NETWORKING: 2 or more connected computers allow users to share data easily and quickly through a system of protocols, cables and hardware.

NETWORK MODELS

Mainframe	Client/Server	Web-Based
Power computing	***Scalable computing***	***Collaborative computing***
Backend/Server Process Remote (dumb terminals)	Distributed Processing • Client processes much of work • Server responsible for storing and presenting info	Uses mainframe & client server technology using TCP/IP
Unacceptable network congestion due to : • Mainframe must handle all processing work • Requests & response packets occupy large amount of network bandwidth	Not limited to one solution; can add new system components • Considerable flexibility in distributing resources on the network (2 tier, client/server and 3 tier computing) • More control of own files; unlike operating systems (i.e., UNIX-WinNT-Novell NetWare) systems can work together through TCP/IP • Scalable ~ able to adjust to new demands • Distributed database involves storage across several machines as if stored centrally • Uses SQL (Structured Query Language) to translate human-readable language into machine-readable code	More distributed and decentralized • Relies on browser to interface with complex server mechanisms • Combines power of mainframe w/scalability of client/server • Most radical form of 3-tier computing (extranets, VPNs) 1. Client 2. Shared server or network element 3. Server and database

NETWORK TYPES (Categories)

Peer-to-peer	Server based	Enterprise
• Doesn't require dedicated resources ~ no server • Any host can share resources with other systems on network • Less secure • Support 10 or fewer users • Each client serves as both client and server	• Nodes are dedicated to providing resources to other hosts on the network • Dedicated nodes called servers ~ print, file, mail, web, etc.	Includes peer-to-peer (gateways) and server based (multi-protocol)

ELEMENTS OF ALL NETWORKS

Protocols	Transmission Media	Network Services
Agreed upon rules TCP/IP on which all network elements must agree	Method for all networking elements to interconnect	Shared resources, i.e., printers, by all users

TCP/IP is the language of the internet

Java is programming language that operates across platforms

NETWORK TOPOLOGIES (Basic network configurations ~ architectures)

Bus	Star	Ring	Hybrid	Mesh
• All computers or nodes tap into same cable. • Data broadcast to all nodes • Only destination computer reads • Requires terminators at each end to ensure network traffic doesn't echo back through network **Advantages:** Bus networks are relatively simple, inexpensive, easy to operate and reliable. They also use cable efficiently. **Disadvantages:** Isolating problems is difficult; if a cable breaks, the entire network can be affected. The network is likely to slow during peak traffic periods.	• Connects network nodes through a central device, usually a hub, where each computer's connection terminates • 2nd most widely used protocol on LANs, standard IEEE 802.5 • If one cable or node breaks, the rest of the network will continue to function • Network administrators can trouble shoot networks more easily because the failure is usually isolated. **Advantages:** The network is usually not affected if one computer fails. Network expansion and reconfiguration are relatively simple. Network management and monitoring can be centralized. **Disadvantages:** If the hub (or centralized connection point) malfunctions, the entire network can fail.	• Cable connects 1 node to another until ring is formed. No central connection point. • Often connect through MAU (Multi-station Access Unit) device. • One node fails, entire network fails • Isolating problems is difficult. **Advantages:** All computers have equal access to data. During peak usage periods, the performance is equal for all users. (equal performance for all) Ring networks perform well with heavy network traffic. **Disadvantages:** Network expansion or reconfiguration will affect network operation.	• Larger networks combine bus, star and ring 1. Star ring ~ 2 or more star topologies connect using **MAU** as centralized HUB **2.** Star bus ~ 2 or more star topologies connect using bus **"trunk"** which serves as network's **backbone** • Excellent for large companies **Advantages:** Network expansion is relatively simple. The network is usually not affected if one computer fails. **Disadvantages:** If the hub malfunctions, computers on that hub will be unable to communicate. Connections between the malfunctioning hub and other hubs will fail.	• Connects devices with multiple paths so that redundancies exist • All devices are cross-connected so best path can be chosen at any given moment. **Advantages:** If one connection is terminated, another can be chosen to deliver the data to the destination. **Disadvantages:** Additional hardware can make mesh topologies expensive.

