BSc in Telecommunications Engineering

TEL3214

Computer Communication Networks

Lecture 01
Introduction to Computer Networking

Eng Diarmuid O'Briain, CEng, CISSP

Department of Electrical and Computer Engineering,
College of Engineering, Design, Art and Technology,
Makerere University

Table of Contents

Illustration Index

1. Introduction

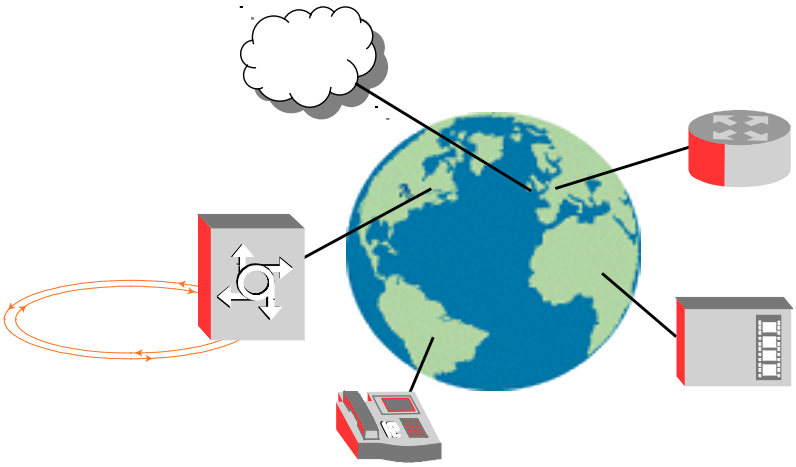


Illustration 1: Global networks

Today there is a tremendous growth in demand for high speed Internet access, driving a demand for very high speed cores as more and more applications become more and more connected. This is witnessed by the continuing requirement for high speed Internet access by individual home users as well as school and business users. The data and telecommunications industries struggle with the continuous demand for ever increasing speeds.

Those working in the field also require knowledge of technologies that were traditionally separated. It is this coming together of both Wide Area Networking (WAN) and Local Area Networking (LAN) technologies that demands an increased set of skills.

This course is intended to cover the various areas that are important to fully grasp the implementation and administration of networks and give you a fundamental grounding in the principal technologies used to connect computers.

1.1 Basic Concepts

- **Communications**
  - o is the activity associated with distributing or exchanging information.

- **Telecommunications**
  - o is the technology of communications at a distance that permits information to be created anywhere and used everywhere with little delay.

Today this involves the transmission of:

- **Data**
  - o digital and analogue.
- **Voice**
  - o spoken word.
- **Video**
  - o telecommunication imaging.

1.2 Essentials for Communications

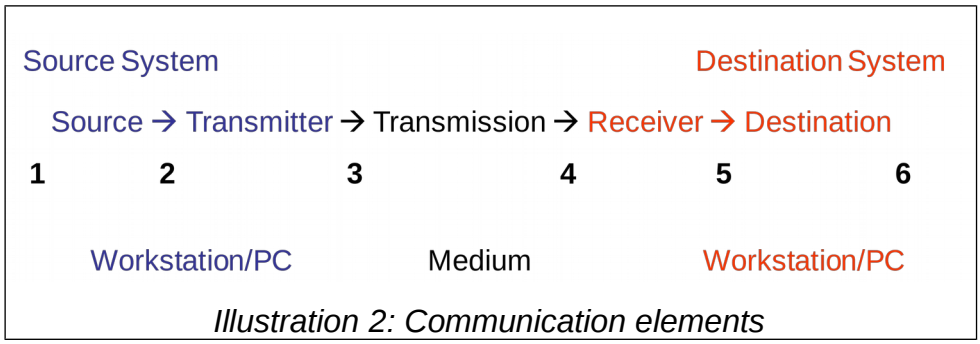


Illustration 2: Communication elements

- Must have a message
- Message must have a transmitter
- Message must have a medium
- Message must be understood
- Message must have some level of security

1.3 Data Communication Tasks

Data System Utilisation	Addressing	Multiplexing Capacity Congestion Control
Interfacing	Routing	Router / Server / Media Control / Protocol
Signal Generation	Recovery	Repeater/Amplifier; Propagation; Interoperable
Synchronisation	Message Formatting	Signal Begins & Ends
Exchange Management	Security	Nature and Timing of Signal
Error Detection & Correction	Network Management	Signal Distortion Bit Error
Flow Control		Routing Delivery Error Feedback

