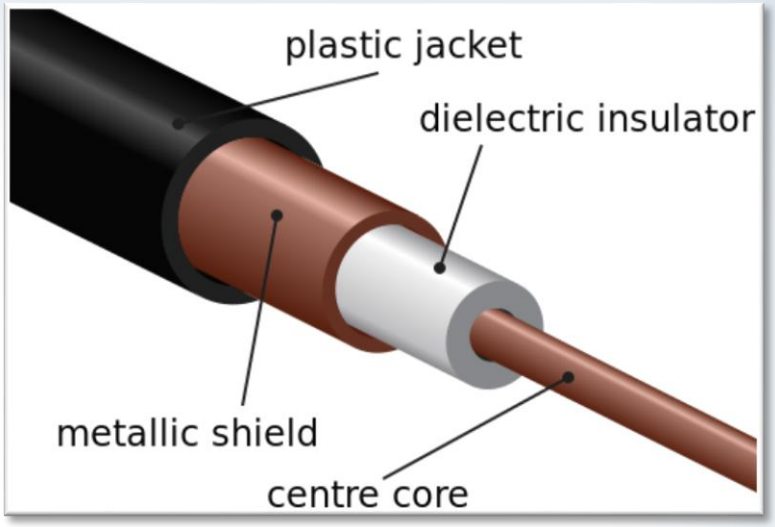
Plenum Cable

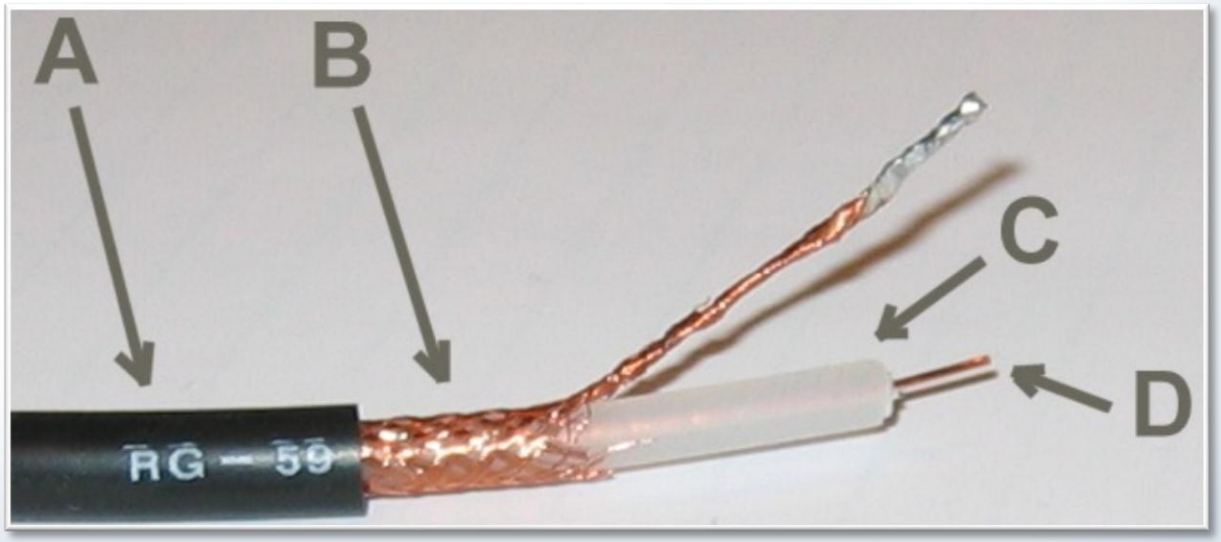
- Out jacket does not produce noxious gases when burned
- Stiffer and more expensive than PVC
- Has center plenum piece to help separate some wires
- Designed for the “plenum” space – air handling space or ceiling
- Many times required by building and fire codes

Coaxial Cables

- Central conductor surrounded by:
- -Dielectric insulator
- -Braided or foil shielding
- -Plastic jacket

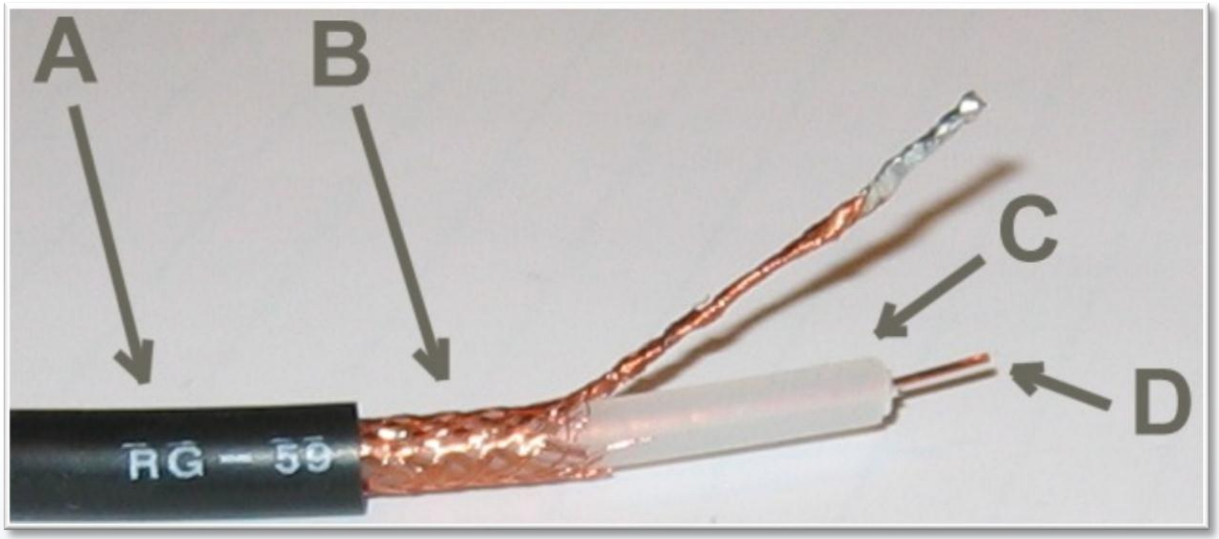
- Significantly reduces EMI





Coaxial Cables RG-58/59

- “Thinnet” (10BASE2)
- Max length: 185 meters
- Other uses
- -Short range audio/video
- -Radio antenna connection



