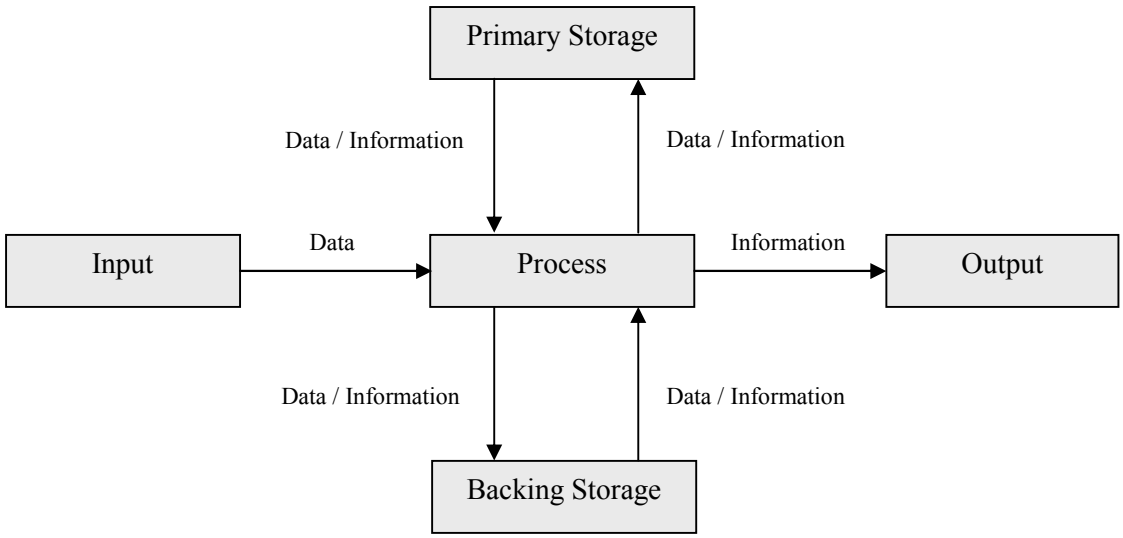
Chapter 1.1 – Components of a Computer System and their Uses

A computer information system generally carries out the following tasks:



A computer information system consists of hardware, software and live ware

What is hardware?

Hardware is the physical parts (parts which can be seen and touched) of a computer system. They are:

1. Input devices (devices used to enter data to the system such as keyboard, mouse and scanner)

2. Output devices (devices used to output information from the system such as monitors, printers and speakers)

3. Storage devices (devices used to store programs, data and information)

   Storage devices are of two kinds:

   Primary storage – This is also called RAM (random access memory). It stores currently running operating system, application programs and data files.

   Secondary storage – This stores programs, data and information for future use. Examples are hard disks, CDs, magnetic tapes, flash drives etc.

4. Communication devices - devices used to transmit data between computers in a network such as modems, ISDN adaptors, network interface cards, bridges and routers)

What is software?

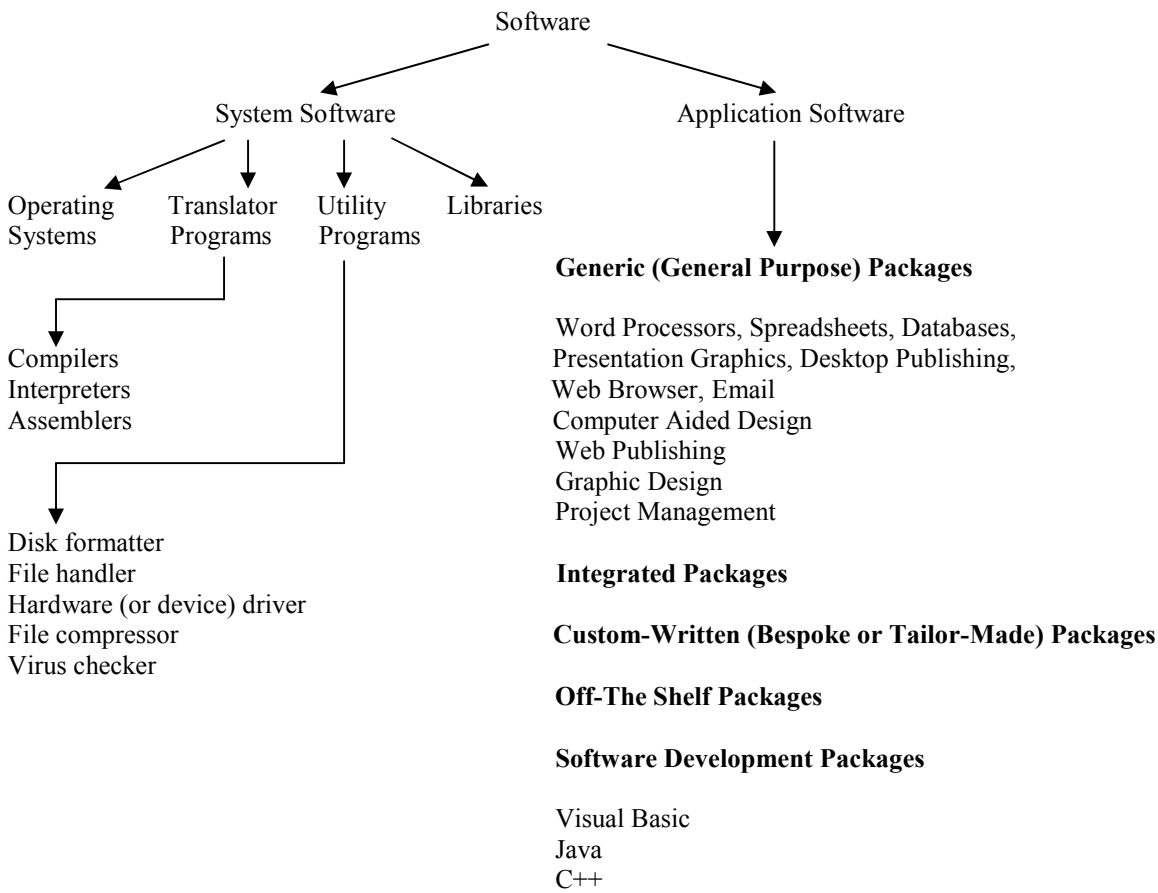
1. Software is a set of instructions coded in a programming language, which tells the computer's processor how to perform a certain data processing task.

2. Software makes the computer system produce useful results.

What is live ware?

Live ware is people involved in developing and implementing an information system. Examples: system analysts, software engineers, network administrators etc.

How software is classified?



What is a package?

A package is a software program, which is bundled with a user manual

Why does a computer system need to have input devices?

To enter data to a computer system

Why does a computer system need to have output devices?

To present the results produced by the computer system to the user

Why does a computer system need to have secondary storage devices (backing stores)?

1. To store files when the power to the processor is turned off
2. To store data when they have to be used again later
3. To store files which are too large to be stored in the main memory
4. To allow for the transfer of data from one computer system to another

What is system software?

System software controls how the computer system works.

What is application software?

Application software allows the user to make the computer do something useful.

What is operating system?

1. Operating system is a software program which controls the operations of the computer system.
2. It provides a user interface.
3. It controls how the computer responds to user's requests
4. It controls how the hardware communicate with each other
5. It provides an environment in which application software can be executed

What is source code?

Source code is the code written by a computer programmer in a high level programming language

What is machine language?

This is the code that can be understood by the computer's processor. It contains only 1's and 0's.

What is translator program?

1. Translator program converts source code written in a high level programming language to machine code.

2. Translator programs are of three kinds: Compilers, Interpreters and Assemblers

What is compiler?

Compiler translates source code written in a high level programming language to object code which can be saved as an object code file and later run to execute the program. Compiler does this by scanning through the source code in one run.

What is interpreter?

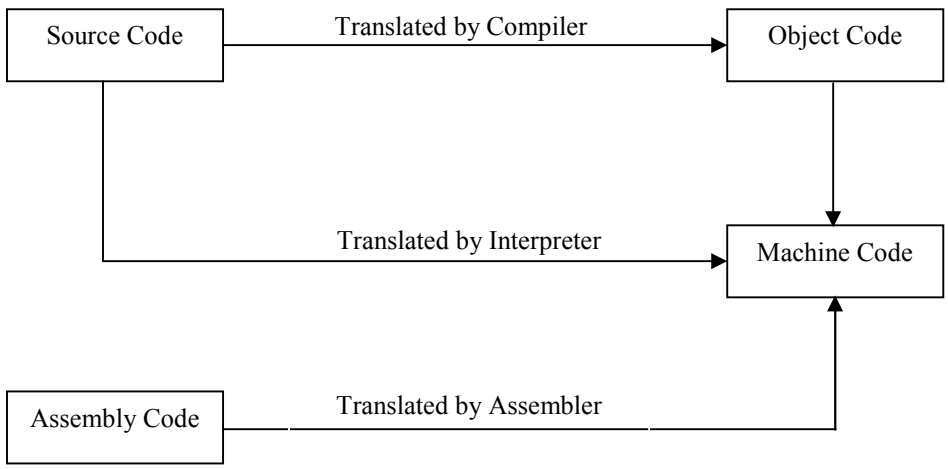
Interpreter converts source code written in a high level programming language to machine language line by line and executes each line.