Illustration 3: Communication tasks

1.4 What is a Network ?

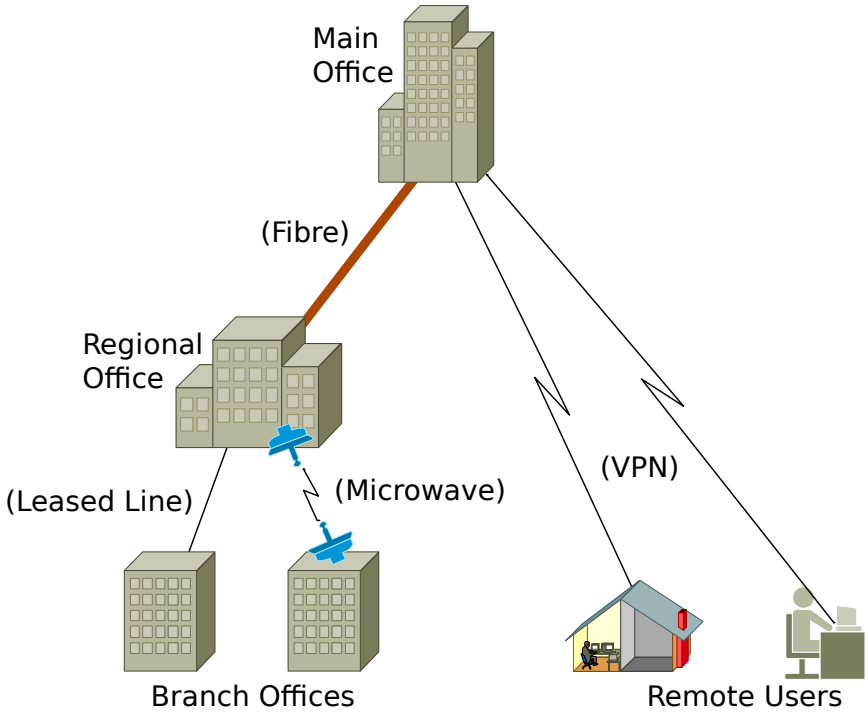


Illustration 4: Network

A network is a connected collection of devices and end systems that can communicate with each other.

Networks carry data in many kinds of environments, including homes, small businesses and large enterprises.

Networks generally centre around a main office to which all other offices or people are connected via the network and where the bulk of accessible information is located. This may be duplicated for redundancy and security purposes. The main

office can consist of several connected networks, which span floors within a building or it may contain several buildings.

This main office may have many and a variety of different type remote locations or remote individuals connected to it. These remote locations are generally called Branch offices and in these a small number of people operate. These branches can be linked via a link provided by a telecommunications company, an independent microwave radio link or even over the internet via a Virtual Private Network (VPN) router.

The other type of remote site is the location independent user working from a home office, hotel or even while mobile, these users generally connect to the network over the internet via a Virtual Private Network (VPN).

1.5 What are the major parts of a network ?

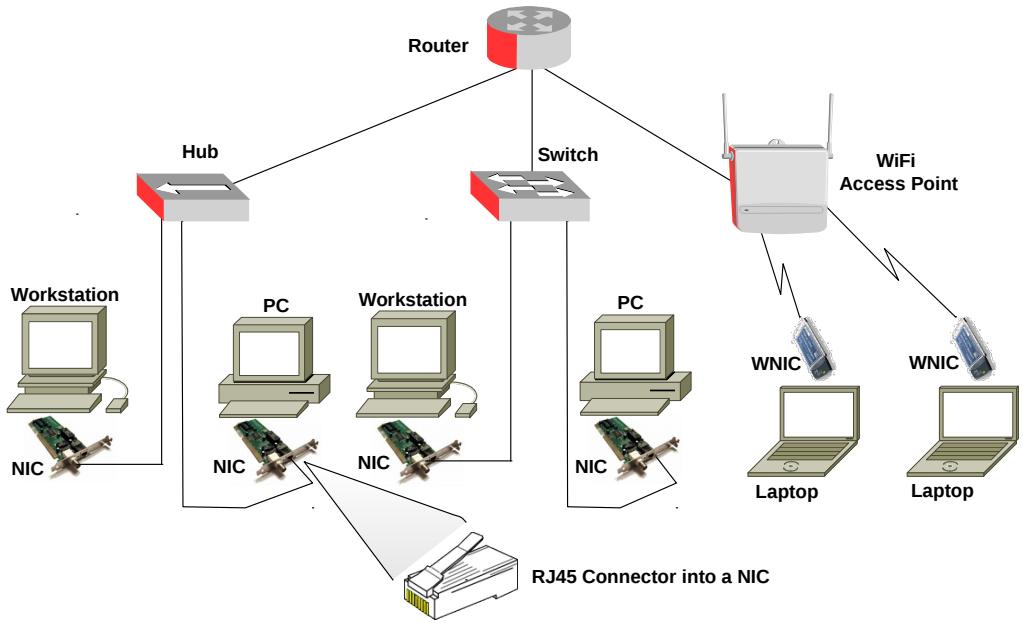


Illustration 5: Parts of a network

The **Computer** serves as end points in a network, sending and receiving data. This can be a UNIX Server or Workstation an Apple Macintosh, a workstation or Laptop running Windows or Linux.

Computers are interconnected with components that provide a means for data to travel between each other in the network.

- Network Interface Cards (NICs) or Wireless NICs
  - Translate the data produced by the computer into a format that can be transmitted over the local network.
- Network Media
  - Cables (Patch leads, Straight through, cross over) or wireless media (e.g. 802.11 Wireless PC Card) provide the means by which the signals are transmitted from one networked device to another.
- Connectors
  - Provide the connection points for the media (RJ 45 connector).

- Hubs join multiple computers (or other network devices) together to form a single network segment. On this network segment, all computers can communicate directly with each other.
-
- Switches also join multiple computers together however instead of creating a single network segment they divide the network into multiple segments and selectively bridge between the segments after learning about the devices connected to it.
-
- Routers interconnect networks and choose the best paths between them.

1.6 Resource-Sharing

Networks allow end users to share both information and hardware resources.

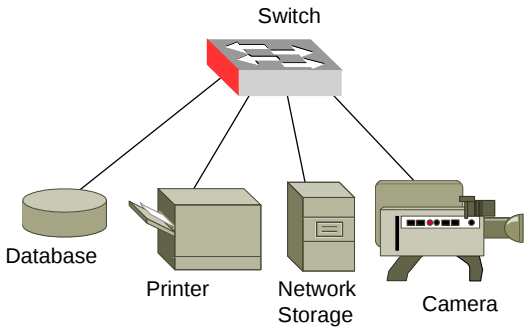


Illustration 6: Resource Sharing

The major resources that are shared in a computer network include the following:

- **Data and Applications**
  - When users are connected through a network, they can share files and software programs, making data more easily available and promoting more efficient collaboration on work projects.