TRANSMISSION TYPES

Transmission Mode	Data Transmission Flow	Transmission Method	Transmission Topologies
▪ **Synchronous Transmission** ✶ Access device and network device share a clock and transmission rate. *Synchronized so entire message received in order transmitted.* ✶ Data exchanged in character streams called message-framed data. *A start-and-stop sequence is associated with each transmission.* ✶ T1 is an example ▪ **Asynchronous Transmission** ✶ Absence of clock in transmission media and not synchronized with the network device. ✶ Transmission speeds must be the same and are transmitted as individual characters. Each character is synchronized by info contained in header/trailer bits. ✶ Dial up modems are an example.	**Three methods of circuit operation**: ▪ **Simplex** ~ data travels in only one direction ▪ **Half Duplex** ~ data travels in two directions, but only one direction at a time. ▪ **Full Duplex** ~ Data travels in 2 directions simultaneously. *Similar to a phone conversation. Full-duplex ethernet, an extension of ethernet, supports full-duplex transmissions in a switched environment.*	▪ **Baseband** ✶ Uses the cable's full signal spectrum. Signal applied to the cable changes the voltage level to indicate a digital value of 0 or 1 establishing a communication session between two systems using cable's entire bandwidth. ✶ Signals are susceptible to attenuation *reduction in signal (analog or digital) strength* and interference from electrical fields can corrupt signal. ▪ **Broadband** ✶ Signals from multiple channels are modulated onto separate carrier frequencies. Bandwidth is subdivided into separate communication channels that occupy a specific frequency range. ✶ Technique for transmitting data, voice and video. Signify data rates of T1, 1.544 Mbps or higher Uses FDM Frequency Division Multiplexing (cable TV technology) ✶ Examples of broadband packet-switching technologies are frame relay, ATM Asynchronous Transfer4 Mode, Cable TV networks, and DSL.	▪ **Logical Topologies** refer to a generated signal's **actual path over a network** ✶ Bus generates a signal to all devices on network ✶ Ring generates a signal that travels in one direction along a determined path. ▪ **Physical Topologies** refer to **the way network devices are connected.** ✶ Bus ✶ Star ✶ Ring ✶ Mesh

TRANSMISSION MEDIA

Twisted Pair

- Most widely used cabling system in ethernet networks. *10baseT=ethernetLAN running @ 10Mbps using baseband transmission and twisted pair cable*
- 2 copper wires twist around each other to form the twisted pair cable. Several insulated wire strands can reside in the cable.
- Cannot exceed 100 meters
- **RJ-45** Register Jack-45 connectors hold up to eight wires and are used with twisted pair wires
- Two basic Twisted Pair Cable types:
  1. **STP** Shielded Twisted Pair. Metal sheath wrapped around wires protects from external electromagnetic interference. (harder to install)
  2. **UTP** Unshielded Twisted Pair. Most common, less secure and prone to electromagnetic interference
- Two varieties of **STP** and **UTP** wire:
  1. Stranded ~ the most common type; flexible and easy to handle around corners and objects.
  2. Solid ~ can span longer distances without as much ***attenuation*** (loss in strength of signal) as stranded wire, but is less flexible; will break if bent multiple times.
- Five twisted pair standards specified by the **TIA/EIA 568 Commercial Building Wiring Standard**. Two more levels (6&7) are used commercially and are not standardized. Twisted Pair Categories are:
  1. Used for voice, not data (**UTP** only)
  2. Contains four twisted pairs and a data transmission up to 4 Mbps. Used for some token ring networks (**UTP** only)
  3. Contains four twisted pairs and a data transmission up to 10 Mbps. Used for ethernet.
  4. Contains four twisted pairs and a data transmission up to 16 Mbps. Used from some token ring networks.
  5. Contains four twisted pairs and a data transmission up to 100 Mbps. Used for ethernet and fast ethernet. Allows ethernet to be easily upgraded to fast ethernet.
  6. Contains four twisted pairs and a data transmission up to 155 Mbps. Used for fast ethernet.
  7. Contains four twisted pairs and a data transmission up to 1000 Mbps. Used for gigabit ethernet.