What is an assembler?

Assembler converts assembly language code into machine language.

What is object code?

Object code is the product obtained when source code is translated by a compiler. Object code may almost be machine code or close to machine code.



What is an executable?

This is a compiled program which has a user interface and can run independently.

Three different times associated with an application program

Design time, compile time and runtime

What is design time?

This is the time spent on developing a software application.

What is compile time?

This is the time spent on compiling source code.

What is runtime?

This is the time during which a software application executes. This occurs after the compilation.

What is a routine?

A routine is a block of code which carries out a particular task. Routines are either procedures or functions. In the example given below, Procedure1 and Function1 are routines.

```
Main:                          (Line 1)
   Procedure1 x, y             (Line 2)
   Answer = Function1 x, y     (Line 3)
EndMain                        (Line 4)

Procedure1 (a, b)              (Line 5)
   a + b                       (Line 6)
EndProcedure                   (Line 7)

Function1 (a, b)               (Line 8)
   Function1 = a + b           (Line 9)
EndFunction                    (Line 10)
```

What is a statement?

Line 2, “Procedure1 x, y” is a statement.
In Line 3, “Answer” is one statement and “Function1 x, y” is another statement.

What is an expression?

An expression is a line of code where two statements are combined by an equal sign.
For example Line 3 is an expression.

What is a procedure?

A procedure is a routine which carries out a task and may or may not return a value to the calling statement.

For example the block of code from Line 5 through Line 7 is a procedure. The name of the procedure is Procedure1.

What is a function?

A function is a routine which carries out a task and always returns a value to the calling statement. For example the block of code from Line 8 through Line 10 is a function. The name of the function is Function1.

What is a calling statement of a routine?

The statement "Procedure1 x, y" in Line 2 is the calling statement for Procedure1
The statement "Function1 x, y" in Line 3 is the calling statement for Function1
The calling statement executes the routine (procedure or function).

What is a parameter?

A parameter is a value passed to a routine (procedure or function) by a calling statement.
Examples: In Line2, x and y are parameters.
In Line 3, x and y are parameters.

What is a utility program?

1. Utility programs are routines added to the operating system to carry out common tasks in the computer system.

2. Examples for utility programs are:
   Disk formatter
   File handler
   Hardware (or device) driver
   File compressor
   Virus checker

What is a component?

A component is a compiled routine or a set of compiled routines which carries out a specific task or a set of tasks and which does not have a user interface.

What is library?

1. A library is a collection of components.
2. A library is different from an executable because it cannot run as an independent program.
3. A Library gets linked to an executable at compile time or runtime to provide the executable some specific service in data processing.

What is DLL?

A library that links to an executable in runtime is called a dynamically linked library (DLL). In contrast, a library that links to an executable in compile time is called a statically linked library.

What is generic (or general purpose) software?

1. Generic software is software which is appropriate to many applications within a skill area.

2. Examples of generic software are:
   Word Processors
   Spreadsheets
   Database Management systems
   Presentation Graphics
   Desktop Publishing
   Web Browser
   Email
   Computer Aided Design
   Web Publishing
   Graphic Design
   Project Management

What is an Integrated Software Package?

This is a software package built by combining parts from several application programs where those parts can share data and communicate data with each other easily.

For example, the user can move a drawing done with the graphic designing part of an integrated package to the word processing part of that same package in order to add some text to a graphic.

Advantages of integrated packages

1. Data can be shared
2. Commonly used features of individual packages are available and can be used throughout the package
3. Common screen design, common toolbars, common menus and common icons can be used throughout the package.
4. It is simple for the staff to learn.
5. It is cheaper than buying individual packages separately

Disadvantages of integrated packages

1. Some features that the user needs may not be available
2. Takes too much hard disk space

What is a Custom Written (Bespoke or Tailor-Made) Software Package?

1. This is software package that has been developed to solve a specific problem of a particular organization.
2. Custom written software is needed to be developed when there is no off-the-shelf software package available that would satisfy the needs of an organization.
3. Custom written software includes all the functionalities needed to solve a specific problem but does not contain extra routines that are never used.

Advantages of custom written (bespoke of tailor-made) software packages

1. The software is designed to do exactly what the user wants.
2. The software can be written to run on specific hardware.
3. The software can be integrated with existing software
4. There may not be a suitable software package required for the purpose available in the market.

Disadvantages of custom written (bespoke or tailor-made) software packages

1. Needs to hire a software engineer with that specific developing skill and experience
2. Expensive to develop

What is an Off-the-Shelf Software Package?

1. This is a software package that has already been developed and is immediately available to buy.
2. It is a software package which can be used to carry out all the common tasks related to a specific business area.
3. Examples for off-the-shelf software packages are:
   Income tax processing system
   Airline reservation system
   Hotel reservation system

Advantages of buying an off-the shelf software package

1. Software is immediately available
2. Low price compared to have it developed by a specialist
3. Since the software has already been tested and used for sometime by so many variety of users, it is assured that any bugs should have been found and rectified.
4. Includes all the common features of the system concerned as the developer who has done the system analysis has expertise in that field
5. New releases or editions will be available
6. Because the software is in general use by many users, well established training courses are usually available.

Disadvantages of buying an off-the shelf software package

1. Features specific to the organization may not be available
2. Software may not run on the existing hardware

Hardware used to enable computer systems to communicate (or communications hardware)

1. Network interface card

   This is a device installed in a slot on the motherboard which is used to connect two computers. One end of a network cable is attached to a port on the network interface card

2. Modem

   This is a device installed in a slot on the motherboard or attached to the computer externally by a cable, which is used to convert digital data coming from the processor to analog before it enters the telephone lines and to convert analog data coming along the cable to digital before it enters the computer. The telephone cable is connected to a port on the modem.

Chapter 1.2 – System Software

What are the types of system software?

1. Operating system
2. Translator programs
3. Utility programs
4. Library programs

What is an operating system?

1. Operating system is a software program which controls the operations of the computer system.
2. It provides a user interface.
3. It controls how the computer responds to user's requests
4. It controls how the hardware communicate with each other
5. It provides an environment in which application software can be executed

What is a translator program?

1. A translator program converts source code written in a high level programming language to machine code.
2. Translator programs are of three kinds: Compilers, Interpreters and Assemblers

What are utility programs?

1. Utility programs are routines added to the operating system to carry out common tasks in the computer system such as that control output to the printer and storage of data.
2. Examples for utility programs are:
   Disk formatter
   File handler
   Hardware (or device) driver
   File compressor
   Virus checker

Examples of utility programs

1. Disk formatter
   Deletes the data already on the disk and divides the surface of the disk into tracks and sectors

2. File handler
   Manages files stored in a computer system. For example, saving a file and finding a file

3. Hardware (or device) driver
   Gives the instructions necessary to control communication between the processor and a peripheral device

4. File compressor
   Reduces the size of a file without the loss of any details in it so that the transmission of a very large file can be done faster

5. Virus checker – Checks any files entering a computer system for viruses and delete the virus before it can damage files

What is a library?

1. A library is a collection of components used to develop software.
2. A library is different from an executable in that it is not an independent program but only a Component (a component is a compiled routine or a set of routines which carries out a specific
   task or a set of tasks and which does not have a user interface).
3. A library can be linked to an executable either in runtime or compile time.

Why an operating system is likely to be stored on a backing store rather than in the memory of the computer?

1. Usually the operating system requires a large amount of storage space.
2. It allows for easy upgrading or changing from one system to a different one.

What is batch processing?

Batch processing means collecting data during a specific time period and processing them as one batch in one run without the intervention of the user during the processing of data.

How batch processing can overcome speed mismatch?

- In the computer, the processor carries out its tasks at extremely high speed, the peripherals carry out the tasks at a much slower speed compared to the processor and the user performs tasks at the slowest speed.

- The above difference in speed is known as the speed mismatch between the operator, peripherals and the processor.

- Therefore in this situation, the speed of data processing depends on the speed at which the user interacts with the computer which is very slow.

- Batch processing puts the user off-line (i.e. processing occurs without the intervention of the user) and thereby making the speed of data processing depend only on the speed of the processor and thereby overcome the speed mismatch.

- This is done by collecting and preparing the data during a defined time period and bundling them into one batch. The whole batch will then be processed by the processor where the user does not have to be involved.

What are the instances where batch processing is sensible?

1. When there is a large amount of data to be processed
2. When data collected is very similar
3. When data requires very similar processing
4. When processing cannot be started until all the data is collected
5. When no human intervention is necessary once the processing starts
6. When the computer has identifiable times where it is not being used and so has available processor time

What are examples of batch processing?

1. Producing bank statements from customer's account details
2. Producing utility bills (gas, electricity and telephone bills) from customer records
3. Producing payroll of an organization from hours worked and pay rates
4. Compilation of high level language programs where a number of users want programs Compiled

What is real-time processing?

Data input is processed fast enough to effect the next input.

What are examples of real-time processing?

1. Controlling the temperature of a reaction vessel where the processor accepts temperature data inputted from a sensor and then makes a decision whether to adjust the heating elements of the vessel.

2. Controlling a robot trolley by a processor which accepts input from a sensor while following a black line on the floor and makes a decision concerning steering to keep the trolley on the line.