- **Resources**
  - The resources that can be shared include both input devices, such as cameras and output devices, such as printers.

- **Network Storage**
  - There are several ways in which the network makes storage available to users. Direct attached storage (DAS), directly connects physical storage to a workstation or a shared server. Network attached storage (NAS) makes storage available through a special network appliance. Finally, storage area networks (SANs) provide a network of storage devices.

- **Backup Devices**
  - A network can also include backup devices, such as tape drives, that provide a central capability, business continuance and disaster recovery.

1.7 Network User Applications

1.7.1 E-mail / I-Mail

This is a very valuable application for most users on networks. Users can communicate information (Messages and files) electronically in a timely manner not only to other users on the same network but also to other users outside the network.

1.7.2 Web Browser

This application allows access to the Internet/Intranet, which provides a wealth of information to both home and business users and it has become vital to productivity in both these environments. The most commonly used browsers are MS Internet Explorer and Mozilla Firefox.

1.7.3 Instant Messaging

This type of application started in the personal user to user space, however, it soon provided considerable benefit in the corporate world. There are now many instant messaging applications, which provide encryption and logging.

1.7.4 Collaboration

Working together as individuals or groups is accomplished much more easily when the people collaborating on a project are on a network. Individuals who are creating separate parts of an annual report or business plan, for example, can create their data files and either transmit them to a central resource for compilation or use a workgroup software application to create and modify the entire document without any exchange of paper. One of the best known collaboration software programs is Lotus notes.

1.7.5 Databases

A Database is a structured collection of records or data that is stored in a computer so that a program can consult it to answer queries. The records retrieved in answer to queries become information that can be used to make decisions. The computer program used to manage and query a database is known as a database management system (DBMS). Oracle, MySQL and Micosoft SQL Server are well known examples.

1.8 Network Monitoring & Management Tools

There are also a number of applications that provide administrators of networks with a means to monitor the network.

1.8.1 Packet Sniffer or Network Analyser

Computer software application or computer hardware that can intercept and log traffic passing over a digital network or part of a network.

As data streams travel back and forth over the network, the sniffer captures each packet and eventually decodes and analyses its content according to the appropriate RFC or other specifications.

Packet Sniffers:

- Analyse network problems.
- Detect network intrusion attempts.
- Gain information for effecting a network intrusion.
- Monitor network usage.
- Gather and report network statistics.
- Filter suspect content from network traffic.
- Spy on other network users and collect sensitive information such as passwords.
- Reverse engineer protocols used over the network.
- Debug client/server communications.

Wireshark is a well-known free software protocol analyser, or "packet sniffer" application, used for network troubleshooting, analysis, software and protocol development, and education. It has all of the standard features of a protocol analyser. Wireshark "understands" the structure of different network protocols and is thus able to display encapsulation and single fields and interpret their meaning.

Wireshark can be downloaded from http://www.wireshark.org

1.8.2 Network Management

Involves configuring, monitoring and troubleshooting, and also upgrading as networks grow to accommodate more users and communication requirements.

Typical Network Management tasks:

- Documents the devices on a network and the status of each device.
- Managing software licences.
- Controlling computers on the network remotely.
- Receiving notifications of network problems.

1.9 Network Characteristics

While networks can be defined and compared in a number of ways, a commonly used set of characteristics can be used to describe various network types.

1.9.1 Speed

This is a measure of how fast data is transmitted over the network. This is typically termed the data rate.

1.9.2 Cost

This indicates the general cost of components, installation and maintenance of the network.

1.9.3 Security

This indicates how secure the network itself is and also the data that is transmitted over the network. Security is important and constantly evolving. Security should be considered whenever you take actions that affect the network.

1.9.4 Availability

This is a measure of the probability that the network will be available for use when it is required. For networks that are meant to be used 24/7 365 days a year availability is calculated by dividing the time it is actually available by the total time in a year and then multiplying by 100 to get a percentage.

1.9.5 Scalability

This indicates how well the network can accommodate more users and data transmission requirements. If a network were to be designed and optimised for just the current requirements, when the network requires to expand previous choices can make the expansion both expensive and difficult.

1.9.6 Reliability

This indicates the reliability of the components (routers, switches, PC's etc) that make up a network. This is often measured as a probability of failure called mean time between failures (MTBF).

1.9.7 Topology

In networks there are two kinds of topology, the physical topology which is the arrangement of the cable, network devices and end systems (PC's and servers) and the logical topology which is the path the data signals take through the physical topology.

2. Network Topologies

Network topology is the study of the arrangement or mapping of the elements (links, nodes, etc.) of a network, especially the physical and logical interconnections between nodes.

A local area network (LAN) exhibits both a physical and a logical topology. Any given node in the LAN will have one or more links to one or more other nodes in the network and the mapping of these links and nodes results in a geometrical shape that determines the physical topology of the network.

As well as the physical shape the mapping of the flow of data between the nodes in the network determines the logical topology of the network. It is important to note that the physical and logical topologies might be identical in any particular network but they also may be different.