Coaxial Cables RG-8

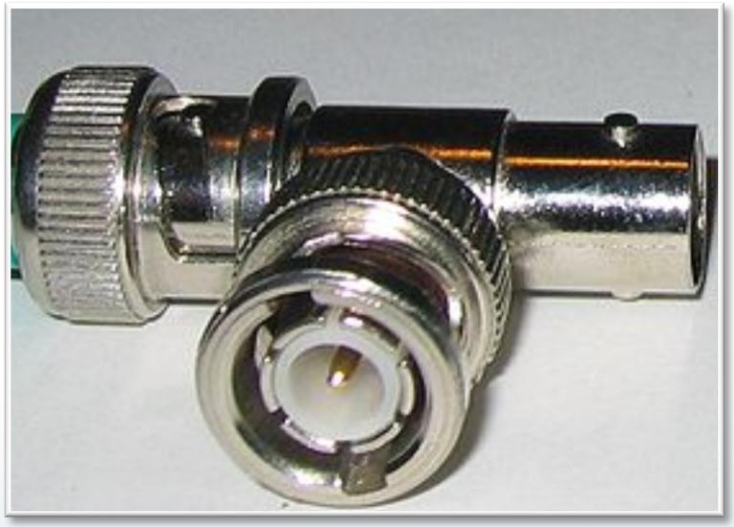
- “Thicknet” (10BASE5)
- Max length: 500 meters
- Other uses
- -Audio / Video for CRT, VCR, CATV, SatTV
- Radio antenna connection

Coaxial Cables RG-6

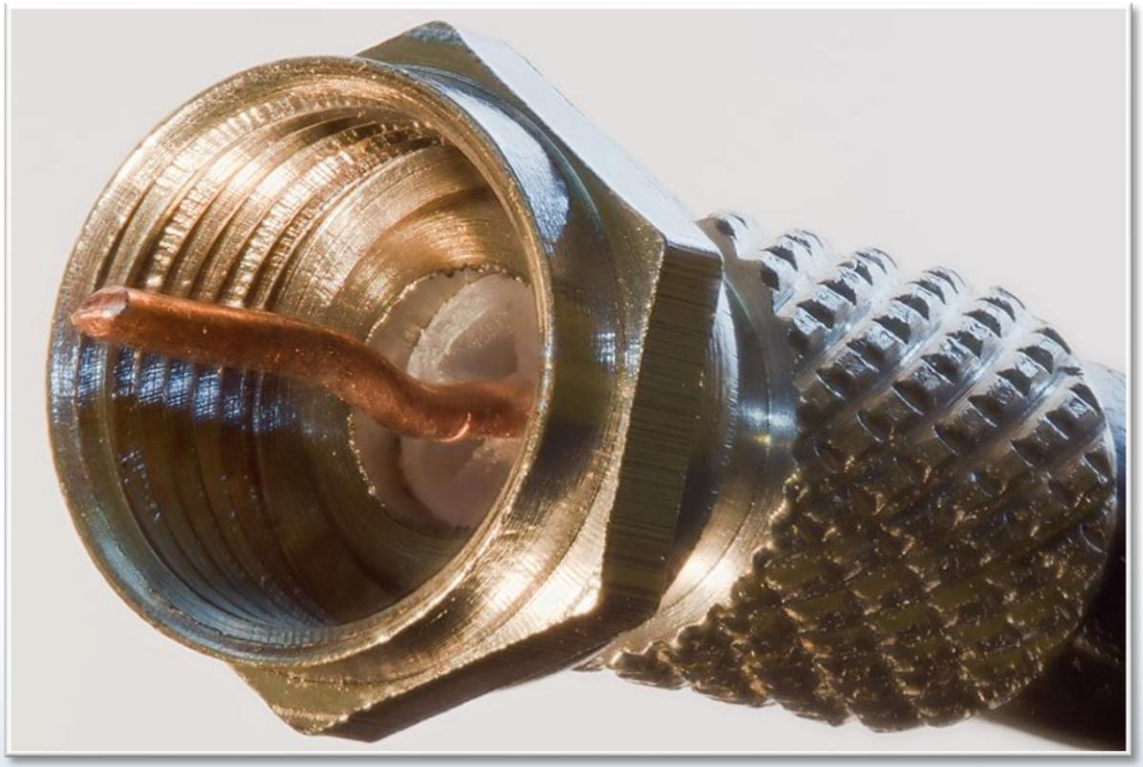
- Broadband Internet
- Other uses
- -Audio / Video for CRT, VCR,
- CATV,SatTV
- -Radio antenna connection

Coaxial Cables BNC Connector

- Bayonet Neill-Concelman
- Twist lock, quick connectors for
- coaxial cables
- Uses
- -Thinnet 10BASE2
- Antennas
- A/V cables

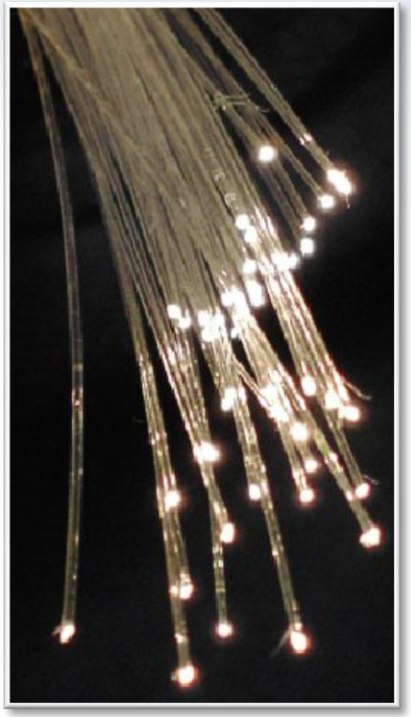


- Screw type with bolt surface
- for tightening
- Primary use if for A/V equipment
- Connector for cable broadband
- data