3. A catalog shop processing orders using the code of a product inputted by the operator and the system then comparing the code with the data containing in the files. If the product is found

and the customer wants to buy the product, it is required to record the fact that the item has been sold. Otherwise a second person might be sold the same item.

Characteristics of a real-time computer system

In real time processing since the data must be processed immediately, the operating system needs to be ready to handle input as soon as it comes in.
This means that the real time computer system cannot be used to do other tasks during some of its slack times

This means that the computer will not be using its full potential as far as processing is concerned. In other words the computer system engaged in real-time processing tends to display a high degree of redundancy.

What is on-line processing

This is processing of data while communicating with the processor directly.

An example for on-line processing is updating a bank's customer accounts master file with the daily transaction file at the end of the business day.

What is off-line processing?

Processing of data without connecting to the processor

An example for off-line processing is filling up an order form downloaded from an e-commerce Web site in order to purchase an item.

Single-user systems

A single-user system and its programs can be used by only one person at a time. An example of a single user system is the personal computer (PC) used at homes. Most single user systems are multi-tasking.

Multi-tasking systems

This is an operating system which allows several application programs to be run at the same time. Even though it appears that more than one task is running simultaneously it does not actually happens. What really happens is that the processor switches processing between the application programs in very quick time.

Multi-user systems

This is an operating system which services more than one user simultaneously.
Example of a multi-user system is a mainframe computer, which services many users who are connected to it through terminals that have very little or no processing power.

Distributed systems

This is a system which uses many storage locations on different computers to store software and data files in a network environment.

Advantage of a distributed system

Advantage of a distributed system is the ability to access data files quickly and to run programs quickly because more than one file handling command can be carried out at a time.

Disadvantage of a distributed system

Disadvantage of a distributed system is the complexity of maintaining the security of the system.

User interface

This is the means of communication between the user and the computer system and consists of both hardware and software.

Form based user interface

1. This is an on-screen form which contains specified areas to enter data such as boxes, drop-down boxes, check boxes, option buttons etc.

2. The user interface has a cursor which can be moved to the next area to be filled in with data.

3. When data is entered to the specific areas it will be validated before it is processed.

How the form based user interface is used?

1. It prompts the operator to ask questions
2. It makes the operator input the data in correct order
3. It makes the checking of the data easier

Menu based user interface

1. Menu based user interface has a list of choices made available to the user followed by a further
   set of choices based on the first choice and so on until the result is obtained.
2. This is used in situations where the operator tends not to know what options are available.
3. Input is often done using a touch screen because of the location of such systems. For example
   menu based systems are used in very busy environments or where many people are waiting to
   use the system such as in factories, restaurants, railway stations and airports.
4. Input is often done using touch screens to facilitate many computer illiterate people who would
   use them.

Example of a menu based system: system at a railway station in a popular holiday location

The first screen may ask for the general area of interest such as accommodation, trips, shopping, entertainment etc. Once the choice of accommodation has been made, the next screen may offer different standards of hotels. Once the choice of hotel type is made the next screen may offer different price bands. Once the choice of price band is made, the final screen will display the hotel or the list of hotels that matches all the requirements of the customer.

Graphical user interface

1. Graphical user interface (GUI) consists of a WIMP (windows, icons, menus and a pointer).

2. The GUI is used by selecting options from menus of choices and from a set of small pictures which represents the different options available.

3. Choices are selected by using some sort of pointing device such as a mouse.

Example of a GUI

Windows Desktop program
Control Panel program of the Windows

Natural language user interface

The computer asks questions which elicit a response which gives the user the impression that he is talking to the computer.

Command line user interface

Here the user communicates with the computer interactively by typing commands at a command prompt. A command prompt is a character or a group of characters which the computer displays in order to let the user know that a command can be input.

Examples: C:\ > or C:\ My folder >

Characteristics of a command line user interface

1. The user needs to know what commands are available

2. The user needs to understand the commands

3. The user needs to understand the way that the data and files are stored in the computer system

4. Used in systems which are much more open than the other types of systems where the user is restricted to the options available to him.

5. Command based interfaces can only be used by computer literate people.

Chapter 1.3 – Programming Tools and Techniques

Structure of a Computer Program

A program is a set of instructions written in a programming language to solve a problem. The processor of the computer reads these instructions and executes them to perform the tasks necessary to solve the problem.

The Lifetime of a Computer Program

There are three stages in the lifetime of a computer program:

1. Design time

This is the time spent by the programmer in coding and testing the computer program. The length of this time depends on how long and complex the program going to be. It can be few days or even several months.

2. Compile time

This is the time that the compiler spends in compiling the source code. This is a relatively short time period. A simple program may take only a second to get compiled. A long and complex program might take even few minutes to get compiled.

3. Runtime

This is the time that the program is getting executed. It is during the runtime that the user enters data to the program and interacts with it.

Variables

A variable is one or more memory locations which can store data. A simple variable can carry only one piece of data at a given instance. A data structure such as an array can carry more than one data at a given time. The number of data that an array can carry at a given time is determined by the size of the array.

A variable must be declared before it is used in a program. When a variable is declared in a program its name and the data type should be specified in the declaration statement.

Simple variable

In Visual Basic a simple variable such as StudentName is declared as:

```
Dim StudentName as String
```

StudentName is the name of the variable and String is the data type of the variable. The data "John" can then be assigned to the variable as follows:

StudentName = "John"

When another piece of data "Peter" is assigned to the variable, the previous data "John" will be replaced by the new value.

StudentName = "Peter"

Array varibales

In Visual Basic an array variable is declared as follows:

Dim StudentNameArray (1 To 100) As String

This means that:

The name of the array is StudentNameArray

The array can contain up to a maximum of 100 pieces of data i.e. it can contain up to 100 student names.

The array can contain only data that have String data type.

Each piece of data in the array is identified by a unique index. The first piece of data in this array is StudentNameArray(1), the second piece of data is StudentNameArray(2) and so on up to StudentNameArray(100). It is wrong to code as StudentNameArray(0) because the indexes fall within the range of 1 to 100 but not from 0 to 99.

Depending on where the variable is declared in the program, the variable's scope is determined. The variables can be identified according to their scope as given below:

- Local variables
- Global variables

Local Variables

Local variables are declared within a procedure or a function. Therefore a local variable can be accessed only by the code within that procedure or function.

Global variables

Global variables are declared in the main program or in a public module of a program. This means that the code anywhere in the program can access a global variable.

Procedures and Functions

A procedure carries out a specific task and may or may not return a value to its calling statement.

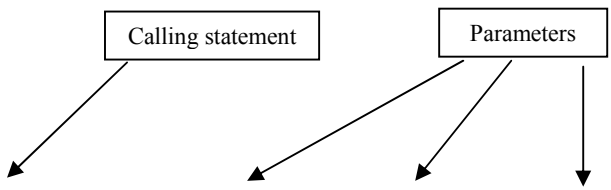
A function carries out a specific task and always returns a value to its calling statement.

A procedure or a function has to be called by a statement or an expression in order for it to execute.

The value returned by a function is contained in the name of the function. The function then returns the value to its calling statement. Therefore the calling statement of the function must be a part of an expression.

A value (or values) passed to the procedure or the function in the calling statement is called parameters.

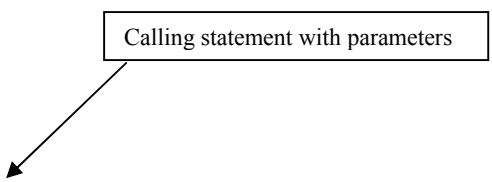
An example of using a procedure




```
CalculateAverage ComputingMarks, PhysicsMarks, AccountsMarks

Private Sub CalculateAverage (ComputingMarks, PhysicsMarks, AccountsMarks)
    Average = (ComputingMarks + PhysicsMarks + AccountsMarks) / 3
    lblAverage = Average
End Function
```

An example of using a function




```
lblAverage = CalculateAverage ComputingMarks, PhysicsMarks, AccountsMarks

Private Function CalculateAverage (ComputingMarks, PhysicsMarks, AccountsMarks)
    Average = (ComputingMarks + PhysicsMarks + AccountsMarks) / 3
    CalculateAverage = Average
End Function
```

Modularizing a Program and Top-Down Design

The process of dividing a program gradually into parts and those parts into further subparts until where each subpart can perform a specific, manageable task is called modularizing the program. Each subpart is called a module. Designing programs in this manner is called top down design.

Consider that it is necessary to develop a program to solve the problem of computerizing the traffic lights in the middle of a city. The solution is a very complex one but it can be split into the following parts.

1. How is the data going to be collected from sensors and stored in the system?
2. How is the decision going to be made about the changing of the lights?
3. How is the data collected from the pedestrian crossing and then stored?
4. How is the data processed?
5. What outputs are necessary and how they are presented?

Each of these solutions performs a specific task and is more manageable than the overall problem and is called a module. Therefore the program to solve the overall problem of developing a solution for the traffic lights system can be coded as a set of separate modules.