2.1 Bus

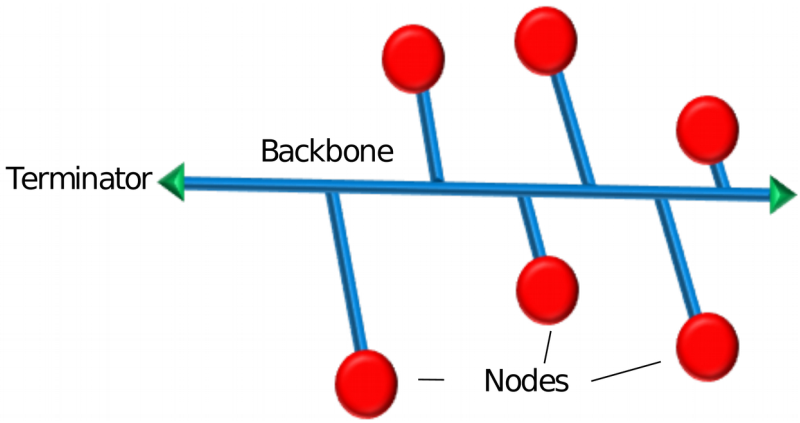


Illustration 7: Bus architecture

A Bus topology is the type of network in which all of the nodes of the network are connected to a common transmission medium which has exactly two endpoints. This is the 'bus', which is also commonly referred to as the backbone. All data that is transmitted between nodes in the network is transmitted over this common transmission medium and is able to be received by all nodes in the network virtually simultaneously.

The two endpoints of the common transmission medium are normally terminated with a device called a terminator that exhibits the characteristic impedance of the transmission medium and which dissipates or absorbs the energy that remains in the signal to prevent the signal from being reflected or propagated back onto the transmission medium in the opposite direction, which would cause interference with and degradation of the signals on the transmission medium.

2.2 Ring

Similar to a bus network, rings have nodes daisy chained, but the end of the network in a ring topology comes back around to the first node, creating a complete circuit.

Each node takes a turn sending and receiving information through the use of a token. The token along with any data is sent from the first node to the second node which extracts the data addressed to it and adds any data it wishes to send. Then second node passes the token and data to the third node, etc. until it comes back around to the first node again.

Only the node with the token is allowed to send data. All other nodes must wait for the token to come to them.

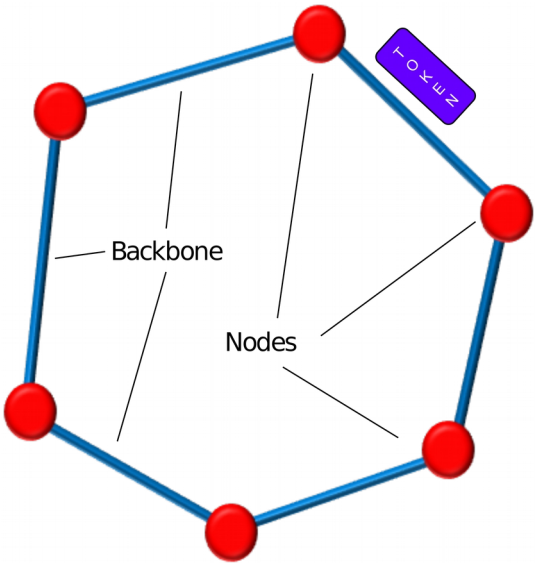


Illustration 8: Ring architecture

2.3 Star

The type of network topology in which each of the nodes of the network is connected to a central node with a point-to-point link in a 'hub' and 'spoke' fashion, the central node being the 'hub' and the nodes that are attached to the central node being the 'spokes'. In other words a collection of point-to-point links from the peripheral nodes that converge at a central node.

All data that is transmitted between nodes in the network is transmitted to this central node, which is usually some type of device that then retransmits the data to some or all of the other nodes in the network.

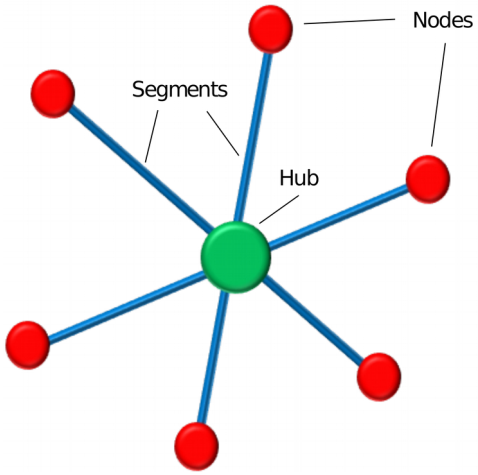


Illustration 9: Star architecture

2.3.1 Star Bus

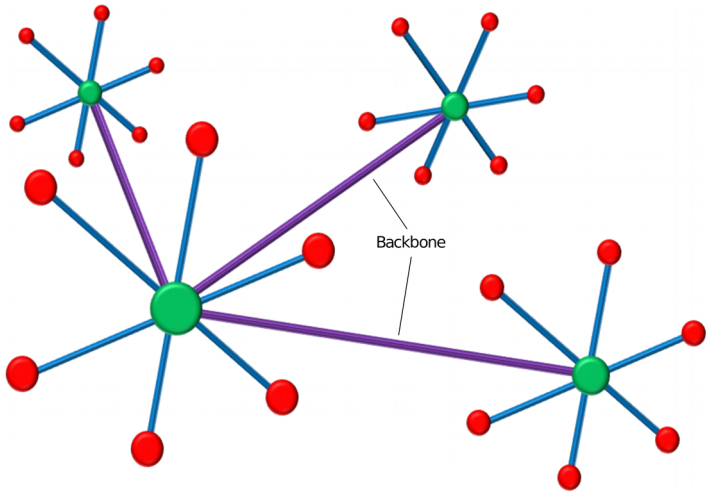


Illustration 10: Star architecture

2.4 Tree

The type of network topology in which a central 'root' node at the top level of the hierarchy is connected to one or more other nodes that are one level lower in the hierarchy, in other words a second level, with a point-to-point link between each of the second level nodes and the top level central 'root' node.

