Networking Basics

Data communications – the electronic transfer of information between computers. This has become a major focus of the computer industry especially since the rapid growth of the internet.

Networks can include all computers and devices in a department, building or multiple building spread over a large geographical area. Many networks carry voice, audio and video traffic.

Uses of a network

A network is a way to connect computers so that they can communicate, exchange information and share resources in real time. Networks enable multiple users to access shared data and programs instantly.

Four of the most important benefits of networks

1. Simultaneous access to critical programs and data.
2. Sharing of peripheral devices such as printers and scanners.
3. Streamlining personal communications.
4. Easier backup process.

Simultaneous Access

Multiple users may need to access the same data at the same time. Without a network that enables file sharing each user typically keep separate copies of the data on different disks and universally updating the data is difficult.

This problem is solved by determining which data is used by more than one person and storing it on a **network server** – a central computer that provides a storage device and other system resources that all users can share. If the server stores data files for users to access it is commonly called a **file server**. A single master copy of the data file is stored on the server which users can access whenever they need.

To protect the integrity of the data users can be granted 2 basic types of access to it

1. Read Only
   Some users are entitled only to read the data. The user can read (retrieve) the data but cannot write changes to the master data files. This type of protection prevents unwanted changes from being made to the data.
2. Read/Write
   Some users may be allowed to open shared files from the network server and to make changes to the files. When such users make changes to the files the updated file can be viewed by all users.

With supervisor rights a user can perform any task on the files. Network managers can assign specific access rights to each user on the network on a per-drive, per-folder or per-file basis.

In addition to using the same data files users also use many of the same programs. In a non-networked PC environment each PC must have a separate copy of the software. This can prove expensive and time consuming. 2 solutions to this problem

1. Site Licences – a business purchases a single copy of an application then pays the developer for a licence to copy the application to a specified number of computers. Each user has a complete individual copy of the program on separate PCs but the business generally pays less for the site licence than to individually licence each separate copy.
2. Network versions – Connect the users computers to a central network server and enable users to share a network version of a program. Only one copy of the application is stored on the network server with a minimum number of supporting files copied to each individual computer. The program is loaded from the sever into the individual RAM when needed. In the case where the network server handles some or all of the processing tasks it is called an **application server** because it handles some application processing as well as storage.

Some software designed for networks is classified as **groupware**. This type of software includes scheduling software, email and document management software. Groupware allows multiple users on a network to co-operate on projects. Best know examples of groupware are Lotus notes, Microsoft exchange and Novell Groupwise.

Shared Peripheral Devices

Best incentive to link computers in a network → sharing of peripheral devices such as laser printers.

By using a process called **spooling** multiple users can send print jobs to a printer simultaneously. When users send documents (**print jobs**) to a networked printer each job is stored temporarily on the file server. As the printer finishes a job the next one is sent by the file server so it can be printed. An advantage to spooling is that it allows the user to continue working while the document is printing.

Personal Communications

One of the most far reaching applications of data communications is **electronic mail (email)**, a system for exchanging written messages (or voice and video) through a network.

Each user has a unique identifier typically referred to as an email address. To send an email message you must use an email program that works with the network to send and receive.

Process for sending and receiving email

1. Sender composes message and sends it.
2. Message is stored on the server
3. Server alerts recipient that there is a message.
4. when the recipient is readyto read the message he retrieves it from the server.

Many email systems allow you to attach data files to a message. This allows uses to share files even when they do not have access to the same storage devices.

A **teleconference** is a virtual meeting in which a group of people in different locations conduct discussions by typing messages to each other. Each message can be seen by all participants.

If users have the necessary hardware and software, they can see and speak to each other as they meet online – **videoconferencing**.

Easier backup

If all valuable data is kept on a shared storage device that user access through a network then the person managing the network has the responsibility of making regular backups of the data on this device.

How networks are structured

2 main types of networks distinguished mainly by geography,

- Local Area Network
- Wide Area Network

Some networks use servers

- Server based Networks

Some don't

- Peer – to – Peer Networks.

Local Area Networks

A **local area network (LAN)** is a network of computers located relatively near to each other and connected in a way that enables them to communicate with each other. A LAN can consist of just 2 or 3 PCs connected together to share resources or can include hundreds of different computers. Any network that exists within a single building or group of adjacent buildings is considered a LAN.

It may be helpful to connect different LANs together. To understand how this may be possible there is a need to understand how networks transmit data and how different types of networks share data.