Advantages of Designing a Program in Modular Form

1. Fewer errors are made when coding because code containing in each module is shorter.
2. Algorithm in a module can be easily understood.
3. A team of programmers can be used where each one would code one module. It will reduce the
   overall development time of the solution.
4. Programmers can be assigned modules to be coded based on their individual expertise
5. Each module can be tested thoroughly
6. Allows library programs to be inserted easily

Disadvantages of Designing a Program in Modular Form

1. Can lead to problems when naming variables
2. Can lead to problems when modules are linked because links must be thoroughly tested
3. Documentation of modules will become tedious

Bottom up Programming

Building a program by writing code to use a set of components is called bottom up programming.

Program Translation

Computer's processor can understand only the binary code which is represented by 1's and 0's. A language which contains only binary code is called a machine language.

Machine language code is very hard for a programmer to understand. Therefore programmers use high level programming languages to write programs.

A program written by a programmer in a high level language is called source code.

Source code (code written in high level language) is more English-like and can be understood easily by a programmer.

The process of converting source code (a program written in a high level language) to machine language is called program translation.

Program that performs translation is called the translator.

When source code file is translated, the code produced is also called object code.

The object code is normally much bigger than the source code because it needs several machine language instructions to represent one high level language instruction.

There are three types of translators:

- Compilers
- Interpreters
- Assemblers

Types of Programming Errors

1. Syntax Errors

The errors made by violating the rules of a programming language are called syntax errors. The correct spelling of a code may be PRINT. If the code is written by the programmer as PLINT the translator program would not recognize it and so would not be able to translate it. A compiler detects syntax errors and highlights the error in the source code, usually by displaying an error message to alert the programmer. The program does not get executed until the syntax error is corrected.

2. Logic Errors

This is an error in the way that the program solution has been designed. For example an instruction in the program may tell the processor to jump to another part of the program. This is

fine as long as the instruction tells the processor to go to the right part of the program. If it tells the processor to go to the wrong place the program will not produce the expected result.

Unfortunately, a logic error does not usually prevent a program from executing, it just make the program produce wrong results.

Another example of a logic error is when an incorrect formula is used such as:

Net Salary = Gross Salary + Tax

This produces wrong results for Net Salary. The correct formula should be:

Net Salary = Gross Salary – Tax

3. Arithmetic Errors

This is an error caused by inappropriate arithmetic. This is sometimes thought of as a type of logic error but is rather different because the computer is asked to do something that is impossible. A good example is when it is coded to divide by 0. This is impossible and would cause the program to fail.

Testing Methods

1. White Box Testing

Testing all possible routes through the program logic is called white box testing.

2. Black Box Testing

Testing performed to check whether the results are as expected as for a given input.

3. Alpha Testing

Testing carried out by the programmer at the programmer's site.

4. Beta Testing

Testing carried out by the intended users of the program at the users' site.

Selection of Test Data

The data used to test a program are divided into the following three types.

1. Valid Data

Valid data are accurate and reasonable data within the context of the program, which produce correct output. Valid data is used to test whether the program would produce the expected outcome when valid data is entered.

Examples of valid data which can be used to test a program which processes exam marks to evaluate the grade for mathematics at a school exam are 79, 92, 44, 12 etc.

2. Extreme Data

When valid data falls within a specific range, the borderline data are called extreme data.

Examples of extreme data which can be used to test a program which processes exam marks to evaluate the grade for mathematics at a school exam are 0 and 100.

3. Invalid data

These are the data which are inaccurate and unreasonable within the context of the program.

Examples of invalid data which can be used to test a program which processes exam marks to evaluate the grade for mathematics at a school exam are -47 and 127.

Debugging Tools and Techniques

1. Translator diagnostics

When the source code is translated the translator looks up the reserved words of the programming language in a dictionary. If the word is spelt incorrectly or has not followed the rules of the programming language, a message detailing the error and hints about correcting the error is displayed to the programmer. These messages are called translator diagnostics.

2. Cross referencing

Identifying errors caused by duplicate variable names.

3. Traces

Tracing the values of variables through a program run as each instruction is executed. This way the values can be checked to see where they suddenly change or take on an unexpected value.

4. Variable dumps

This is the display of the values of all the variables at a specified part of a program. This enables the programmer to compare those values with the expected results.

5. Desk checking (dry run)

The programmer works through the logic in the program code manually keeping track of the values of the variable. Since programs contain a large number of instructions, usually only small segments of code that the programmer suspect of containing an error is dry run.

6. Break points

This is to stop execution at significant points in the source code.

7. White box testing

Testing all possible routes through the program logic is called white box testing.

8. Black box testing

Testing performed to check whether the results are as expected as for a given input.

9. Bottom up programming

Building a program by writing code to use a set of components is called bottom up programming. The code in these small modules enables it easy to check the errors.

Annotation

Help given to understand code within the code itself is called annotation.

The following are the common ways of annotating code:

1. Indentation of program code

By indenting the code within a programming construct with a fixed number of spaces.

Examples are the code within a Procedure, a Function, an IF … THEN … ENDIF construct, SELECT … ENDSELECT construct, DOWHILE … ENDWHILE construct, FOR … NEXT construct etc.

2. In-line comments

The comments written within the code itself is known as in-line comments. Programming languages have different rules of writing in-line comments. For example in Visual Basic an in-line comment must start with a single quote character.

3. Use of meaningful names for variables

Naming the variable that carries the value of the customer's name as CustomerName instead of just naming it as "x".

4. Dividing the program code into modules

The code that carries out a specific task can be written as a separate module.

Advantages of annotation

1. It helps in following the solution or the algorithm of the program.

2. It helps in understanding the code easily and thereby improves the maintainability of the program.

3. It helps in reducing the errors in the program.

4. It helps in documenting the program

11. Algorithms

An algorithm is a sequence of step by step instructions for solving a problem. Two ways of presenting an algorithm are:

1. Pseudo-code
2. Program flowchart

Example 1:

Write an algorithm to calculate and display the sum of all even numbers and the sum of all odd numbers less than 20.

```
START
TotalOfEvenNumbers =  0
TotalOfEvenNumbers = 0
Counter = 1

Read Number
WHILE Counter < 20
    Read next number
    IF Number Mod 2 = 0 THEN
        TotalOfEvenNumbers = TotalOfEvenNumbers + Number
    ELSE
        TotalOfOddNumbers = TotalOfOddNumbers + Number
    ENDIF
    Counter = Counter + 1
ENDWHILE
DISPLAY TotalOfEvenNumbers
DISPLAY TotalOfOddNumbers
END
```

Example 2:

Write an algorithm to calculate and display the square numbers between 1 and 20.

```
N = 1

WHILE S < 100
    S = N * N
    N = N +1
    Display S
ENDWHILE
```

Example of an algorithm: Algorithm to turn on a cooling fan only when a motion sensor detects that there is a person in the room (M=1) and the temperature in the room (T) measured by a thermistor is above a set value "D"

```
START
WHILE system is ON
    WHILE M "Not Triggered"
        IF Fan is "On" THEN
            Fan "Off"
        ENDIF
    ENDWHILE
    IF T > D THEN
        IF Fan is "Off" THEN
            Fan "On"
        ENDIF
    ELSE
        IF Fan is "On" THEN
            Fan "Off"
        ENDIF
    ENDIF
ENDWHILE
END
```

The same algorithm can also be written as given below:

```
START
WHILE system is "Triggered on"
    READ M
    REPEAT
        IF T > D AND Fan =  "off" THEN
            Fan = "On"
        ELSEIF T < D AND Fan = "On" THEN
            Fan = "Off"
        ENDIF
```