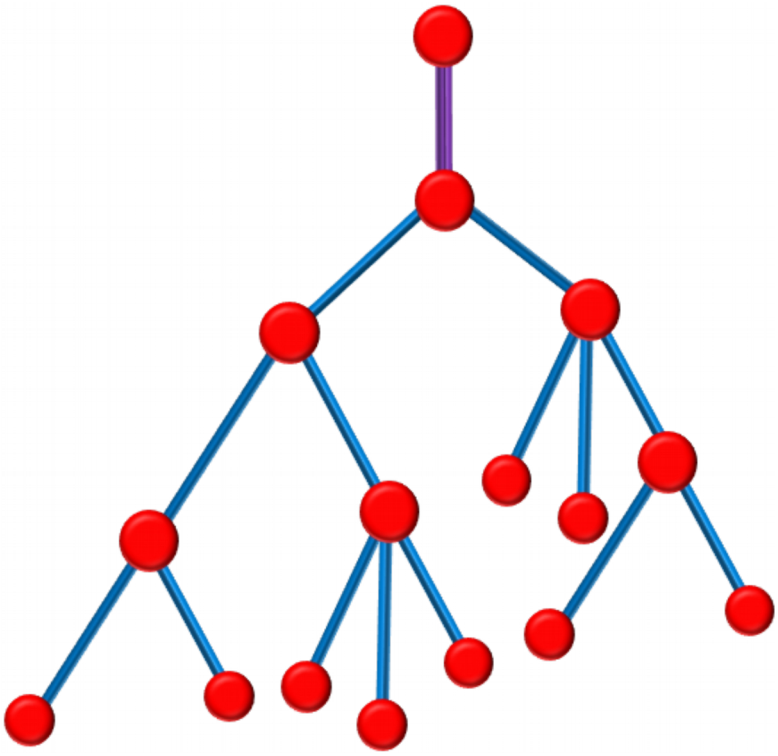


Illustration 11: Tree Architecture

Each of the second level nodes that are connected to the top level central 'root' node will also have one or more other nodes that are one level lower in the hierarchy, a third level connected to it, also with a point-to-point link, the top level central 'root' node being the only node that has no other node above it in the hierarchy.

2.5 Mesh

2.5.1 Fully Connected

A fully connected mesh network topology in which each of the nodes of the network is connected to each of the other nodes in the network with a point-to-point link. This makes it possible for data to be simultaneously transmitted from any single node to all of the other nodes. This is a very costly topology and is generally too costly and complex for practical use unless the number of nodes is very small.

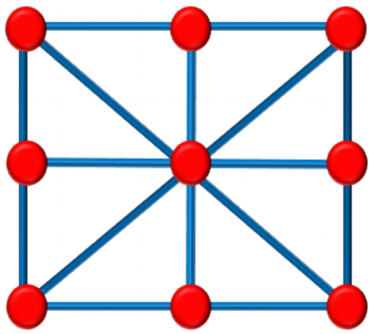


Illustration 12: Mesh Architecture

2.5.2 Partially Connected

The type of network topology in which some of the nodes of the network are connected to more than one other node in the network with a point-to-point link. This takes advantage of some of the redundancy that is provided by a physical fully connected mesh topology without the expense and complexity required for a connection between every node in the network.

2.6 Other Key Terminology

2.6.1 Simplex

A simplex circuit is one where all signals can flow in only one direction at a time. A good example would be television or commercial radio broadcast.

2.6.2 Half-duplex

Such a system provides for communication in both directions, but only one direction at a time (not simultaneously). Typically, once a party begins receiving a signal, it must wait for the transmitter to stop transmitting, before replying.

A good analogy for a half-duplex system would be a one lane road with traffic controllers at each end. Traffic can flow in both directions, but only one direction at a time with this being regulated by the traffic controllers.

2.6.3 Full-duplex

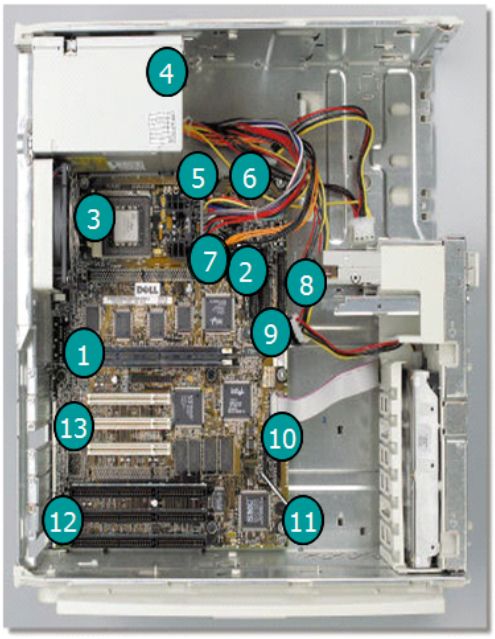
Full-duplex systems allows communication in both directions, and unlike half-duplex, allows this to happen simultaneously. Land-line telephone networks are full-duplex since they allow both callers to speak and be heard at the same time. A good analogy for a full-duplex system would be a two lane road with one lane for each direction.

2.7 Data Transmission

Successful transmission of data depends on the quality of the signal being transmitted and the characteristics of the transmission medium. Some terms to describe such transmission are:

- Data rate
    - Bits per second in data communications.
- Bandwidth
    - Bandwidth or signal is constrained by the transmitter and the nature of the transmission in cycles per second or hertz.
- Noise
    - Average level of noise over the communication path.
- Error rate
    - Rate at which errors occur where error in 1 or 0 bit occurs.