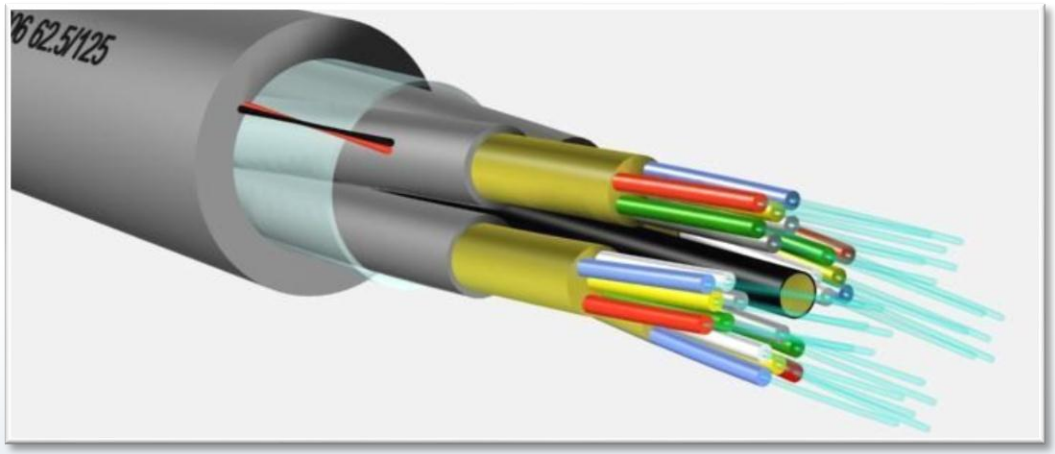


Fiber Optic Cables

- Core
- -1 or more glass or plastic strands
- -5 – 100 microns thick
- Cladding
- -Reflects light back to core
- Coating (Kevlar)
- -Protection and pull strength
- Outer Jacket
- -Protection
- Carries light pulses from a laser or LED pass through individual strands



- Expensive
- Fragile
- Difficult to install
- Very fast
- Reliable over long distances
- Impervious to electromagnetic interference
- Difficult to monitor or tap



Fiber Optic Cable Types

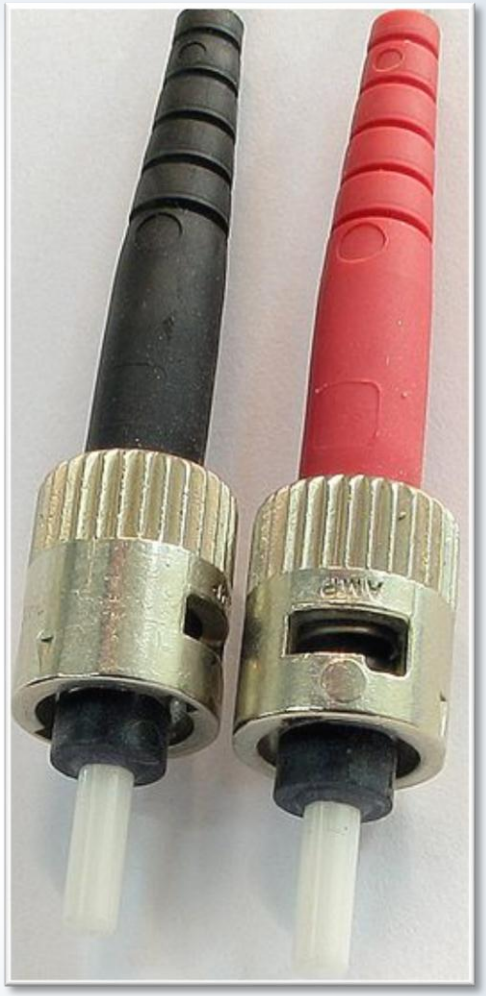
- Single Mode
  - -Single strand with single string of light
  - -Long range: 100 km

- Step Index Multi-mode Fiber
  - -Multiple cores
  - -Step down refractive index once light enters core
  - -Range: 2 km

- Graded Index Multi-mode Fiber
  - -Multiple cores
  - -Variations in core glass to compensate for distance
  - -Up to 2 Ghz of bandwidth = faster than step index
  - -Range: 2 km

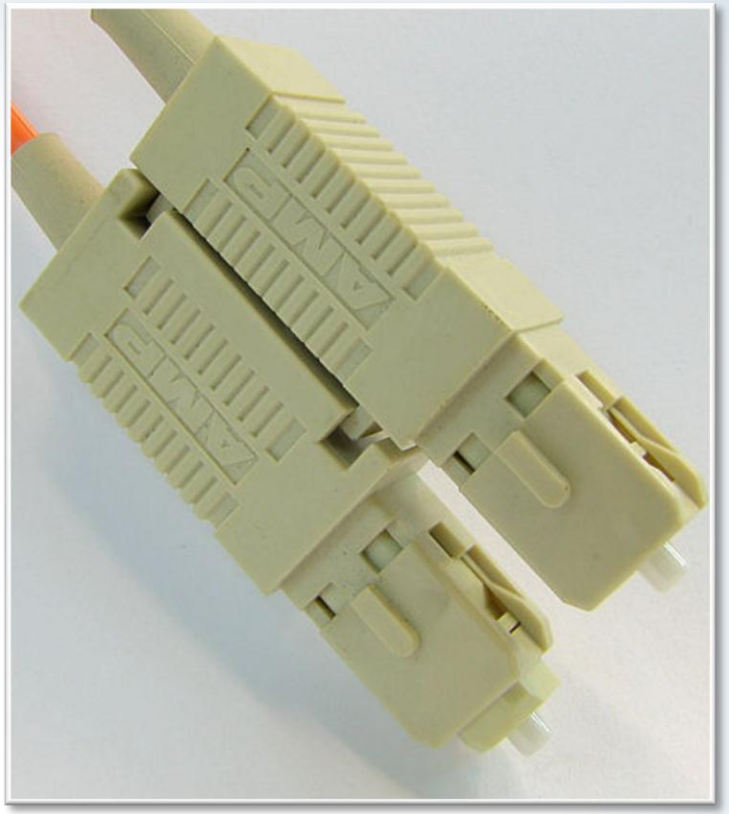
- Straight Tip (ST)

  - -Connects multimode fiber
  - -Resembles BNC connector
  - -Straight ceramic center pin with bayonet lug
  - -Used in network patch panels
  - -Most popular type