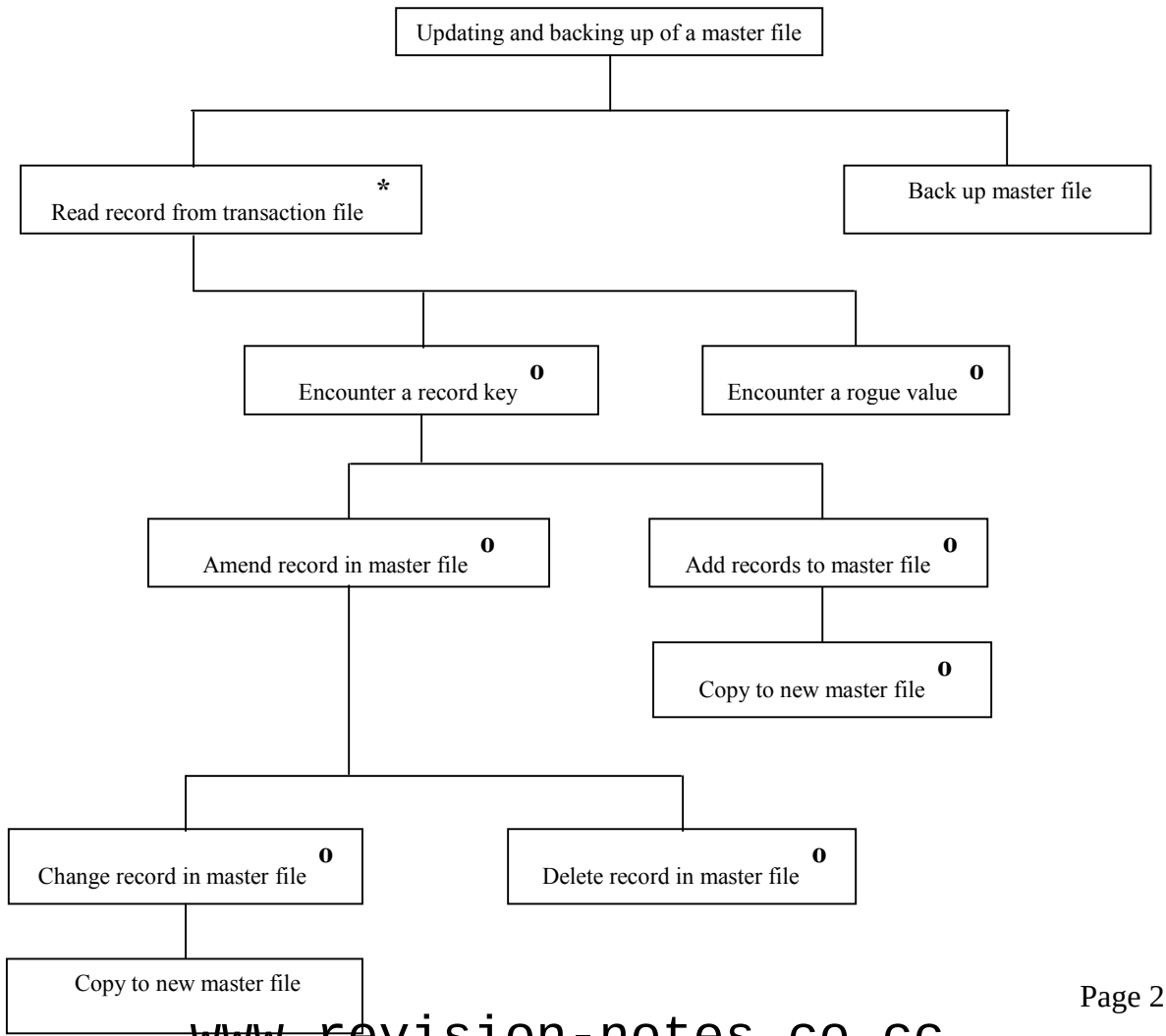
```
    UNTIL M = 0
ENDWHILE

{M = 0 if person is not in the room}
```

Algorithm for updating a master file with a sorted transaction file

```
READ record from master file
READ record from transaction file

WHILE Not EOF (transaction file)
    IF primary key of master file = primary key of transaction file
        Update master file
        READ next record from transaction file
        IF primary key of master file <> primary key of transaction file
            READ next record from master file
        ENDIF
    ELSEIF primary key of master file < primary key of transaction file
        READ next record from master file
    ENDIF
ENDWHILE
```



Chapter 1.4 – Data Representation, Structure and Management

What is a character set?

This is the set of symbols that the computer's software can recognize.

How the character set is represented in the computer?

The character set is represented in the computer by using bit patterns. The bit patterns are interpreted in different ways under different methods of data representation such as binary number system, ASCII system, EBCDIC system etc.

Denary System

Denary system is made up of powers of 10.

	Position 8	Position 7	Position 6	Position 5	Position 4	Position 3	Position 2	Position 1
Value	107	10^6	10^5	10^4	10^3	10^2	10^1	10^0
	10,000,000	1,000,000	100,000	10,000	1,000	100	10	1

Binary Number System

Binary number system is made up of powers of 2.

	Position 8	Position 7	Position 6	Position 5	Position 4	Position 3	Position 2	Position 1
Value	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	128	64	32	16	8	4	2	1

Conversion of data between denary and binary systems

Examples

1. Convert denary number 117 to the corresponding binary number using an 8-bit register.

2	117	
2	58	1
2	29	0
2	14	1
2	7	0
2	3	1
	1	1

Answer: 01110101

2. Convert binary number 10110110 to the corresponding denary number.

Denary	128	64	32	16	8	4	2	1
Binary	1	0	1	1	0	1	1	0

Answer: 128 + 32 + 16 + 4 + 2 = 182

Binary numbers represented by storage locations of different sizes

Size of Storage	Smallest Positive Data	Largest Positive Data
1 Byte	0	11111111 = 255
2 Bytes	0	1111111111111111 = 65535

Largest data that can be stored in a storage location of the size 2 bytes is calculated as follows:

1 + 2 + 4 + 8 + 16 + 32 + 64 + 128 + 256 + 512 + 1024 + 2048 + 4096 + 8192 + 16384 + 32768 = 65535

What is a field?

This is the storage space for one data item.

What is a record?

This is the data structure which contains all the data about an instance of an entity.

What is a fixed length record?

This is a record where each field is defined with a specific length.

What is a variable length record?

This is a record where at least one of its fields has a varying length.

What is a file?

This is the data structure which contains the data of all the instances of an entity.

Estimating the size of a file

When the fields of the records containing in the file and the approximate maximum number of records in the file are given, the size of the file can be estimated. Some acceptable field sizes according to the Cambridge International Exam mark schemes are given in the following example.

A file contains records which has the following fields:

Customer Name, Telephone Number, Item ID, Item Name, Price, Order Date, Whether or not the Order Outstanding, Whether or not the Order is paid for

It is assumed that there will never be more than 10,000 records in the file. Estimate the size of the file.

Field Name	Minimum Length	Maximum Length
Customer Name	10 bytes	30 bytes
Telephone Number	5 bytes	20 bytes
Item ID	2 bytes	4 bytes
Item Name	10 bytes	30 bytes
Price	2 bytes	4 bytes
Order Date	2 bytes	8 bytes
Whether or not the Order Outstanding	1 byte	1 byte
Whether or not the Order is paid for	1 byte	1 byte
Length of one record in bytes	**33**	**98**
Length of 10,000 records in bytes	**33 * 10,000**	**98 * 10,000**
Estimated file size in KB	**330,000 / 1024 = 322**	**980,000 / 1024 = 957**
Estimated file size in MB	**333,000 / (1024 * 1024) = 0.315**	**980,000 / (1024 * 1024) = .0.935**

Data Type of a field

Numeric data type

Numeric data type is assigned to data that are used in mathematical calculations. There are different sub types of the numeric data type such as integer and real.

1. Integer data type

Integer data type is assigned to data that can be counted or the data that can be expressed as a whole number. Examples are:

Number of students in a class

Number of cakes sold at the bakery today

2. Real data type

This is assigned to data that may include decimal values. Examples are:

Height of a student in centimeters
Average mark of a student at the semester exam

3. Text or String data type

Text or string data type is assigned to data which are not used in mathematical calculations. These data may include any Keyboard character. Examples are:

School admission number such as “LW12345”
An email address such as john-smith_colombo@yahoo.com

4. Boolean data type

Boolean data type is assigned to data that have values either “Yes/No” or “True/False”.
Examples are: Is Male?
Is Married?

ASCII System

ASCII system is used to represent the data generated by the computer keyboard.

ASCII Codes

The ASCII codes of the keyboard characters are given in the following table:

Character	ASCII Code	Character	ASCII Code	Character	ASCII Code	Character	ASCII Code
NULL	0000000	Space	0100000	@	1000000	`	1100000
SOH	0000001	!	0100001	A	1000001	a	1100001
STX	0000010	“	0100010	B	1000010	b	1100010
ETX	0000011	£	0100011	C	1000011	c	1100011
EOT	0000100	$	0100100	D	1000100	d	1100100
ENQ	0000101	%	0100101	E	1000101	e	1100101
ACK	0000110	&	0100110	F	1000110	f	1100110
BEL	0000111	‘	0100111	G	1000111	g	1100111
BS	0001000	(	0101000	H	1001000	h	1101000
HT	0001001	)	0101001	I	1001001	i	1101001
LF	0001010	*	0101010	J	1001010	j	1101010
VT	0001011	+	0101011	K	1001011	k	1101011
SF	0001100	,	0101100	L	1001100	l	1101100
CR	0001101	-	0101101	M	1001101	m	1101101

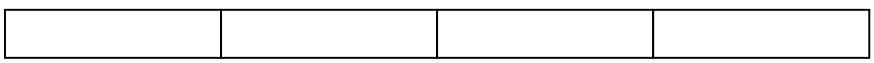
SO	0001110	.	0101110	N	1001110	n	1101110
SI	0001111	/	0101111	O	1001111	o	1101111
DLE	0010000	0	0110000	P	1010000	p	1110000
DC1	0010001	1	0110001	Q	1010001	q	1110001
DC2	0010010	2	0110010	R	1010010	r	1110010
DC3	0010011	3	0110011	S	1010011	s	1110011
DC4	0010100	4	0110100	T	1010100	t	1110100
NAK	0010101	5	0110101	U	1010101	u	1110101
SYN	0010110	6	0110110	V	1010110	v	1110110
ETB	0010111	7	0110111	W	1010111	w	1110111
CAN	0011000	8	0111000	X	1011000	x	1111000
EM	0011001	9	0111001	Y	1011001	y	1111001
SUB	0011010	:	0111010	Z	1011010	z	1111010
ESC	0011011	;	0111011	[	1011011	{	1111011
FS	0011100	<	0111100	\	1011100 |	1111100
GS	0011101	=	0111101	]	1011101	}	1111101
RS	0011110	>	0111110	^	1011110	~	1111110
US	0011111	?	0111111	_	1011111	del	1111111

What is EBCDIC system?