3. The Computer



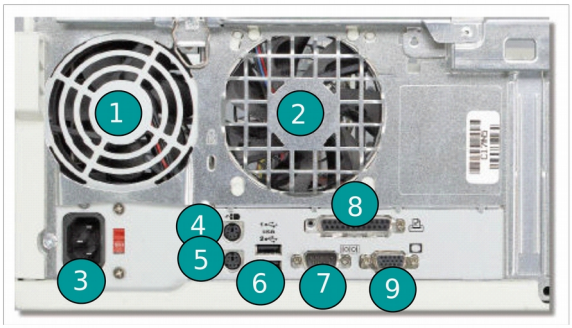
1. DIMM memory sockets
2. Secondary EIDE channel connector
3. Microprocessor
4. Power supply
5. Power input connector
6. Battery socket
7. 3.3-V power input connector
8. Diskette drive interface connector
9. Primary EIDE channel connector
10. Control panel connector
11. System board jumpers
12. ISA expansion card connectors
13. PCI expansion card connectors

Illustration 13: Computer parts

Most components of a computer are contained inside the casing and are largely involved with the internal processing of the computer. These components include the following:

- **Motherboard**
  - Main circuit board of a computer.
- **Central Processing Unit (CPU)**
  - The brains of the computer in which most of the computations and operations take place.
- **Bus**
  - A collection of wires through which data is transmitted from one part of a computer to another and which connects all the internal computer components to the CPU.
- **Random Access Memory (RAM)**
  - Computer memory that has new data written into it and also stored data read from it.
- **Read Only Memory (ROM)**
  - Computer memory on which data has been preset.

- **Power Supply**
  - Component that supplies power to the computer.
- **Hard Drive**
  - Device that reads and writes data on an internal disk drive.
- **Operating System**
  - Software that controls the operation of the computer (UNIX, Linux, Microsoft Windows etc).



1. Power supply cooling fan
2. Cooling fan
3. Power input
4. PS/2 mouse connector
5. Keyboard connector
6. USB ports
7. Serial port
8. Parallel port
9. Monitor port

Illustration 14: Computer ports

Other components of a computer whilst located inside the computer require access from outside; these are usually located on the back or the front of the computer.

- **External Ports**
  - Connectors to which other devices attach, including;
- **Serial Port**
  - Asynchronous serial devices, such as an external modem connection.
- **Video Port**
  - External video monitor connection.
- **Ethernet Port**
  - Ethernet network data cable connection.
- **USB Port**
  - USB devices connection.
- **PS/2 Port**
  - External keyboard and mouse connection.
- **CD/DVD Rom Drive**
  - A device into which a CD/DVD can be inserted and the data read from it.
- **CD/DVD-RW Drive**
  - A device into which a CD/DVD can be inserted and the data read from it, if writable CD media is used, data can also be stored on it.

- **Diskette Drive**
    - Allows use of removable storage, typically 1.44 MB floppy disks. This device has been obsolete by the USB Flash Disk which plugs into the computer USB Port.

3.1 Computer terms

3.1.1 Bits and Bytes

The “bit” and the “byte” are terms long associated with the computer. A bit is the smallest unit of data in a computer. A bit equals 1 or 0 in the binary format in which data is processed by computers. These bits are grouped into Bytes.

Both Random Access Memory (RAM) and hard disk capacities are measured in bytes, as are file sizes when you examine them.

Here is a summary of Bit terms you may come across in relation to computers.

- **Bits**
  - Kilobit (kb) 10^3
  - Megabit (Mb) 10^6
  - Gigabit (Gb) 10^9
  - Terabit (Tb) 10^{12}
  - Petabit (Pb) 10^{15}

Originally, a byte was a small group of bits of a size convenient for data such as a single character from a Western character set. Its size was generally determined by the number of possible characters in the supported character set and was chosen to be a sub multiple of the computer's word size; historically, bytes have ranged from five to twelve bits. The popularity of IBM's System/360 architecture starting in the 1960s and the explosion of microprocessors based on 8-bit microprocessors in the 1980s has made eight bits by far the most common size for a byte. The term octet is also widely used as a more precise synonym to prevent ambiguity in things like protocol definitions.

The prefixes used for byte measurements are usually the same as the SI prefixes used for other measurements, but have slightly different values. The former are based on powers of 1,024 (2^{10}), a convenient binary number, while the SI prefixes are based on powers of 1,000 (10^3), a convenient decimal number. The table below illustrates these differences.

- **Bytes**

Name	SI Meaning	Binary meaning	Size difference
Kilobyte (kB)	$10^3 = 1000^1$	$2^{10} = 1024^1$	2.40%
Megabyte (MB)	$10^6 = 1000^2$	$2^{20} = 1024^2$	4.86%
Gigabyte (GB)	$10^9 = 1000^3$	$2^{30} = 1024^3$	7.37%
Terabyte (TB)	$10^{12} = 1000^4$	$2^{40} = 1024^4$	9.95%
Petabyte (PB)	$10^{15} = 1000^5$	$2^{50} = 1024^5$	12.59%

Illustration 15: Bytes chart

Remember to do the proper calculations when comparing transmission speeds that are measured in kilobytes per second and those measured in kilobits per second.

For example software usually shows the connection speed in bits per second (3 Mbps). However popular browsers and peer to peer programs display file download speeds in kilobytes per second.

3.1.2 Speed

Speed in terms of computers is measured in Hertz (Hz). A hertz is a unit of frequency. It is the rate of change in the state or cycle in a sound wave, alternating current or other cyclical waveform. A hertz represents one cycle per second and is used to describe the speed of a computer microprocessor.