On a small network data is broken into small groups called packets before being transmitted from one computer to another. A **packet** is a data segment that includes a header, payload and control elements that are transmitted together. The receiving computer reconstructs the packet into the original structure.

The payload is the part of the packet that contains the actual data being sent. The header contains info about the type of data in the payload, the source and destination of the data and a sequence number so that data from multiple packets can be reassembled at the receiving computer in the proper order.

Each LAN is governed by a **protocol**, which is a set of rules and formats for sending and receiving data and an individual LAN may utilise more than 1 protocol.

Some of the mail protocols in use today include

- **TCP/IP**
  Originally associated with UNIX hosts, this is the protocol of the internet and is required on every client machine for direct communication across the internet to occur. TCP/IP is now the default networking protocol on Win. 2000 and many other OS.
- **IPX/SPX**

A proprietary protocol of Novell and has been used in most versions of the Netware network OS for networking offices throughout the world.

- **NetBEUI**
  Relatively simple protocol with no real configurable parameters. Sends messages through broadcasts to every computer that can receive it. It is an excellent protocol for networking small offices or homes but does not expand well into larger environments. NetBEUI was the default networking protocol of Win 3.11, Win 95 and other Microsoft client OS.
- **DLC**
  Originally a protocol used with large mainframe computer systems, it is now used to control communications with network printers. It allows the printers to be configured remotely and to send status messages.

If 2 LANS are built around the same communication rules then they can be connected with one of 2 devices

1. **Bridge**
   A device that looks at the information in each packet header and forwards the data that is travelling from one LAN to another.
2. **Router**
   More complicated device that stores the routing info for networks. Like a bridge a router looks at the packet header to determine where the packet should go and then determines a route for the packet to take and thus reach its destination.

If you need to create a more sophisticated connection between networks you need a **gateway**, a computer system that connects the 2 networks and translates information from one to the other. Packets from different networks have different types of information in their headers and the info can be in various formats. The gateway can take a packet from one type of network, read the header, encapsulate the whole packet into a new one, adding a header that is understood by the second network.

Wide Area Network

A **wide area network (WAN)** is 2 or more LANs connected together generally across a wide geographical area. Each site needs resources, data and programs locally but it also needs to share data with the other site. To accomplish this routers can be connected over public utilities (such as phone lines) to create a WAN. A WAN does not have to include any LAN systems e.g. 2 distant mainframe computers can communicate through a WAN even though neither is part of a LAN.

Geographical distance aside the main difference between a WAN and a LAN is the cost of transmitting data. In a LAN all components are typically owned by the organisation that owns them. To transmit data across great distances a WAN based organisation typically lease many of the components used for data transmission – such as high speed phone lines or wireless technologies such as satellite.

Server based Networks

Describing a network as a LAN or WAN gives no info on how individual computers on a network (**nodes**) interact with each other.

Many networks includes not only nodes but also a central computer with a large hard disk used for shared storage – the server.

One relatively simple implementation of a network with nodes and a file server is a **file server network**. This arrangement allows each node to have access to the files on the server but not necessarily to files on other nodes. When a node needs information from the server it requests the entire file. In other words the file server is simply used to store files and to forward them on to the nodes that request them.

Client/server Networks

Client/server networks are a hierarchical strategy in which individual computers share the processing and storage workload with a central server. This type of arrangement requires specialised software for both individual node and the server, this software can be used on both LANs and WANs.

Most common example

- A database that can be accessed by many different computers on a network. Database is stored on the network server as is the server portion if the database management system (DBMS) which allows users to add or extract info from the database.

Client/server software is valuable to large modern organisations because it distributes processing and storage workloads among resources efficiently, users get the info that they need faster.

This is also a commonly used model on the Internet. Users typically have client software that provides an easily used interface for interacting with this giant WAN.

Peer – to – Peer Networks

In a **peer – to – peer** network (sometimes called a workgroup) all nodes on the network have equal relationships with all others and all have similar types of software that support the sharing of resources. The relationship is typically non-hierarchical.

Some high-end peer – to – peer networks allow distributed computing, which enables users to draw on the processing power of other computers in the network.

Peer – to – peer networks are commonly set up in small organisations or schools where the primary benefit of a network is shared storage and printers or enhanced communications.

Network Topologies for LANs

Another distinguishing feature among LANs is the topology – the physical or logical layout of the cables and devices that connect the nodes of the network. The 3 basic topologies are,

- Bus
- Star
- Ring

A less common one is

- Mesh

Factors in determining the topology or combination of topologies to use include

- Type of computers currently installed
- Type of cabling (if any) currently installed
- Cost of components and services required to implement the network
- Distance between each computer
- Speed with which the data must travel around the network.