- EBCDIC stands for Extended Binary Coded Decimal Interchange Code.
- EBCDIC system is used in mainframe computer to represent data as text.
- It uses 8 bits to represent each keyboard character.

Array

An array is a data structure which consists of a set of adjacent memory locations and can hold only a defined number of data items.



The array has to be initialized before it is used in a program. Initializing means declaring the

- Name of the array
- Data type of the array
- Maximum number of data items that can be contained in the array (size of the array)

In Visual Basic an array that would hold a maximum of 100 student names can be initialized as:

Dim StudentNameArray (1 to 100) as String

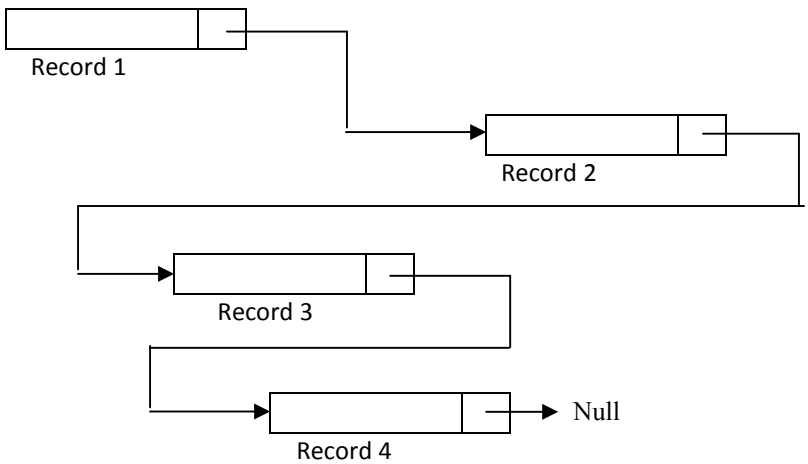
The data can be assigned to the array as following:

StudentNameArray (1) = “John”
StudentNameArray (2) = “Peter”
StudentNameArray (3) = “Michael”

It is incorrect to indicate a data item as StudentNameArray (0) because the indexes of the array start from 1 but not from 0.

When an array is initialized it has a fixed size in memory. Therefore it is not possible for a program to increase the number of data items more than the size declared for the array.

Linked List



1. A linked list is a data structure, which is a list where the nodes may not be next to each other in
the computer’s memory.

2. Each node contains a data item or a record and a pointer which carries the address of the next
node in the list

3. Start pointer references to the first node of the linked list

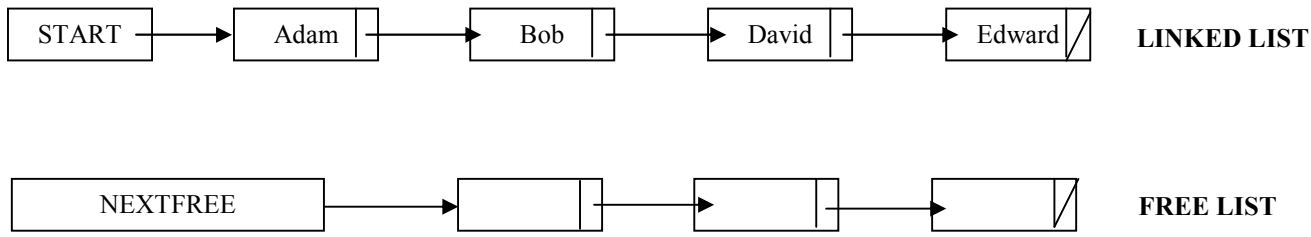
4. Nextfree pointer points to the next free location of the free list

5. The last node contains a Null pointer to indicate that there are no further items

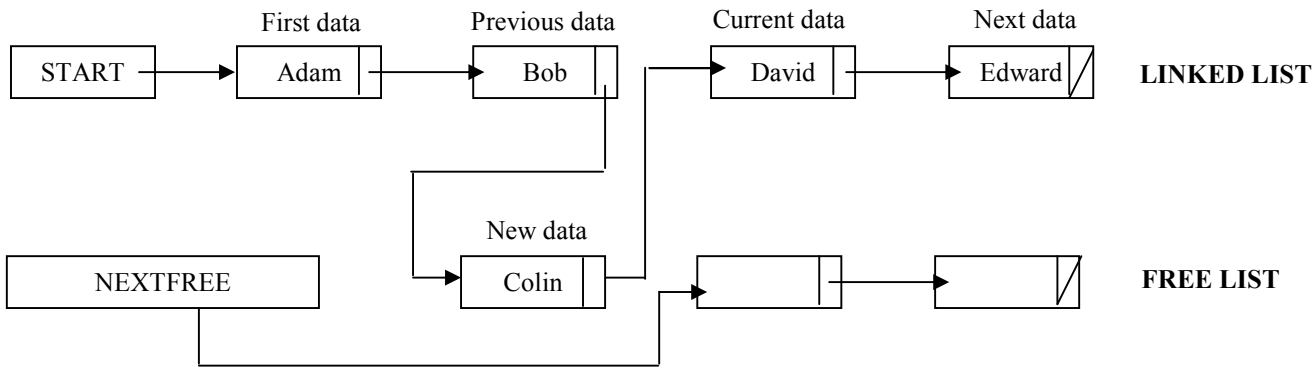
Algorithms involving Linked Lists

Algorithm 1: Insertion of a data item to a sorted linked list

Before the data was inserted



After the data was inserted




```
IF free list is empty THEN
    OUTPUT error message
ELSE
    store the new data in the node pointed to by the NEXTFREE pointer
    READ data from the linked list following the pointers
    IF new data = < current data
        IF current data <> first data
            change the pointer of the previous data to point to the new data
            change the pointer of the new data to point to the current data
        ELSEIF current data = first data
            set the pointer of the new data to point to the current data
            set START pointer to point to the new data
        ENDIF
    ELSEIF End Of List has reached and new data > = current data
        set the pointer of current data to new data
        set the pointer of new data to NULL
```

```
    ENDIF
    set NEXTFREE pointer to point to the next free location
ENDIF
```

Algorithm 2: Deleting an item from a linked list

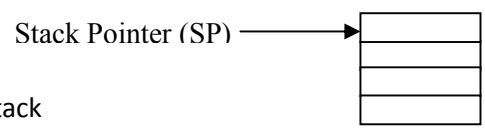
```
REPEAT
READ data from the linked list by following the pointers
IF current data = data to be deleted THEN
    set the pointer of the previous data to the next data
    add the current data to the free list and
ENDIF
```

Algorithm 3: Searching for an item in a linked list

```
REPEAT
READ data from the linked list by following the pointers
IF current = data searched THEN
    DISPLAY message "A match is found"
    STOP
ENDIF
UNTIL end of the list
IF current data <> data searched THEN
    DISPLAY message "A match is not found"
    STOP
ENDIF
```

Stack

Stack is a list of items where

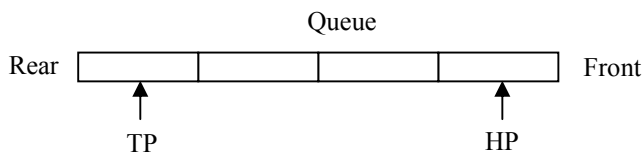


- Data are both pushed to and popped off from the top of the stack
- Last item in becomes the first item to be out (LIFO)

A stack needs one pointer because adding data to the stack and popping data off the stack are done at the same end, which is called the "Top" of the stack. The Stack Pointer (SP) points to the top of the stack.

Queue

Queue is a list of items where



- Insertions are made to the rear of the queue and deletions are made from the front of the queue
- First item in becomes the first item to be out (FIFO)

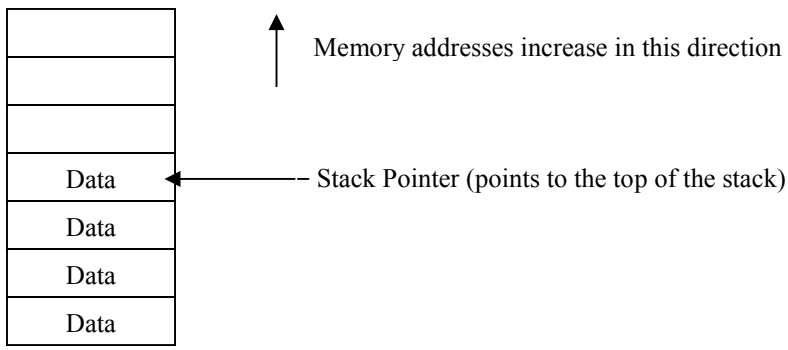
A queue needs two pointers because adding data to the queue is done at the rear of the queue and deleting an item from the queue is done at the front of the queue. The Head Pointer (HP) points to the front of the queue and the Tail Pointer (TP) points to the rear of the queue.

Algorithms involving Stacks and Queues

A problem that can occur when a program tries to insert a new value to a stack or a queue which is represented as an array is encountering the situation where the array is full. The stack pointer helps to recognize this situation by pointing to the outside of the array.