Coaxial Cable

- High-capacity cable used for video and communication networks. Provides higher bandwidth than twisted pair cable.
- Contains a signal wire at the center, which is either stranded or solid, surrounded by a metallic shield that serves as a ground. The shield is either braided or solid and is wrapped in plastic.
- Is designed for **baseband** (*original frequency range of a signal before it is modulated into a higher and more efficient frequency),* **broadband** (*telecommunication that provides multiple channels of data over a single communications medium, typically using some form of frequency or wave division*), and television networks.
- **Thick coaxial cable, thicknet, ½"**
  - ✶ Cannot exceed 500 meters
  - ✶ Does not bend easily around tight corners.
  - ✶ Considered the ethernet (*most widely installed LAN technology*) standard, IEEE 802.3**.** *10base5=ethernet LAN running @ 10 Mbps, using baseband transmisssion and thick coaxial cable, .5" dia.*
  - ✶ Works well where magnetic radiation may interfere with cable. Commonly used in hospitals for CT Computed Tomography and MRI Magnetic Resonance Imaging Scanners.
- **Thin coaxial cable, thinnet, ¼"**
  - ✶ Cannot exceed 185 meters
  - ✶ Highly flexible. Works well in small areas
  - ✶ Ethernet standard for small networks. *10base2=ethernet LAN running @ 10Mbps, using baseband transmission and thin coaxial cable, .25" dia.*
- **BNC Connector,** British Naval Connector or Bayonet Neil-Concelman Connector
  - ✶ Crimped to coaxial cable using a bayonet mount to connect to NICs, hubs, etc. The bayonet mount connects signal and ground wires in the coaxial cable to the connector. The connector is then inserted into another connector and turned, which causes the bayonet mechanism to pinch several pins into the BNC's locking groove.

Fiber Optic

- Send data pulses of light over threads of glass in the **gigabits-per-second** range.
- Free of electromagnetic interference and are extremely difficult to tap.
- Consist of 2 small glass strands. One sends and one receives. These strands are called the **core**, and they are sometimes made of plastic. Each core is surrounded by glass cladding, and each core and cladding element is wrapped with a plastic reinforced with Kevlar fibers.
- **Laser transmitters send** the modulated light pulses and **optical receivers receive** them.
- Two major (**frequencies**) types of fiber optic cable:
  1. **Single-mode**
     - ✶ Core diameter is 8 to 10 microns
     - ✶ Often used for intercity telephone trunks and video applications
  2. **Multimode**
     - ✶ Uses a large number of frequencies (or modes).
     - ✶ Core is larger than that of single-mode
     - ✶ Type usually specified for LANs and WANs
- Expensive and requires a professional to install it and connect the network devices; however, technological advances are simplifying the installation and connection process.
- ***100baseFX, 1000baseCX, 1000baseSX and 1000baseLX***

Wireless

- Usually implemented in a hybrid environment that is one which wireless components communicate with a network that uses cables.
- The only difference between a wireless LAN and a cabled LAN is the medium itself, as well as a **wireless NIC and transceiver for each wireless computer. The transceiver is often called the access point because it sends and receives signals to and from the network**.

HARDWARE DEVICES

CSU/DSU Channel Service Unit/Data Service Unit	Modem	Patch Panel
▪ Terminates physical connections ▪ This device is required when using dedicated circuits, such as T1 Lines. ▪ The digital data stream is translated by the **CSU/DSU** into bipolar signals, which are suitable for line transmission. ▪ Also performs some error-reporting and loopback functions and operate at the physical layer ▪ Enters building with **RJ-45** Registered Jack-45	▪ Traditional or Analog modem is a device enabling computers to communicate over phone lines by translating digital data into audio/analog signals (on sending computer) and back into digital form (on receiving computer) ▪ Must define the following when configuring modem for connectivity: 1. **Serial Port IRQ** Interrupt Request. An IRQ Line is used by components to request attention from the system processor. *Serial modems can use IRQ Lines 3 or 4, which are both used for serial ports*. 2. **I/O** input/output **Address.** I/O address transfers info between the CPU and a specific device. *The base I/O port settings for a modem are: COM1 ~ 3F0 to 3FF and COM2 ~ 2F0 to 2FF.* 3. **Maximum Port Speed** for the modem must be set to ensure it functions properly. [*Modem can be any device that adapts a computer to a phone line or Cable TV network, whether it is digital or analog*]	▪ Central point where cables from different areas can be connected to each other forming a LAN and can then be used to connect a network to the internet or other WAN. ▪ One side connects from wall jacks; and the other side connects to network devices such as routers or switches that connect to the internet or other WAN. ▪ Patch cords are used in ports to cross-connect computers that are wired to the patch panel.

LAN METHODS

IEEE (Institute of Electrical & Electronic Engineers) **802 Standard/Ethernet Standards Specify LAN Data Transfer Methods**

CSMA/CD (Carrier Sense Multiple Access/Collision Detection**)**
Access Method (802.3)

IEEE 802 standard divides the OSI/RM Data Link layer into 2 Sublayers:

- **LLC** (Logical Link Control)- manages transmissions and can provide flow control. ***Logical Addresses used to send data over internetworks***.
- **MAC** (Media Access Control) access to LAN media and responsible for placing data on wire. ***Physical Address used to send data between 2 devices on a single network.***

MAC Address: 12 hexadecimal digits burned on NIC (1st 6 digits – vendor code; last 6 digits – interface serial no.)