- Kilohertz (kHz) 10^3
- Megahertz (MHz) 10^6
- Gigahertz (GHz) 10^9

Computer processors are getting faster all the time. The microprocessors used in workstations in the 1980's typically ran under 10 MHz (the original IBM Pc was 4.77 MHz). Today these microprocessors are measured in Gigahertz.

3.1.3 Other memory associated with networking devices

3.1.3.1 NVRAM

Non-volatile random access memory (NVRAM) is the general name used to describe any type of random access memory which does not lose its information when power is turned off. This is in contrast to the most common forms of random access memory today, DRAM and SRAM, which both require continual power in order to maintain their data. NVRAM is a subgroup of the more general class of non-volatile memory types, the difference being that NVRAM devices offer random access, as opposed to sequential access like hard disks.

3.1.3.2 Flash memory

Flash memory is non-volatile computer memory that can be electrically erased and reprogrammed. It is a specific type of EEPROM that is erased and programmed in large blocks; in early flash the entire chip had to be erased at once. Flash memory costs far less than byte-programmable EEPROM and therefore has become the dominant technology wherever a significant amount of non-volatile, solid-state storage is needed.

Switches and routers tend to use flash instead of a hard drive, the cost is higher and the capacity is less, but this is more than offset by the gain in reliability.

3.2 Operating Systems

An operating system (OS) is a set of computer programs that manage the hardware and software resources of a computer.

An operating system processes raw system and user input and responds by allocating and managing tasks and internal system resources as a service to users and programs of the system.

At the foundation of all system software, an operating system performs basic tasks such as controlling and allocating memory, prioritising system requests, controlling input and output devices, facilitating networking and managing file systems.

The operating system forms a platform for other system software and for application software. UNIX, Linux, Mac OS and Microsoft Windows are some of the most popular OS's.

3.2.1 Services

3.2.1.1 Process management

Every program running on a computer, be it background services or applications, is a process. Modern operating systems enable concurrent execution of many processes at once via multitasking even with one CPU. Process management is an operating system's way of dealing with running multiple processes. Since most computers contain one processor with one core, multitasking is done by simply switching processes quickly.

3.2.1.2 Memory management

Current computer architectures arrange the computer's memory in a hierarchical manner, starting from the fastest registers, CPU cache, random access memory and disk storage.

An operating system's memory manager coordinates the use of these various types of memory by tracking which one is available, which is to be allocated or deallocated and how to move data between them. This activity, usually referred to as virtual memory management, increases the amount of memory available for each process by making the disk storage seem like main memory. There is a speed penalty associated with using disks or other slower storage as memory.

3.2.1.3 Disk and file systems

Modern file systems comprise a hierarchy of directories. While the idea is conceptually similar across all general-purpose file systems, some differences in implementation exist. Two noticeable examples of this are the character used to separate directories, and case sensitivity.

UNIX Linux and Mac OS X demarcates its path components with a slash (/), a convention followed by operating systems that emulated it or at least its concept of hierarchical directories. MS-DOS also emulated this feature, but had already also adopted the CP/M convention of using slashes for additional options to commands, so instead used the backslash (\) as its component separator. Microsoft Windows continues with this convention.

UNIX and UNIX-like operating allow for any character in file names other than the slash, and names are case sensitive. Microsoft Windows file names are not case sensitive.

3.2.1.4 Networking

Most current operating systems are capable of using the TCP/IP networking protocols. This means that one system can appear on a network of the other and share resources such as files, printers, and scanners using either wired or wireless connections.

Many operating systems also support vendor-specific legacy networking protocols as well, for example, SNA on IBM systems, DECnet on systems from Digital Equipment Corporation, and Microsoft-specific protocols on Windows. Specific protocols for specific tasks may also be supported such as NFS for file access.

3.2.1.5 Security

Many operating systems include some level of security. Security is based on the two ideas that:

- The operating system provides access to a number of resources, directly or indirectly, such as files on a local disk, privileged system calls, personal information about users, and the services offered by the programs running on the system.
- The operating system is capable of distinguishing between some requesters of these resources who are authorised to access the resource, and others who are not authorised.

3.2.1.6 Graphical user interfaces

Most modern operating systems contain a Graphical User Interface (GUI). A few older operating systems like the original implementations of Mac OS and Microsoft Windows tightly integrated the GUI to the kernel. More modern operating systems are modular, separating the graphics subsystem from the kernel as is the case with Linux and Mac OS X.

Many operating systems allow the user to install or create any user interface they desire. The X Window System in conjunction with GNOME or KDE is a commonly found setup on most UNIX and UNIX derivative (BSD, Linux) systems.

3.2.1.7 Device drivers

A device driver is a specific type of computer software developed to allow interaction with hardware devices. Typically this constitutes an interface for communicating with the device, through the specific computer bus or communications subsystem that the hardware is connected to, providing commands to and/or receiving data from the device, and on the other end, the requisite interfaces to the operating system and software applications.

It is a specialised hardware-dependent computer program which is also operating system specific that enables another program, typically an operating system or applications software package or computer program running under the operating system kernel, to interact transparently with a hardware device, and usually provides the requisite interrupt handling necessary for any necessary asynchronous time-dependent hardware interfacing needs.

3.2.2 UNIX®

UNIX is a computer operating system originally developed in the 1960s and 1970s by a group of AT&T employees at Bell Labs including Ken Thompson, Dennis Ritchie and Douglas McIlroy. Today's UNIX systems are split into various branches, developed over time by AT&T as well as various commercial vendors and non-profit organisations.