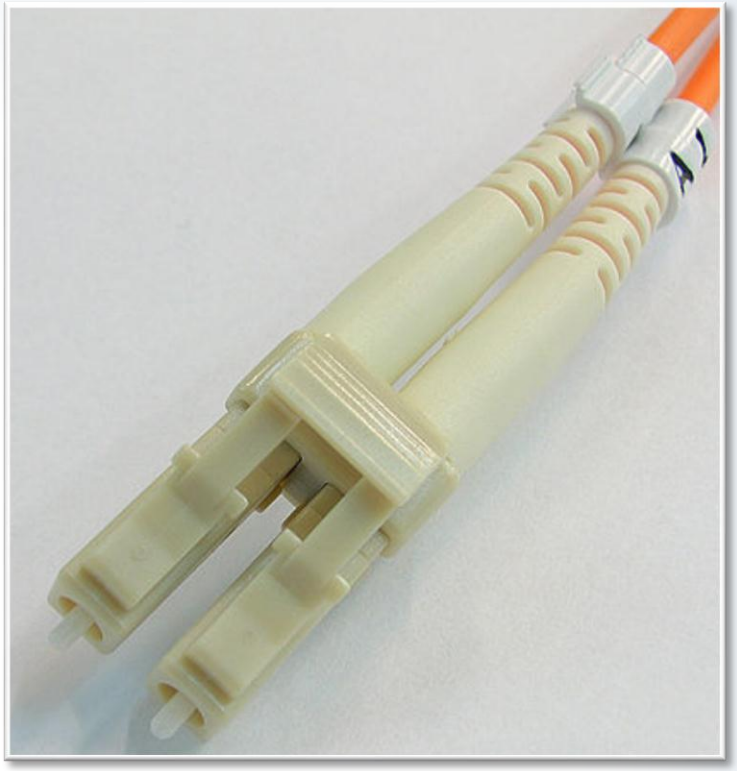
Fiber Optic Connector SC

- Standard/Subscriber/Square Connector (SC)
  - -Box shaped
  - -Snaps when connected
  - -Used with single mode fiber
  - -Commonly used to combine 2 single
  - mode fiber cables



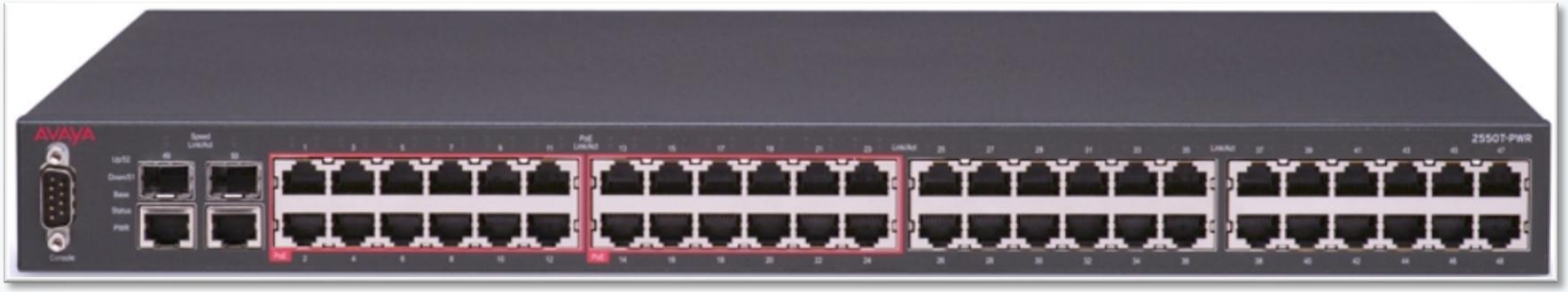
Fiber Optic Connector LC

- Local/Lucent/Little Connector (LC)
  - -Small
  - -Half the size of SC or ST
  - -Single and multi mode fiber
  - -Uses RJ-45 latch
  - -Transition UTP to fiber



- Connects multiple twisted pair devices together
- Receives data, then rebroadcast to all connections
- Can increase signal strength
- Unsophisticated device
- - Many packet collisions
- - All connected devices receive all data packets
- Largely replaced by switches and routers

- Connects multiple computers together in the same LAN or LAN segment
- Only forwards packets to the destination MAC address
- Smarter than hubs, operate on TCP/IP Link Layer, OSI Data and Network Layer 2 and 3