Broadcast system for communication between systems:

- Ethernet: 10bast2, 10base5, 10baseT. Cat. 3 UTP wiring standard – *can be fiber also*
- Fast Ethernet: 100baseTX, 100baseT4. Cat. 5 UTP wiring standard – *100baseFX (fiber)*
- Gigabit Ethernet: 1000baseT. Cat 5 UTP wiring standard

Token Passing
Access Method (802.5)

- Uses **MAU** Multistation Access Unit to form ring network using internal connections
- Network passes token on one direction around the network
- 4 or 16Mbps data rates
- No specified wiring standard
- Collisions do not occur

Demand Priority
Access Method (802.12)
100VG-Any LAN

- Hub simultaneously arbitrates when and how systems can access the network
- Transmissions with highest priority are serviced first
- Can use Category 3, 4, or 5 UTP, StP or fiber optic cable wiring standards.

CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance)
Network Access Method

- **LocalTalk** is a network type used by **Apple** that specifies each node must inform other nodes of intent to transmit. **Not an IEEE Standard**

FDDI (Fiber Distributed Data Interface**)**
Network Access Method

- Standard specifies the MAC sublayer of the data link layer as well as the physical layers for a 100Mbps counter-rotating, token ring, fiber optic LAN.
- Often used to cover a city or specific geographic area and can be classified as a **MAN** Municipal Area Network

WAN METHODS

PPP Point-to-Point Protocol

Protocol for communication between two computers using a serial interface, typically a personal computer connected by phone line to a server.

SLIP Serial Line Internet Protocol

Protocol used for communication between two machines that are configured for communication with each other, i.e., ISP may provide a SLIP connection so that the provider's server can respond to requests, pass them on to the Internet, and forward requested Internet responses back. Dial-up connection to the server is typically on a slower serial line

ISDN Integrated Services Digital Network

- concept is the integration of both analog or voice data together with digital data over the same network
- requires adapters at both ends
- can have up to 128 Kbps service

X.25

- Packet service used for Automatic Teller Machine transactions
- Operates at 56kbps or slower
- Operates at network layer checking errors at many points along the data's path.

Frame Relay

- Relay service using fast packet switching technology uses fiber optic and digital cabling
- From 64kbps to 1.544Mbps (T1)
- Variable length packets ~ limited error control support
- Use **PVCs** Permanent Virtual Circuits
- Shares physical network with other frame relay networks
- Implemented at the MAC sublayer of Data Link Layer

ATM Asynchronous Transfer Mode

- Fast packet switching commonly used as Internet Backbone
- Typical speeds 155Mbps to 622Mbps with potential of 1.2Gbps supports data as well as real-time video and voice.
- Organizes data into 53 byte fixed-length cells, and bandwidth is allocated depending on the application class being used
- Implemented at MAC sublayer of the Data Link Layer

T-Carrier System

North American (also used in Japan and Korea) digital transmission format that provides dedicated and private-line services for digital voice and data transmission. Usually used to connect a company network to the Internet or a frame relay network

T1=1.544 Mbps: Common digital leased-line service supporting 24 channels at 64 Kbps,, each able to carry voice or data transmission **Fractional T1** yields a rate of 1.536 Mbps and allows leasing channels instead of a full T1 line Connections require:

- **CSU** Channel Service Unit ~ the first point of contact for the T1 wires; it diagnoses and prepares the signals on the line for the LAN
- **DSU** Data Service Unit ~ connects to the CSU and converts LAN signals to T1 signaling formats.
- **Multiplexor** ~ provides a mechanism to load multiple voice and data channels into the digital line.
- **Router** ~ provides the interface between the LAN and the T1 line.