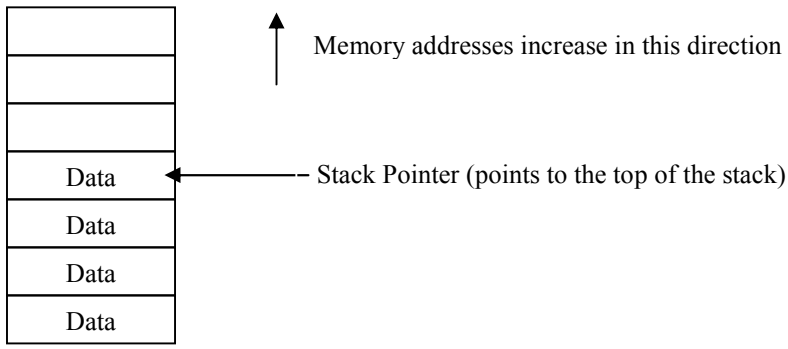
A problem that can occur when a program tries to read a value from a stack or a queue which is represented as an array is encountering the situation where the array is empty. The stack pointer helps to recognize this situation by pointing to the null value.

Algorithm 4: Insertion of an item to a stack (when the stack is represented by an array)




```
IF stack is full
    DISPLAY message “Stack is full.”
    STOP
ELSE
    Increment stack pointer by 1
    Store the new data at the location pointed to by the stack pointer
    STOP
ENDIF
```

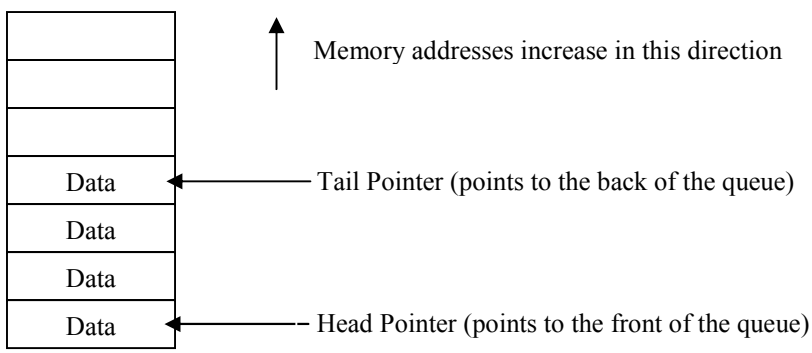
Algorithm 5: Deletion of an item from a stack (when the stack is represented by an array)



IF stack is empty
    DISPLAY message "Stack is empty"
    STOP
ELSE
    READ the item to be deleted.
    Set data in the cell pointed to by the stack pointer to the variable item_deleted
    Decrement the stack pointer by 1
    STOP
ENDIF

Algorithm 6: Insertion of an item to a queue (when the queue is represented by an array)

If the Head pointer points to the front of the queue and the tail pointer points to the back of the queue:

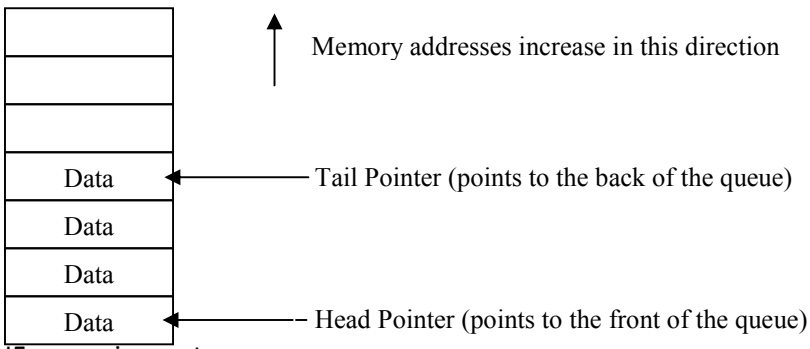


IF queue is full
    DISPLAY message "Queue is full."
    STOP
ELSE

Increment tail pointer by 1
Store the new data at the location pointed to by the tail pointer
STOP
ENDIF

Algorithm 7: Deletion of an item from a queue (when the queue is represented by an array)

If the Head pointer points to the front of the queue and the tail pointer points to the back of the queue:



IF queue is empty
DISPLAY message "Queue is empty"
STOP
ELSE
Set data in the cell pointed to by the head pointer to the variable item_deleted
Increment the head pointer by 1
STOP
ENDIF

What is serial (or sequential) access?

This is the method used by a computer program to access a record in a file where each and every record is checked from the beginning of the file until a match is found.

What is direct (or random) access?

This is the method used by a computer program to access a record in a file directly without going through each and every record starting from the beginning of the file. The computer program uses the mechanism called hash keys for direct access.

What is a serial file and how it is created?

This is a file where records are written to it in the order that they are received. The records in a serial file may not be in order with respect to a key field.

How a program access records in a serial file?

The program accesses the records sequentially. A program cannot access records in a serial file directly.

What is a sequential file?

This is a file where records are organized in ascending or descending order with respect to the primary key.

How a program creates a sequential file?

The program writes a new record to the end of the file and sorts the file each time a new record is added.

How a program access records in a sequential file?

The program accesses the records sequentially. A program cannot access records in a sequential file directly.

What is an indexed sequential file?

1. This is a file where records are organized in the ascending or descending order with respect to the primary key and where the records are divided into pages of equal size.

2. The data pages of the index sequential file are associated with an index file. Index is a pointer which contains the absolute memory or disk address of the first record of a data page.

3. Index file contains two fields: Primary key and the index. All the records in one data page have the same index (which is the memory address of the data page where that record is contained).

4. A computer program can access records in an indexed sequential file both sequentially and directly.

How a program creates an index sequential file?

1. The program writes the new record to the end of the file, divides the records into equal sized pages and sorts the records within each page. This process happens each time a new record is added to the indexed sequential file.

2. Then the program creates the index file which contains the primary keys and the corresponding
index of each primary key (index is the pointer which contains the absolute memory or disk address of the first record of a data page).

3. When the number of records containing in an indexed sequential file increases, the number of pages in the file and therefore the number of indexes also increase. This makes it necessary to
divide the index also into pages. An index which itself is divided into pages is called a **multi-level index**.

Index File

Primary Key	Index
LW00001	20001
LW00002	20001
LW00003	20001
LW00125	20101
LW00126	20101
LW00127	20101
LW00257	20201
LW00258	20201
LW00259	20201

Page 1

Memory Address	Primary Key	Student Name	Telephone	Address
20001	LW00001	John	0112398752	Colombo
20100	LW00100	Peter	0112764900	Jaffna

Page 2

Memory Address	Key	Student Name	Telephone	Address
20101	LW00101	Brian	0112367489	Kalutara
20200	LW00200	Lisa	0114872901	Negambo

Page 3

Memory Address	Key	Student Name	Telephone	Address
20201	LW00201	Wendy	0112897236	Colombo
20300	LW00300	Colin	0115278340	Kandy

How a program access records in an indexed sequential file?

1. When the user enters the primary key of the record which he wants to access, the program uses
   the index file to find the index of that primary key. When the above sample file is considered
   the program uses the following algorithm to find the index.

```
IF primary_key > LW00001 and primary_key < LW00100
    Index = 200001
IF primary_key > LW00001 and primary_key < LW00100
    Index = 200101
IF primary_key > LW00001 and primary_key < LW00100
    Index = 200201
.
.
.
ENDIF
```

2. Since the index is the pointer containing the memory address of the page, it helps the computer
   program to access the page directly. Within the page the program accesses the record by using
   sequential access method.

What is a random access file?

1. This is a file where records are written to the absolute memory or disk addresses pointed to by
   a set of hash keys stored in a hash table.

2. A computer program can access records in a random file only directly but not sequentially.

How a program creates a random access file?

1. When a new record is to be written to the random access file, the computer program creates the
   corresponding hash key of the record by applying a hash function (or a hashing algorithm) on
   the primary key of the record. When deriving the hash function to be applied, the program
   takes into account the estimated number of records in the random access file.

2. The program then stores the record at the memory or disk address pointed to by the hash key.

3. The program stores the primary keys and the corresponding hash keys in the hash table
   associated with the random access file.

4. The hash keys are written to the hash table at sequential locations until a collision occurs.

5. A **collision** occurs when the computer program finds two hash keys with the same value competing for the same location in the hash table.

6. Even though the hash keys are stored in the sequential order in the hash table, the records in the random access file may not be in the sequential order.

How a program access records in a random access file?

1. The program which searches a record in a random access file calculates the hash key of the record being searched by applying the hash function on the record's primary key (which is entered to the program by the user).

2. The computer program then accesses the absolute memory or disk address pointed to by the hash key. This is the location where the search record is stored.

3. If the same hash key occurs more than once in the hash table (this happens if there had been collisions while writing the hash keys to the hash table), the computer program which searches the record accesses the primary key pointed to by each occurrence of that hash key to find the matching one.

4. A computer program can access records in a random access file only directly but not sequentially

What is a hash function (or hashing algorithm)?

Hashing algorithm is a formula that is applied on the primary key of a record to calculate the address of the relative memory location where that record should be saved. An example is:

h(key) = key MOD 1000

Where
key is the primary key
h(key) is the hash key.
1000 is the number of records intend to be written on the file

key MOD 1000 gives you the remainder after dividing key by 1000.