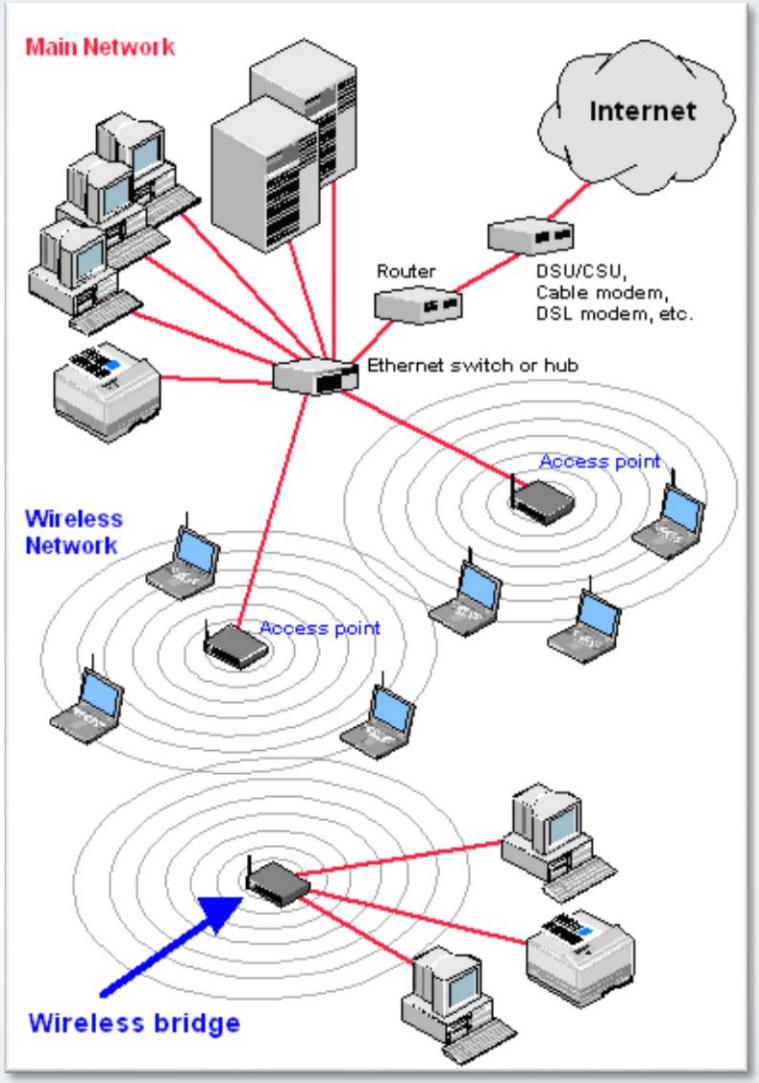


- Connects multiple networks
- Uses routing tables to direct packets to proper network/destination
- Is the “traffic cop” of the Internet
- Operates on the TCP/IP Link and Internet Layer and OSI Layer Data and Network (Layer 2 and 3)

Network Devices - Bridge

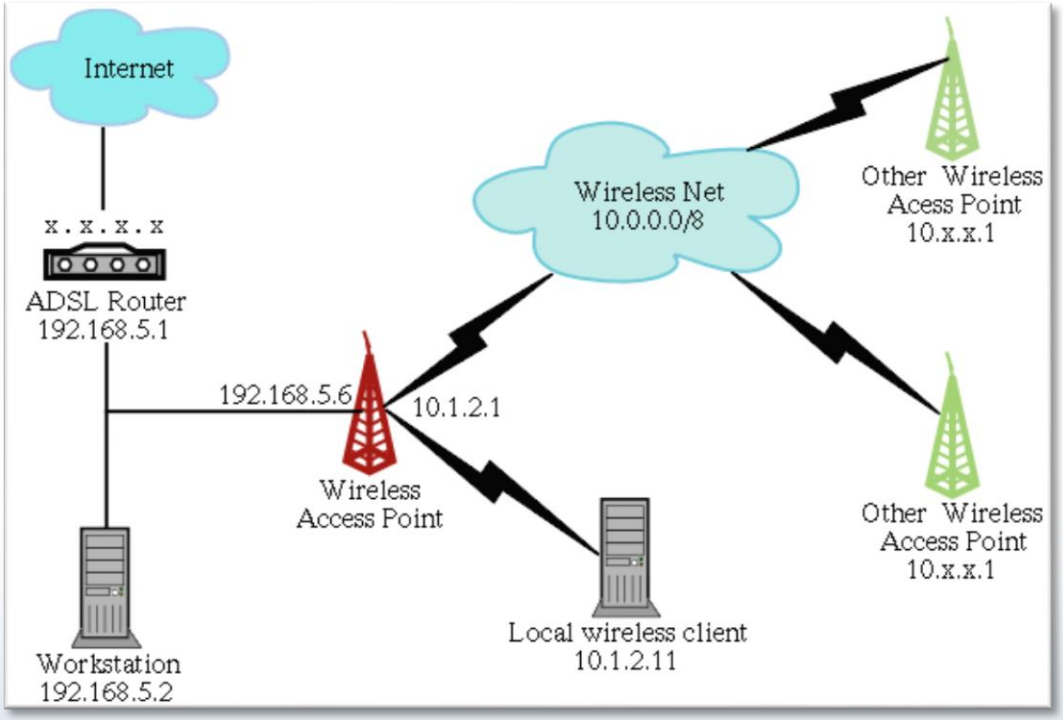
- A device that connects 1 or more network segments
- Only forwards packets that are outside of its segment, therefore reducing data
- Uses MAC address to accomplish, works on TCP/IP Link Layer and OSI Data

Network Devices - Bridge



Network Devices - Access Point

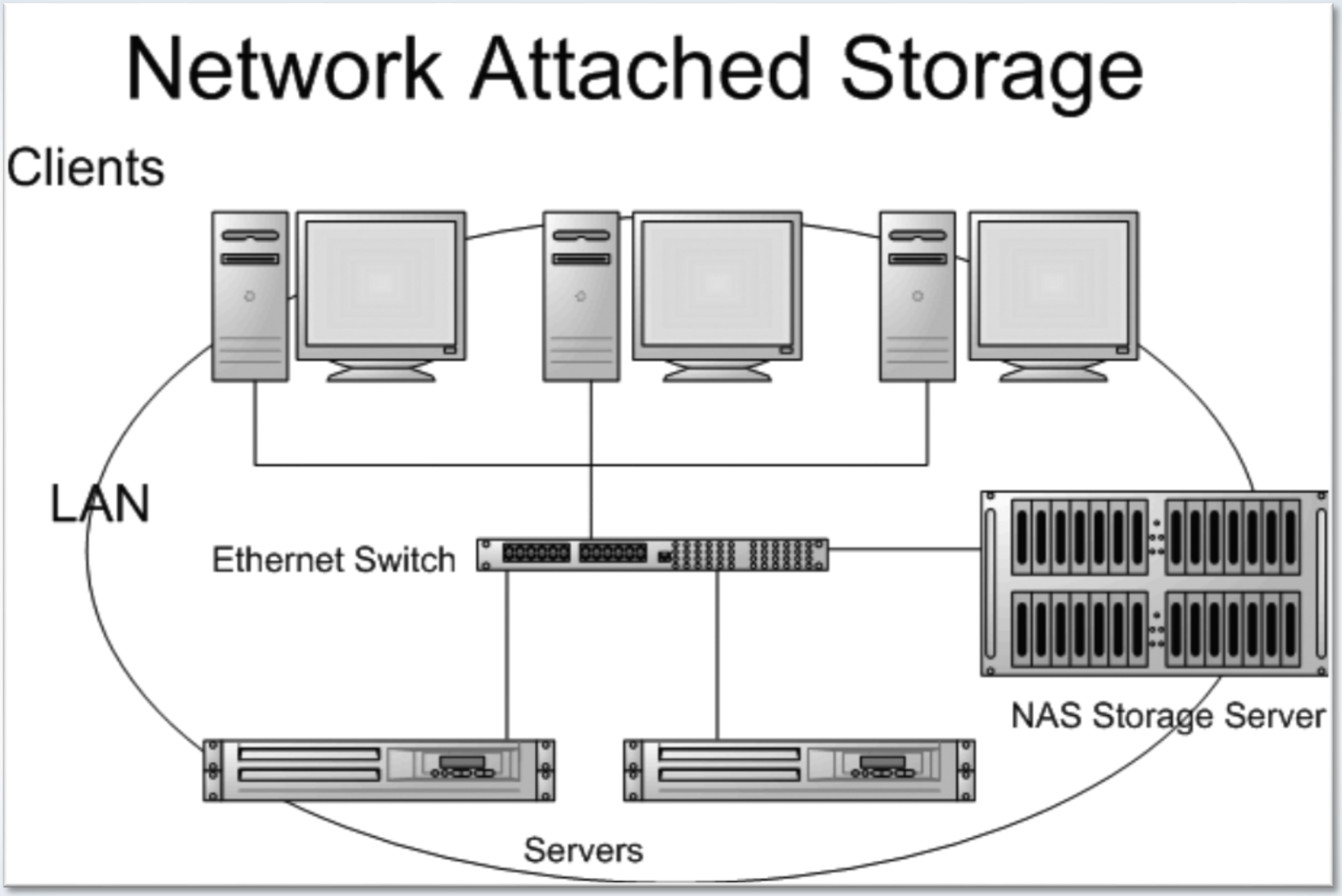
- Provides network connectivity to devices usually using Wifi technology
- May provide additional features such as encryption and authentication
- Functions as a network bridge for connected clients