T2=6.312 Mbps (=4 T1 lines) not offered to general public **T3=45,736 Mbps** (=28 T1 circuits)
Fractional T3 allows leasing less than full T3 **T4=274,176 Mbps**

E-Carrier System

European digital transmission format

- E1=2.048 Mbps
- E2=8.448 Mbps
- E3=34,368 Mbps
- E4=139,264 Mbps
- E5=565,148 Mbps

NETWORK OPERATING SYSTEMS

- **A Networking Operating System (NOS)** manages resources on a network. This function includes managing multiple users on a network, providing access to file and print servers, and implementing network security.
- **A Networking Operating System (NOS)** enables clients to access remote drives as if they were on the client's own machine. They also allow servers to process requests from clients and decide whether that client can use a particular resource.
- Similar to a client/server relationship, part of the NOS must run from the client, and part of it must run from the server.
- Major NOSs can inter-operate with one another by creating a network even though the clients and servers use different operating systems. In most cases, software must be installed on the server and client for interoperability.

Novell NetWare Fundamentals

- Most widely installed NOS began in 1989
- NetWare 5 is most recent version and supports
  1. TCP/IP as it's networking protocol
  2. Java as it's application language
- Pre NetWare 5 was a proprietary NOS communicated using:
  1. Internetwork Packet Exchange (IPX) protocol
  2. Sequenced Packet Exchange (SPX) protocol
  3. And NetWare Core Protocol (NCP)

Microsoft Windows NT Fundamentals

- Uses TCP/IP as default network protocol
- Windows New Technology family of NOS
  1. Windows NT Server
  2. Windows NT Workstation
- Windows 2000
  1. Windows 2000 Server (Supports all window clients, 3.1, 95/95, 2000 and NT 4.0 Workstation)
  2. Windows 2000 Professional (replacing Windows NT Workstation)
- Developed to simplify command based DOS operations.
- Dominates PC market

UNIX Fundamentals

- Developed in 1969. Consists of a **kernel** (essential part of operating system, provides basic services, always resides in memory), a **file system**, and a **shell** (a command-based interface).
- Uses TCP/IP as its core networking protocol.
- Multi-user operating system used as a NOS for majority of non-PC networks. Almost all hardware vendors include UNIX as primary or secondary operating system.
- Because there are more than 600 UNIX commands, GUIs (graphical user interfaces) were developed to simplify UNIX operations.
- Popular UNIX versions are RedHat, Linux, Sun Solaris, Digital UNIX, Hewlett Packard HP-UX, SCO UNIX Ware, and IBM AIX (Many IBM mainframes run UNIX)

OPEN SYSTEM INTERCONNECTION REFERENCE MODEL (OSI/RM)

Consists of 7 layers, each reflecting a different function that has to be performed in order for program-to-program communication to take place between computers. Layering is the organization or programming into separate steps that are performed sequentially, defined by specific interfaces for passing the result of each step to the next program or layer until the overall function, such as the sending or receiving of some amount of information, is completed. Exist on both client and server,

3 Practical Functions:
1. Gives developers necessary and universal concepts so they can develop and perfect protocols.
2. Explains the framework used to connect unlike systems.
3. It describes the process of packet creation.

Gateways: Protocol converters operate at any OSI/RM layer and convert from one protocol stack to another (TCP/IP to IPX/SPX or AppleTalk nodes to a DECnet network.