The present owner of the trademark UNIX® is The Open Group, an industry standards consortium. Only systems fully compliant with and certified to the Single UNIX Specification qualify as "UNIX®" (others are called "UNIX system-like" or "UNIX-like").

During the late 1970s and early 1980s, UNIX's influence in academic circles led to large-scale adoption of UNIX by commercial startups, the most notable of which is Sun Microsystems. Today, in addition to certified UNIX systems, UNIX-like operating systems such as Linux, Mac OS X and BSD derivatives are commonly encountered.

Examples include: Sun Solaris, HP UX, SCO UNIX, BSD UNIX.

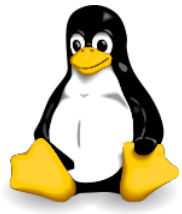
3.2.3 BSD

Berkeley Software Distribution (BSD, sometimes called Berkeley UNIX) is the UNIX derivative distributed by the University of California, Berkeley, starting in the 1970s. BSD should not be used to refer to the different BSD like operating system around today. Instead they should be called BSDlike or BSD descendants.

BSD is one of several branches of UNIX operating systems. Another one is evolved from UNIX System V developed by AT&T's UNIX System Development Labs. A third consists of the GNU/Linux operating systems which draw from UNIX System V and BSD, as well as Plan9, and non-UNIX operating systems.

3.2.4 Linux

Linux is a UNIX-like computer operating system family, as well as one of the most prominent examples of free software and open source development; its underlying source code can be modified, used, and redistributed by anyone, freely.



After the Linux kernel was released to the public on 17 September 1991, the first Linux systems were completed by combining the kernel with system utilities and libraries from the GNU project, which led to the coining of the term GNU/Linux. From the late 1990s onward Linux gained the support of corporations such as IBM, Sun Microsystems, Hewlett-Packard, and Novell.

Predominantly known for its use in servers, Linux receives use as an operating system for a wider variety of computer hardware than any other operating system, including desktop computers, supercomputers, mainframes, and embedded devices such as cellphones. Linux is packaged for different uses in Linux distributions, which contain the kernel along with a variety of other software packages tailored to requirements.

Examples include: Ubuntu, Debian, Redhat.

3.2.5 Mac OS X

Mac OS X is a line of proprietary, graphical operating systems developed, marketed, and sold by Apple Inc., the latest of which is pre-loaded on all currently shipping Macintosh computers. Mac OS X is the successor to the original Mac OS, which had been Apple's primary operating system since 1984. Unlike its predecessor, Mac OS X is a UNIX-like operating system built on technology that had been developed at NeXT through the second half of the 1980s and up until Apple purchased the company in early 1997.

The operating system was first released in 1999 as Mac OS X Server 1.0, with a desktop-oriented version (Mac OS X v10.0) following in March 2001. Since then, four more distinct "end-user" and "server" editions of Mac OS X have been released, the most recent being Mac OS X v10.4, which was first made available in April 2005. Releases of Mac OS X are named after big cats; Mac OS X v10.4 is usually referred to by Apple and users as "Tiger".

3.2.6 Microsoft Windows

Microsoft Windows is the name of several families of proprietary software operating systems by Microsoft. Microsoft first introduced an operating environment named Windows in November 1985 as an add-on to MS-DOS in response to the growing interest in graphical user interfaces (GUI). Microsoft Windows eventually came to dominate the world's personal computer market, overtaking OS/2 and Mac OS which had been introduced earlier.

4. Lab Exercise – Computer Hardware and Operating System

4.1 Objective

- Become familiar with the basic peripheral components of a computer system.
- Identify computer connections including network attachment.
- Examine the internal computer configuration and identify major components.
- Observe the boot process for the operating system.
- Discover information about the computer.

4.2 Background

Knowing the components of a computer is valuable when troubleshooting. This knowledge is also important to success in the networking field. Before beginning, you should have a typical computer available with all peripherals. Peripherals include the keyboard, monitor, mouse, speakers or head phones, a network interface card (NIC), and a network cable. The system unit cover should be removed. If the cover is not removed, the tools should be provided to remove it.

4.3 Lab Steps

4.3.1.1 Examine the computer and peripheral components

Examine the computer and peripheral components both front and back.

What are the manufacturer and model number of this computer?

Manufacturer:

Model Number:

What are the major external components of the computer including the peripherals?

	Component Name	Manufacturer / Description / Characteristics
1.		
2.		
3.		
4.		
5.		

Remove the computer system unit cover and examine internal components
List at least 8 major internal components inside the system unit.

	Component Name	Manufacturer / Description / Characteristics
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

4.3.1.2 Assemble the computer components observe the boot process

Assemble the computer components, attach all peripherals, and boot the computer. Observe the boot process. The computer should boot to the installed operating system (OS).

Did the OS boot correctly? What OS was installed on the computer?

_____ _____

Did the screen show how much memory there was as the system was booting? How much memory?

_____ _____

4.3.1.3 Gather basic information about the computer CPU and RAM

Gather basic information about the computer CPU and memory. The instruction to complete this step may vary slightly depending on the version of Windows.

Windows

Click the Start button. Select Settings then Control Panel. Click on the System icon and then the General tab. View the information about the computer using the operating system.

What is the Central Processing Unit? _____

What is the speed in MHz of the CPU? _____

How much RAM is installed? _____

Linux

Open a terminal on the Linux distribution and execute the following commands.

```
$ cat /proc/cpuinfo
$ cat /proc/meminfo
```

What is the Central Processing Unit? _____

What is the speed in MHz of the CPU? _____

How much RAM is installed? _____