- A device the converts between analog and digital signals
- Includes:
  - - POTS phone modem
  - - DSL modem
  - - Cable modem
  - - Radio modem

Network Attached Storage

- Data storage device with network connectivity
- Does not require active connection or control from a computer

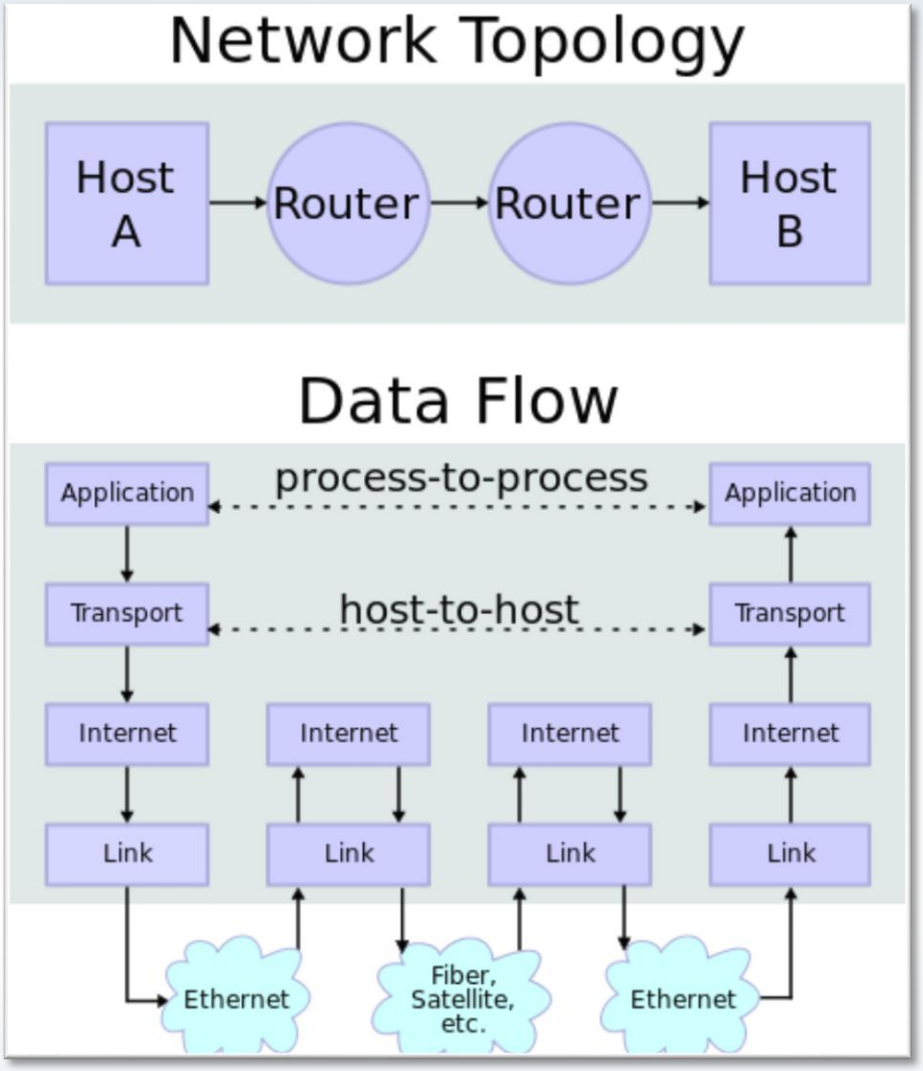

Network Attached Storage
Clients
LAN
Ethernet Switch
NAS Storage Server
Servers

- Process to process communication
- Higher level protocols used by most applications for network communication
- Examples: DHCP, DHCPv6, DNS, FTP, HTTP, IMAP, IRC, LDAP, MGCP, NNTP, BGP, NTP, POP, RPC, RTP, RTSP, RIP, SIP, SMTP, SNMP, SOCKS, SSH, Telnet, XMPP

- Establishes a basic data channel and host to host communication, end to end messaging, error control, segmentation, flow control, congestion control, and ports
- Details of data transmission are separate from data
- Examples: TCP, UDP, TLS/SSL

- Sends packets across multiple networks or routing
- Host addressing, packet routing
- The IP in TCP/IP
- Examples: IPv4, IPv6, OSPF, ICMP, ICMPv6, IGMP, IPsec

- Host to host on the same network
- Hardware level connection between hosts
- Includes physical media, hardware, drivers, and software
- Lowest layer and independent of higher layers
- Examples: ARP, NDP, Tunnels, PPP, Media access control (MAC), Ethernet, DSL, ISDN, FDDI