Packet Elements	OSI/RM Divisions	OSI/RM Layers	#	Description of Division of Responsibility Between Layers *Network Components
Packets are fixed pieces of info sent across a network	**Application Layer Protocols** *Packet creation, adding/removing headers. Upper layer protocols that allow applications to speak to one another across networks.* **SMPT, BOOTP, FTP, HTTP, AFP SNMP, SMB, X.500, NCP, NFS**	**Application** *End User Interface*	**7**	Supports file transfer. Communication partners and quality of service are identified. User authentication and privacy are considered, and any constraints on data syntax are identified.
		Presentation *Translator*	**6**	Translator, syntax layer, converts presentation from **ASCII** (American Standard Code for Information Interchange to **EBCDIC** (Extended Binary Coded Decimal Interchange Code.
		Session *Manages Connection*	**5**	Establishes, manages, and terminates connections (sessions) between cooperating applications. Session and connection coordination.
	Transport Layer Protocol *Provides reliable data delivery* **TCP, SPX, NWLink, ATP, NetBEUI**	**Transport** *Complete Data Transfer*	**4**	How packets travel (formatted across wire). Error checking. Ensures complete data transfer. ***Layer 4 Switches** make forwarding decisions based on Layer 4 info, such as the specific **TCP/UDP** (User Datagram) port and application uses, as well as layer 2 and 3.
Header		**Network** *Organizes data into packets, routes and forwards*	**3**	Packages output with correct network address info. ***Routing (IP) Switch** forwards traffic based on if it supports network protocols such as **IP** and **IPX.** ***Brouters** examine all data units, are protocol dependent and can forward to LAN, interconnected LAN or WAN, i.e., bridge DECnet packets and route TCP/IP packets. ***Routers** connect networks that are part of a WAN. Determine best (most efficient) routes for packets offering a number of paths based on networks connected using protocols such as IP and IPX.
	Network Layer Protocols *Provide addressing IP and rules for particular networks* **IP, IPX, NWLink, DDP, NetBEUI, X.25, Ethernet**	**Data Link** ***Formats*** *Provides error control and synchronization for the physical level. Furnishes transmission protocol knowledge & mgmt.*	**2**	Assures initial connection has been set up, divides output data into data frames, and handles the acknowledgements from a receiver that data arrived successfully. Two sub-layers: **LLC** Logical Link Control ~ responsible for error and flow control and **MAC** Media Access Control ~ responsible for placing data on the transmission medium, i.e., copper wire, described in **IEEE** (Institute of Electrical and Electronics Engineers) -802 LAN Standards. ***LAN Switch** forwards traffic based on MAC addresses. ***NICs** operate at this layer (ethernet and token ring) and most contain a transceiver that transmits/receives analog or digital signals.. ***Brouters** (see Layer 3) ***Bridge** Connects a LAN to another LAN using same protocol, i.e., ethernet, token ring. Copies a dataframe from 1 network to the next network using one path. Use **MAC** hardware address to determine segment to receive dataframe and forwards independent of all upper layer protocols.
		Physical *Provides hardware means of sending and receiving data on a carrier.*	**1**	Transmit networking and internetworking binary code over physical line. ***CSU/DSU** hardware device when using dedicated circuits, i.e., T1, converts digital data frames from LAN technology to WAN appropriate frames suitable for line transmission to a Telcom network. Performs some error-reporting and loopback functions. ***Switching Hub** Switch determines how and where data is forwarded, is faster because it can give sender/receiver entire bandwidth. ***Hubs** have several ports interconnecting each node and is where data comes together. ***Repeaters** strengthen signal, remove noise, and make extension of a signal possible over a distance. Receive signal, amplify signal, retransmit to next leg.
Actual Data	Actual client request or server response in binary 1s and 0s			
Trailer	Contains info that validates packet and techniques that ensure errors don't occur during transmission. Receiving computer verifies through mathematical calculation whether packet is valid. Could contain **CRC** Cyclical Redundancy Check ~ error checking control			

MAJOR NETWORKING PROTOCOLS

Connection-oriented: Stateful network protocol. TCP. Connection (session must be made)
Connectionless: Stateless network protocol. IP. "Best effort" technology. Provides addresses for the TCP/IP suite.
Routable: Can travel through LANs, WANs, and beyond because they can pass through a router.
Nonroutable: Predefined, static routes that cannot be changed; don't use functions.of OSI/RM layer. NetBEUI, NetBIOS, LAT, DLC, etc. A bridge can be added to encapsulate a non-routable protocol within a routable protocol.
Combining Protocols: Combining TCP/IP and IPX/SPX provides system redundancy and can speed connectivity. NetBEUI is useful in a LAN or WAN because it can deliver traffic to local computers without TCP/IP overhead.. When someone sends a message to another LAN, the system will automatically use a routable protocol
Binding Protocols: When creating a network must attach (bind) it to NIC Network Interface Card, use a compatible network interface card driver, and choose a protocol. Bind UNIX by reconfiguring the kernel because it incorporates all drivers and protocols. Windows NT, access the Network dialog box.