The Bus Topology

A **bus** network uses a single conduit to which all the nodes and peripheral devices are attached.

Each node is connected in series to a single cable, at the cables start and end points a special device called a terminator is attached. This stops the network signals so they do not bounce back down the cable.

The disadvantages

- Keeping data from colliding requires extra circuitry and software.
- A broken connection can bring down or crash all or part of the network.

Primary advantage

- Uses the least amount of cabling of any topology.

<u>The Star Topology</u>

The **star** network is the most commonly used topology today. A device called a **hub** is placed in the centre of the network so all nodes are connected to the central hub and communicate through it.

Some hubs known as intelligent hubs can monitor traffic and help prevent collisions. A broken connection does not affect the rest of the network. If you lose the hub however all nodes connected to that hub are unable to communicate.

The Ring Topology

The **ring** topology connects the nodes of a network in a circular chain with each node connected to the next. The final node in the chain connects to the first one to complete the ring.

With this methodology each node examines data sent through the ring. If the data (known as a **token**) is not addressed to the node examining it, it passes it along to the next node in the ring.

There is no danger of collisions because only one packet of data may traverse the ring at a time. If the ring is broken the entire network is unable to communicate until the ring is restored.

The Mesh Topology

The **mesh** topology is the least used topology and the most expensive to implement. A cable runs from every computer to every other computer.

Advantage

- The data can never fail to be delivered, if one connection goes down there are other routes available.

This topology is impractical for most working environments but is ideal for connecting routers on the Internet.

Network Media and Hardware

Twisted-Pair Cable

Normally consists of 2 wires individually insulated in plastic and then twisted around each other and bound together in another layer of plastic.

Except for the plastic nothing shields the wire from outside interference so it is sometimes called UTP (unshielded twisted-pair). Some wires are encased in a metal sheath and are therefore called STP (shielded twisted-pair).

This type of wire is also sometimes called telephone wire as it is used for indoor telephone wiring. Today most twisted-pair wire used for network communication is made to more demanding specifications than voice grade wire.

Network media are sometimes compared by the amount of data that they can transmit per sec. The difference between the highest and lowest frequencies of a transmission channel is known as **bandwidth** – the higher the bandwidth the more data that can be transferred at any one time. Networks based on twisted-pairs now support transmission speeds of up to 1Gbps.

Coaxial Cable

Sometimes called **coax** is similar to cable used in cable television systems. There are 2 conductors in a coaxial cable – one is a single wire at the centre of the cable and the other is a wire mesh shield surrounding the first wire with an insulator in between.

It can support transmission speeds up to 10 Mbps and so can carry more data than older types of twisted-pair wiring. It is more expensive and less popular than the newly improved twisted-pair technology. 2 types of coaxial cable are used

- Thick – old and seldom used in new networks.
- Thin

Fibre-Optic Cable

A thin strand of glass that transmits pulsating beams of light rather than electric frequencies. The strand carries the light all the way from one end to the other bending around corners on the way. Light travels at much greater speeds than electrical signals → fibre-optic cables can carry data at more than a billion bps. Speeds are now approaching 100Gbps.

Fibre-Optics offer extraordinary bandwidth and are a very secure transmission medium. It is however relatively expansive and difficult to install.

Wireless Links

Wireless communication relies on radio signals or infrared signals for transmitting data.
4 common uses

1. Office LANs can use radio signals to transmit data between nodes.
2. Laptops can be equipped with cellular phone equipment and a modem.
3. Corporate WANs often use microwave transmission to connect 2 LANs within the same area. Requires unobstructed line of sight between 2 antennas.
4. WANs that cover large distances often use satellites and microwave communication.

Network Interface Card, Network Protocols and Cabling Specifications

Cables or wireless technologies are used to link a network together in a topology. Regardless of the wiring and topology the network still needs a hardware component to control the flow of data – the **NIC** (network interface card).

Ethernet

The most commonly used network technology originally designed for the bus topology and thick coaxial cable. A new technology uses pre-existing telephone wiring to provide a network medium for interconnecting computers. Easy to integrate and does not require installing any new media.

With Ethernet, if 2 nodes transmit simultaneously the collision is detected and they retransmit one at a time – this approach is called carrier sense multiple access/collision detection (CSMA/CD).

Most popular implementation of Ethernet is called 10Base-T and uses a star topology and twisted-pair, speeds up to 10Mbps.