Network Topology
Host A
Router
Router
Host B
Data Flow
Application
process-to-process
Application
Transport
host-to-host
Transport
Internet
Internet
Internet
Internet
Link
Link
Link
Link
Ethernet
Fiber, Satellite, etc.
Ethernet

Decimal to Binary Conversion

- Decimal system = 0,1,2,3,4,5,6,7,8,9
- Binary = 0 (off) or 1 (on)
- To convert a decimal system number to a binary:
  - List the powers of 2 from right to left
  - Find the greatest 2 power that will fully fit the number you are converting to binary
  - and write a 1 above it
  - Subtract the conversion number from the fully fit 2 power
  - Find the next greatest 2 power that will fully fit the subtracted answer and write 1
  - If you cannot fully fit the 2 power then write 0
  - Continue until you get to the 20 power (1)

1024	512	256	128	64	32	16	8	4	2	1
2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Convert 7 to Binary

- Start with filling 4 (write 1 above 4)
- Subtract 7-4= 3

								1		
1024	512	256	128	64	32	16	8	4	2	1
2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

- Fill up 2 (write 1 above 2)
- Subtract 3 – 2 = 1

								1	1	1
1024	512	256	128	64	32	16	8	4	2	1
2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Answer: 111

Convert 35 to Binary

- Start with filling 32 (write 1 above 32)
- Subtract 35-32= 3

					1					
1024	512	256	128	64	32	16	8	4	2	1
2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

- Fill up 2 (write 0 above 16, 8, 4, write 1 above 2)
- Subtract 3 – 2 = 1

					1	0	0	0	1	1
1024	512	256	128	64	32	16	8	4	2	1
2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Answer: 100011

Convert 148 to Binary

- Start with filling 128 (write 1 above 128)
- Subtract 148 – 128= 20

			1							
1024	512	256	128	64	32	16	8	4	2	1
2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

- Fill up 16 (write 0 above 64, 32, write 1 above 16)
- Subtract 20 – 16= 4

			1	0	0	1	0	1	0	0
1024	512	256	128	64	32	16	8	4	2	1
2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Answer: 10010100

- 8 bits for each number (0-255), 4 numbers and 32 bits total.
- Dotted Decimal Notation: 192.168.1.1
- Binary: 11000000.10101000.00000001. 00000001
- Network segment: first 2 groups of numbers (192.168 or 11000000.10101000)
- Node segment: last 2 groups of numbers (.1.1 or .00000001. 00000001)

Subnet Mask

- Allows TCP/IP to be routable
  - Devices know whether a packet is on their network or not. If it is not on the network, then the packet must be routed to another network
- Uses a binary operation to remove the node segment from the IP address, leaving the network segment
- Apply a subnet mask
  - Convert IP address and subnet mask to binary
  - Binary AND the binary IP and binary subnet mask
  - 0 and any number = 0
  - 1 and 1 = 1
  - The result is a network ID

Classful Based Sub Masks

- Very specific subnetting
- Not used since 1993
- Still referenced in conversation

Class	Address
Class A	255.0.0.0
	11111111.00000000.00000000.00000000
Class B	255.255.0.0
	11111111.11111111.00000000.0000000
Class C	255.255.255.0
	11111111.11111111.11111111.00000000

IP Address Classes

Class	Leading Bit	Size of *Network Number* bit field	Size of *Node* bit field	Number of Networks	Addresses per Network	Start Address	End Address	Default Subnet Mask
A	0	8	24	128 (27)	16,777,216 (224)	0.0.0.0	127.255.255.254	255.0.0.0
B	10	16	16	16,384 (214)	65,536 (216)	128.0.0.0	191.255.255.254	255.255.0.0
C	110	24	8	2,097,152 (221)	256 (28)	192.0.0.0	223.225.255.254	255.255.255.0
D multicast	1110	undefined	undefined	undefined	undefined	224.0.0.0	239.255.255.255	undefined
E reserved	1111	undefined	undefined	undefined	undefined	240.0.0.0	255.255.255.255	undefined

- CIDR, Created 1993
- No strict dividing line between IP addresses and subnet mask addresses
- Incorporated because of the limitations of the Class A-F system
- Allows the network designer to decide the IP address range and subnet mask for each network

- Notation 192.168.1.1/24
  - - /24 = number of bits of subnet 11111111.1111111.1111111.000000
  - - /24 = 255.255.255.0 (254 addresses per subnet)

- Example: 10.1.0.1/16
- - Subnet mask = 255.255.0.0 (65,534 addresses per subnet)

- Example: 10.1.0.1/26
- - Subnet mask = 255.255.255.192 (62 addresses per subnet)

- Private Network

IP Address Range	Number of Addresses	Largest CIDR Block (subnet mask)	Classful Description
10.0.0.0 - 10.255.255.255	16,777,216	10.0.0.0/8 (255.0.0.0)	single class A network
172.16.0.0 - 172.31.255.255	1,048,576	172.16.0.0/12 (255.240.0.0)	16 contiguous class B networks
192.168.0.0 - 192.168.255.255	65,536	192.168.0.0/16 (255.255.0.0)	256 contiguous class C networks

- Public Network– IP address used on the Internet assigned by an Internet Service Provider

Network Address Translation (NAT)

- Allows private network IP address to us a public IP address (usually assigned to a router) to communicate with the Internet
- NAT conceals the IP addresses of the private network
- Internet computers do not know how many computers are behind an IP address that is used for NAT (there are other methods)
- NAT enables more than 4.3 billion computers to connect to the Internet with IPv4
- NAT uses network ports to keep private IP addresses private

Demilitarized Zone (DMZ)

- Nodes placed in the DMZ are exposed to WAN traffic without protection from network firewalls and routers
- Nodes in DMZ are vulnerable to security attacks
- Web, mail, FTP, VoIP servers are sometimes placed in a DMZ to improve connectivity and reduce connections problems from a firewall
- Databases and confidential information should never be placed in a DMZ

Automatic Private IP Addressing (APIPA)

- Feature of MS Windows that automatically configures an IPv4 address when a computer is not connected to a DHCP server
- Uses 169.254.0.0/16 address range
- Also known as auto-IP or link local address
- Linux – AVAHI
- Mac OS X – APIPA, Bonjure