TCP/IP ***Transmission Control Protocol/Internet Protocol***	**IPX/SPX** ***NOVELL***	**NetBEUI**	**AppleTalk**	**DLC** ***Data Link Control IBM ~ HP***	**SNA** ***System Network Architecture (IBM)***
• Adopted 1/1/83 • Default protocol for NOSs: ✶ WindowsNT 4.0 ✶ Windows 2000 ✶ UNIX ✶ NetWare5 ▪ Ipv6 ~ TCP version 6 ▪ Suite of Protocols **TCP** ensures reliable communication and uses ports to deliver packets. Fragments and reassembles messages using a sequencing function to ensure that packets are reassembled in the correct order. **IP** connectionless protocol responsible for providing addresses of each computer and performing routing. 32 bit addresses falling into 5 classes, A-D, divided into halves, network portion and host portion. Subnet mask helps determine which bits form the network and host portions. **TCP/IP is an open-ended architecture that allows unlike networks to communicate efficiently.** **UDP** User Datagram **ICMP** Internet Control Message **ARP** Address Resolution	▪ Once-dominant LAN/WAN protocol ▪ Microsoft supports IPX/SPX (renamed it NWLink, NetWare Link ▪ Protocol Suite ✶ **IPX** Internetwork Packet Exchange resides at the **network layer** of the OSI/RM. Responsible for network addressing and forwarding packets to their destination, which is called routing. **NOVELL** proprietary ✶ **SPX** Sequenced Packet Exchange connection-oriented **transport layer protocol** that uses services provided by IPX ▪ **Advantages:** Thousands of IPX/SPX WANs, private networks and VPNs use to communicate over long distances. Offers better performance than TCP/IP. ▪ **Disadvantages:** Developed for Novell NetWare networks and is not a vendor-neutral protocol. IPX/SPX is not supported on the internet	▪ **Network Basic Input/Output System** (NetBIOS) **Extended User Interface** ▪ 1st developed by IBM ▪ A non-routable protocol which limits its usefulness in many networks ▪ Microsoft implemented as peer-to-peer network solution ***Appropriate for small peer-to-peer networks mainly because it is fast, has low overhead, and is easy to configure and maintain.***	▪ Proprietary ~ used only in Apple networks ▪ AppleTalk Phase II allows this protocol to work with others. ▪ Divides groups of computers into zones rather than using the term domain or network.	▪ IBM developed to enable client machines to work with mainframes ▪ HP has adopted as a means to connect its laser printers to LANs	▪ IBM introduced in 1974 as a mainframe network architecture ▪ Includes a network topology and a series of protocols which inspired creation of the OSI/RM 1. Physical control layer 2. Data Link control layer 3. Path control layer 4. Transmission control layer 5. Data Flow control layer 6. Transaction services layer (which interfaces with application subsystems) ▪ Widely used within mainframe networks

<table>
<tr><th>OSI/RM Divisions</th><th>OSI/RM Layers</th><th>#</th><th>Internet Architecture Protocol Layers</th><th colspan="5">Internet Protocols: TCP/IP is most widely used networking protocol suite in the world & allows computers from different vendors with various operating systems/capabilities to communicate.</th></tr>
<tr><td rowspan="3">Application Layer Protocols</td><td>Application
End User Interface</td><td>7</td><td rowspan="2">Application
Process Layer

Interacts with transport layer protocols to send or receive data</td><td colspan="5">Users Can Invoke Application Programs</td></tr>
<tr><td>Presentation
Translator</td><td>6</td><td>HTTP
Hypertext Transfer Protocol
RFC1945 & 2068
Transports HTML documents across internet. Requires browser at one end and server at other.</td><td>FTP
File Transfer Protocol
RFC959, STD9
System for transferring files between computers on a TCP/IP network.</td><td>Telnet
Remote Terminal Protocol
RFC854/855, STD8
Allows user at one site to log on and run programs from a remote system.</td><td>NNTP
Network News Transfer Protocol
RFC977
Allows internet sites to exchange Usenet news articles via authorized access to NNTP server.</td><td>Gopher
RFC1436
Menu-based program used to find (search) file structures (resources) maintained on servers</td></tr>
<tr><td>SMTP
Simple Mail Transfer Protocol
RFC821, STD10
Specifies how 2 mail systems transfer email messages between computers. (POP3)</td><td>SNMP
Simple Network Management Protocol
RFC1157, STD15
Standardized TCP/IP network management scheme.</td><td>DNS
Domain Name Service
RFC1034/1035, STD13
DNS servers translate computer names into IP addresses.</td><td>BOOTP
BOOTstrap Protocol
RFC951/1497/2132
RARP alternative BOOTP specifies internet, router, server addresses on startup.</td><td>DHCP RFC2131
Dynamic Host Configuration Protocol
Assigns Internet, router, server addresses to nodes on TCP/IP networks during initialization.</td></tr>
<tr><td rowspan="2">Transport Layer Protocol</td><td>Session</td><td>5</td><td rowspan="2">Transport
Host-to-host layer
End-to-end Layer
Source-to-destination Layer</td><td colspan="5">Accepts application layer data and provides the flow of information between 2 different protocols
Also divides the data received from the application layer into smaller pieces, called packets</td></tr>
<tr><td>Transport</td><td>4</td><td colspan="2">TCP (RFC793, STD7)
Transmission Control Protocol
Session must be established. Provides session management between systems ensuring data delivery in sequence without duplication of data</td><td colspan="3">UDP (RFC768, STD6)
User Datagram Protocol
Session not necessary. One UDP packet is created for each output operation by an application. Does not provide congestion control, use acknowledgements, re-transmit lost datagrams, or guarantee reliability.</td></tr>
<tr><td rowspan="4">Network Layer Protocols</td><td>Network</td><td>3</td><td rowspan="2">Internet