Fast Ethernet

100Base-T is available using the same media but different NICs are used to achieve speeds of up to 100Mbps.

Token Ring

IBMs network technology – controlling hardware transmits an electronic token to each node on the network many times per sec if the token is not already in use by another node. A computer can copy data into the token and set the address where the data should be sent. The token continues around the ring until it reaches the required destination. The receiving computer then sends an acknowledgement. The tokens status is then reset to empty.

Hardware is expensive and speeds can go up to 100Mbps.

Network Software

The group of programs that manage the resources on the network is often called the **network operating system (NOS)**.

Popular NOS include

- Novell NetWare
- Microsoft Windows NT Server 4.0
- Microsoft Windows 2000
- Banyan VINES
- AppleShare
- Linux

Data communications over Standard Telephone Lines

The alternative to using dedicated media is to use the telephone system – called POTS (plain old telephone system). This is a popular option because it is really just a giant electronic network owned by the telephone companies.

By connecting your computer to the phone line you can potentially send data to anyone else in the world. Typically analogue lines that carry voice signals are not well suited to carrying data because the limit for transmission speeds is only about 0.005 as fast as a 10Base-T Ethernet network.

In response to user demand Hayes Microcomputer Products Inc. developed the first modem for PCs in 1978.

Modems

Attaching a computer to an analogue telephone line requires a modem. Because a computers voice is digital – on and off pulses representing 1s and 0s – the modem (short for modulator-demodulator) is needed to translate the digital signal into analogue signals that can travel over the phone line. Modulation phase → modem turns computers digital signal into analogue. Demodulation → opposite.

Choosing a modem

A modem can be an expansion card that plugs into an expansion slot or can be an external device that plugs into a serial port.

A software modem replaces most of the hardware with an application program.

Considerations

1. Transmission speed - bps
2. Data Compression – technologies to shrink the size of the data prior to sending, standard today v90.
3. Internal vs External – external modem is a box housing the circuitry outside the computer. Internal modem is a circuit board that plugs into an expansion slot.
4. Error Connection – error connection protocols enable a modem to detect errors in the data being received and request a resend.

Modems also come in the form of cards for a laptop – referred to as PCMCIA cards.

Cable modems perform functions similar to a standard modem but connect through the cable TV system.

Most modems emulate fax machines and can exchange faxes with any other fax machine or fax modem.

Uses of a modem

File transfer – term used to describe sending a file to a remote computer. Act of sending is known as **uploading** and receiving is known as **downloading**. For a file to be transferred between 2 modems both computers must use the same file transfer protocol (FTP). The most common FTPs are

- Kermit
- Ymodem
- Xmodem
- Zmodem

Modem communication is **full-duplex** – data can travel in both directions at the same time. Modem communications can be **half-duplex** – data can be sent in only one direction at a time. In either type the receiving computer can respond to the sender and verify the data received contained no errors. If there are errors the sending computer resends the incorrect portion.

Using Digital Phone Lines

The transformation from analogue to digital will affect most users in 3 ways

1. You will need a new phone – digital one that translates your voice into bits rather than an analogue signal.
2. No modem will be needed to send data, just an adaptor.
3. You can send data much quicker.

ISDN, T1 and T3

ISDN – integrated services digital network, is a system that replaces analogue services with digital services.

BRI (basic rate ISDN) provides 3 communication channels on one line – 2 64kbps data channels and 1 19kbps control channel. The 2 data channels can be used simultaneously.

A higher level of service is called primary rate ISDN or PRI providing 24 channels at 64kbps each → total bandwidth of 1.554Mbps. This level of bandwidth is referred to a T1.
T3 offers 672 channels → 44.736Mbps.

DSL Technologies

Digital subscriber line (DSL), less expensive than ISDN and much faster.

Several types

- ADSL – Asymmetrical, Upstream – 1Mbps, Downstream 8Mbps.
- RADSL – Rate adaptive, Upstream – 512kbps, Downstream 1.554Mbps.
- HDSL – High bit rate, Upstream – 1.554Mbps, Downstream 1.554Mbps.
- IDSL – ISDN, Upstream – 128kbps, Downstream 128kbps.
- SDSL – Symmetric, Upstream – 1.554Mbps, Downstream 1.554Mbps.
- VDSL – Very high rate, Upstream – 1.6Mbps, Downstream 12.96Mbps.

ATM

Asynchronous transfer mode – a protocol designed as a more efficient way to send voice and computer data over a single network.

Fast, flexible and well suited to all types of data it has become the technology used for backbones in telephone company branches.