Static vs Dynamic IP Address

- Static – IP address is assigned by an administrator or user using the computer OS settings
- Dynamic – uses DHCP and DNS where IP addresses and FQDN (fully qualified domain name or web address) are controlled automatically

- Port range: 0 – 65535
- Well Known Ports: 0 – 1023 (registered with IANA
- - Assigned to common or well known services (i.e. HTTP (80), FTP, IMAP (143), DNS (53))
- Registered Ports: 1024 – 49,151
- - Generally registered by software companies (i.e. VNC (5900), RDP (3389), MS SQL (1433), Oracle database (1521/2483)

- Dynamic Ports: 49,152 – 65,535
- Short lived temporary usage for the duration of the communication session
- Also known as ephemeral ports
- All TCP/IP computers communicate using an IP address and port (i.e.: 192.168.6.076:80 (:80 is port 80), 10.1.3.10:143 (:143 is port 1)

- Connection oriented, guaranteed delivery port
- Breaks up packets, reassembles packets upon delivery, resend/resequence missing packets
- Creation and teardown of connection
- Occurs in the TCP/IP Transport layer
- Keeps track of every byte for out of order and missing data packets
- Recognizes duplicates
- For services that need to ensure data transmission (FTP, SMTP, HTTP, POP3, HTTPS)
- Slower than UDP because of all the transmission control overhead

User Datagram Protocol Ports

- Connectionless, transport layer protocol
- “Best effort”, sends data packets out and simply hopes it gets to its destination
- Lacks reliability, flow control, error recovery, retransmission, reordering
- No formal connection start and stop
- UDP is unreliable
- Services that need a fast connection where it can tolerate the loss of data packets (Voice over IP, video, video and sound portion of remote desktop, Bit-torrent transfer ports)

Common Ports

Port	Type	Service Name	Description
20/21	TCP/UDP	FTP	20 – File Transfer Protocol Data 21 – File Transfer Protocol Control
23	TCP/UDP	Telnet	Unencrypted text/terminal
25	TCP	SMTP	Simple Mail Transfer Protocol – sending mail
53	TCP/UDP	DNS	Domain Name System
80	TCP	HTTP	Hyper Text Transfer Protocol – web pages unsecured
110	TCP	TCP	Post Office Protocol v3 – receiving mail
143	TCP	TCP	Internet Message Access Protocol – email management
443	TCP	HTTPS	Hyper Text Transfer Protocol – web pages over TLS/SSL
3389	TCP/UDP	RDP	Remote Desktop Protocol – MS windows remote desktop

Dynamic Host Control Protocol (DHCP)

- A network service (usually performed by a network router) that automatically assigns IP addresses and subnet masks to computers that connect to a network
- The DHCP server is assigned a scope of IP addresses and subnet mask to use when assigning addresses
- Includes and automatically configures information such as default gateway address and domain name server addresses
- The specific IP address is assigned for a finite period of time "leased time"

- Assigns human readable “named” address that corresponds to a computer's IP address
- Translates a FQDN (web address) to an IP address.
  - - itpedia-solutions.com = 50.17.203.154
  - - Google.com = 173.194.43.2
- Can provide DNS services to a local network so that a computer can be referred to “Asus-G74Sx” vs 192.168.3.112

- OS keep a list of DNS entries in a Host File so it does not have to query a DNS every time a FQDN is entered

- Client Side DNS – a DNS service that runs on a local matching providing local DNS services, decreases traffic to a DNS server

Lightweight Directory Access Protocol (LDAP)

- Defines how a client/server can access and maintain distributed directory information services
- Designed for TCP/IP networks
- Uses DNS to point clients to LDAP servers
- Enables “single sign-on” and user data access across clients
- Microsoft's implementation is call ActiveDirectory

Simple Network Management Protocol (SNMP)

- Collects diagnostic and maintenance information from network devices
- Devices that typically support SNMP include routers, switches, servers, workstations, printers, modem racks, and more
- Agent software collects and stores information for a network engineer to use
- Can include automatic scripting

Server Message Block (SMB)

- Provides shared access to files, printers, serial ports
- Protocol used for “Microsoft Windows Networks”
- Can use NetBIOS over TCP/IP
- Linux/Mac – use Samba
- AKA Common Internet File System (CIFS)

Secure Shell (SSH)

- A cryptographic network protocol for secure data communication, remote command-line login, remote command execution, and other secure network services between two networked computers
- SSH1 – older less secure
- SSH2 – more secure and does not use server keys
- Offers tunneling and port forwarding to enable graphical applications, securely mounting a local file system, etc.
- Mostly used on UNIX/Linux/OS X servers

Secure File Transfer Protocol (SFTP)

- Much more secure than FTP
- Uses SSH tunnel connection to a FTP server

- Internet Protocol version 6
- Uses 128 bit address space vs 32 bit address space of IPv4
- Although not currently widely deployed, it is being used more and more every day
- All modern OS have support for IPv6
- Created because the max number of IPv4 address was 4.2 billion (including the off limit class D and E ranges)

- Max number of IPv6 addresses:
  - -340,282,366,920,938,463,463,374,607,431,768,211,456
  - -3.4 x 1032
  - -7.9 x 1028 times as many IPv4 addresses

- Simplified address headers
- Hierarchical addressing
- Time sensitive network traffic
- Multicasting
- Stateless address auto configuration (SLAAC)
- Network layer security (IPsec)
- Simplified routing
- Optional extensibility for QOS, security, mobility
- Not directly compatible with IPv4, routers need to be upgraded, IPv4 networks need to separate from IPv6

- 128 bits, 16 bytes, 8 “groups”
- 2002:00DB:0000:0000:0031:AB12:0000:3211
- Can be shortened by:
  - - Removing 1 or more leading 0 in a group
  - - Consecutive sections of 0s can be replaced by :: (this can be used only once)
- 2002:DB:0:0:31:AB12:0:3211(removing leading 0)
- 2002:DB::31:AB12:0:3211 (replacing 0s with ::)

- A device, system, or software that converts data between incompatible systems or devices

- Translates data between different networks, operating systems, email formats, etc.

Default Gateway

- In TCP/IP the default gateway routes data packets to another network, usually from a LAN to a WAN
- Required to communicate outside of a LAN
- Usually integrated with a router device

THANK YOU