Responsible for routing packets on TCP/IP Networks</td><td colspan="5">A packet received from the transport layer is encapsulated in an IP packet. Based on the destination host information, the Internet layer uses a routing algorithm to determine whether to deliver the packet locally or send it to a default gateway</td></tr>
<tr><td colspan="2">ICMP (RFC792, STD5)
Internet Control Message Protocol
Troubleshooting Protocol allows Internet hosts/gateways to report errors through ICMP messages.

ARP (RFC826, STD37)
Address Resolution Protocol
Translates Internet addresses to physical addresses; sends local broadcast and obtains hardware address; stores for future requests.</td><td rowspan="2">IP (RFC791, STD5)
Internet Protocol
Basic Internet data transfer method; Performs routing function selecting data path to IP address; Data sent in form of packets or datagrams (self-contained packets); Defines how gateways and routers process packets, when error messages are generated, and under what conditions packets are discarded.</td><td colspan="2">IGMP (RFC1112, STD5)
Internet Group Management Protocol
Source multicasts (sends) message to subscribed members of a multicast group.

RARP (RFC903, STD38)
Reverse Address Resolution Protocol
Uses node's hardware address to request an IP address from diskless workstation w/o IP address.</td></tr>
<tr><td>Data Link
Formats
.</td><td>2</td><td rowspan="2">Network Access

Places data on network media and pulls data off, i.e., LANs (ethernet, token ring, FDDI); WANs (frame relay, serial lines and ATM)</td><td colspan="5" rowspan="2">Accepts higher layer datagrams and transmits them over the attached network, handling all the hardware details of interfacing with the network media. This Layer usually consists of:
✶ The operating system's device driver
✶ The corresponding interface card.
✶ The physical connections (wire)
For ethernet-based LANs, the data sent over the media are called ethernet frames, which range in size from 64 to 1,518 bytes (1,514 bytes without the Cyclical Redundancy Check)</td></tr>
<tr><td>Physical
.</td><td>1</td></tr>
</table>

OSI/RM DIVISION ACRONYMS

Application Layer Protocols Acronyms	Transport Layer Protocol Acronyms	Network Layer Protocol Acronyms
SMTP Simple Mail Transfer Protocol ~ TCP/IP email **BOOTP** Bootstrap Protocol ~ seen on dumb terminals and sends TCP/IP address configuration info to hosts. **FTP** File Transfer Protocol ~ TCP/IP transfers files between 2 hosts **HTTP** Hypertext Transfer Protocol ~ TCP/IP WWW uses to interconnect web pages **AFP** AppleTalk Filing Protocol ~ used exclusively in AppleTalk networks to exchange files **SNMP** Simple Network Management Protocol ~ TCP/IP allows network administrators to troubleshoot and manage networks regardless of architecture **SMB** Server Message Block Protocol ~ used in Microsoft networks allowing clients and servers to access files and request other services **X.500** ~ OSI directory that manages online user/directory resources **NCP** Novell Core Protocol ~ allows files and printer to be shared on a NetWare network **NFS ~** Network File System ~ allows files and printers to be shared on a UNIX network	**TCP** Transmission Control Protocol ~ provides reliable delivery and manages sessions ~ UNIX All **SPX** Sequenced Packet Exchange Protocol ~ manages **Novell** communication sessions **NWLink ~** Microsoft version of Novell IPX/SPX **ATP** ~ AppleTalk networking suite provides reliable transmissions between MAC hosts. **NetBEUI** ~ Windows NT non-routable protocol allows different applications on different computers using NetBIOS to communicate with one another.	**IP** Internet Protocol ~ responsible for addressing hosts in any network running TCP/IP, including the internet **IPX** Internetwork Packet Exchange ~ Novell IPX/SPX **NWLink ~** Microsoft version of IPX/SPX **DDP** Datagram Delivery Protocol ~ AppleTalk networking suite **NetBeui ~** non-routable protocol uses NetBIOS **X.25 ~** WAN connection oriented protocol, precursor to frame relay technology **Ethernet ~** most popular LAN protocol 10 BASE-T (Xerox and DEC created)