Example: 2543876 MOD 1000 = 876
52002 MOD 1000 = 002

What are the criteria to go by when choosing a hashing algorithm?

- It should be able to generate any of the available addresses on the file
- It should be fast to calculate
- It should minimize collisions
- It should give a good spread of records

Methods used to overcome collision

Method 1: Writing the hash key to the next available free location

The computer program which writes records to the random access file writes the hash keys to the hash table serially. If a collision occurs the program writes the hash key to the next available free location in the hash table and the record is written to the memory address pointed by the hash key.

Method 2: Writing the hash key to an overflow area

The computer program which writes records to the random access file writes the hash keys to the hash table serially. If a collision occurs the program writes the hash key to the corresponding location in an overflow area and sets a pointer from the location in the hash table where the collision occurred, to the location in the overflow area. The record is written to the memory address pointed to by the hash key.

An illustration of how a program creates a hash table and handles collisions

Following are the primary keys of the records which are supposed to be written to a random access file:

5219243
7948452
4523001
7005665
4298114
5358243
2167999
0108666
0000667
0000114
9794004
3421999
5443115
1414243
9552666
4119349

5715666
9839349
6869348
6315349

For each primary key apply the hash function h (key) = key MOD 1000. This will give the following hash keys for each primary key.

Primary Key	Hash Key
5219243	243
7948452	452
4523001	001
7005665	665
4298114	114
5358243	243
2167999	999
0108666	666
0000667	667
0000114	114
9794000	000
3421999	999
5443115	115
1414243	243
9552666	666
4119349	349
5715666	666
9839349	349
6869348	348
6315349	349

How does the program create the hash table by writing the hash keys to the next available free location when a collision occurs?

If another hash key has already occupied that location of the hash table, the program writes the second instance of the hash key to the next available disk address.

Position in the hash table	Hash Key	Primary Key that the hash key is pointing to
Position 0	000	9794000
Position 1	001	4523001
Position 2	999	3421999
Position 114	114	4298114
Position 115	114	0000114
Position 116	115	5443115
Position 243	243	5219243
Position 244	243	5358243

Position 245	243	1414243
Position 348	348	6869348
Position 349	349	4119349
Position 350	349	9839349
Position 351	349	6315349
Position 452	452	7948452
Position 665	665	7005665
Position 666	666	0108666
Position 667	667	0000667
Position 668	666	9552666
Position 669	666	5715666
Position 999	999	2167999

Then the hash table would be as given below:

Position in the hash table	**Hash Key**
Position 0	000
Position 1	001
Position 2	999
Position 114	114
Position 115	114
Position 116	115
Position 243	243
Position 244	243
Position 245	243
Position 348	348
Position 349	349
Position 350	349
Position 351	349
Position 452	452
Position 665	665
Position 666	666
Position 667	667
Position 668	666
Position 669	666
Position 999	999

How does the program create the hash table by writing the hash keys to an overflow area when a collision occurs?

When a collision occurs (occurrence of the same hash key at the same position of the hash table), the program writes the second instance of the hash key to an overflow area. If a second collision occurs with the same hash key, the program writes the third instance to a second overflow area and so on. It means that the preceding instance keeps a pointer to the next instance in the next overflow area. The hash table would be as given below:

Hash File	
Position in the hash table	**Hash Key**
Position 0	000
Position 1	001
Position 114	*114
Position 115	115
Position 243	*243
Position 348	348
Position 349	*349
Position 452	452
Position 665	665
Position 666	*666
Position 667	667
Position 999	*999

Overflow Area 1	
Position in the overflow area 1	**Hash Kay**
Position 114	*114
Position 243	*243**
Position 349	*349**
Position 666	*666**
3421999	*999

Overflow Area 2	
Position in the overflow area 2	**Hash Key**
Position 243	**243
Position 349	**349
Position 666	**666

Methods of access performed on different file organizations

When performing serial access, primary key of the search record is compared with the primary keys of the records in the file.

When performing direct access, primary key is converted to a pointer and the processor jumps directly to the memory location of the record in the file pointed by that pointer to access the record.

	Serial Files	**Sequential Files**	**Indexed Sequential Files**	**Random (Direct) Access Files**
Serial Access	Performed	Performed	Performed	Not Performed
Direct Access	Impossible	Impossible	Performed using pointers called indexes	Performed using pointers called hash keys

What are the criteria to go by when deciding which file organization is suitable for a given case?

- If used only as a master file, the organization has to be **sequential**.
- If it is a transaction file, the organization is either **serial** or **sequential**.
- If used as a master file as well as for direct access, the organization has to be **index-sequential**.
- If used only for direct access, the organization can be either **random** or **index-sequential**.

What it means by backing up a file?

Backing up means creating an extra copy of a file to protect data if in case the original file get corrupted or destroyed.

What it means by archiving a file?

Archiving a file means making a copy of little-used data at a certain point of time for long term storage so that it can be removed from the main file to make space for other data.

Backup procedure

1. Create several backup copies on tapes or on other portable storage media such as rewritable CDs or zip drives at sensible and regular time intervals.

2. Backup copies are transported to and stored at locations away from the location of the original file.

3. If applicable keep a copy of the transaction file between backups.

Why it is necessary for a company to archive a file?

1. The file's hit rate has reduced.

2. Many records of the file are not used

3. Necessary to free up space in the hard drive

4. Necessary to store example states of the file before lost forever

5. Replacing the old file with a new file leads to old files being archived

6. To use for taxation purposes

7. To produce management information

Chapter 1.5 – Hardware

Components of the processor

Three main components of the processor are control unit, arithmetic and logic unit and memory unit.

Functions of the control unit are:

1. Decides which instruction to carry out next and then go and fetch it
2. Determines what needs to be done to carry out the instruction (decodes the instruction)
3. Manages the execution of the instruction by telling other parts of the processor what they should do to carry out the instruction.
4. Choreographs the instruction cycle by using a clock

Functions of the arithmetic and logic unit are:

1. Contains circuitry that allows it to carry out arithmetic
2. Performs logical decisions
3. Acts as the gateway between the processor and the peripheral devices of the computer system such as the hard drive

Functions of the memory unit are:

1. Stores the operating system or parts of the operating system
2. Stores application software instructions that are currently being used in the computer
3. Stores the data files that are currently being used in the computer

Data storages in a computer

Data storages in a computer are divided into two categories:

1. Primary storage or main memory
2. Secondary storage or backing store

What is primary storage or main memory?

This is the storage that can be accessed by the computer's processor. It consists of RAM (random access memory), ROM (read only memory), cache memory and registers.

What is secondary storage or backing storage?

This is the storage where the data is stored for future use and cannot be accessed by the processor directly.

Differences between RAM and ROM

RAM	ROM
1. Data in RAM can be easily changed	2. Data in ROM cannot be changed
2. RAM is volatile (contents in the RAM disappears when power is turned off)	4. ROM is non volatile (contents in the ROM does not disappear when power is turned off)
3. RAM stores the operating system, application programs that are currently running in the computer and the data that is being used.	4. ROM stores special programs such as the bootstrap program that is used to load the operating system.
4. RAM is usually larger than ROM	3. ROM is usually small

Similarities between RAM and ROM

1. Data stored in both RAM and ROM can be can be accessed by the CPU directly

2. Data stored in both RAM and ROM can be accessed by the CPU randomly (in any order)

Differences between the primary storage and the secondary storage

1. Data in the primary storage can be accessed directly by the processor whereas the data in the secondary storage cannot be accessed directly by the processor.

2. Data from the primary storage can be read faster than from the secondary storage. This is due to the reason that the secondary storage relies on the physical movement of the recording medium or a reading head. In the secondary storage devices, the movement takes longer than the data transfer, and the retrieval time varies depending on the physical location of the next item.

Why software is stored on ROM?

1. Software in ROM does not have to be loaded in RAM and is readily available and accessible by the processor when the power is turned on in the computer.

2. This software is not supposed to be altered or upgraded.

Why it is important that ROM has some characteristics of RAM?

Processor can only access data held in the primary storage and ROM and RAM are both parts of the primary memory. Data in ROM needs to be accessed randomly otherwise the data access would be too slow.

How secondary storage or backing stores are categorized?

Secondary storage can be categorized according to:

1. Medium (whether magnetic or optical)
2. Technique used to store data (whether data can be stored sequentially or for direct access)
3. Capacity (how much data can be stored)
4. Portability (whether it can be moved around easily)
5. Access time to the data

Backing Stores

Magnetic tape

This can only be used to store data sequentially but not direct access. This is a disadvantage because it is largely unsuitable for many data handling applications which need to perform search for data based on direct access. Access time to data is also very long because data has to be accessed sequentially. However, the data storage capacity is high and the tape is freely portable. It is very useful for producing backup copies of files. Magnetic tapes are used for storing backup copies of files.

Floppy disk

Floppy disk can store data for direct access. Storage capacity is very small. Very portable and can be handled easily because of its small size and the protective jacket. Data access time is very slow because of the limited speed of rotation and the relatively crude nature of the read heads. Floppy disks are used for transferring confidential data files.

Hard disk

Hard disk can store data for direct access. Data storage capacity is very high. Access time is very fast because the hard disk rotates very fast. Hard disks are portable but they are mostly used as stationery devices in the computer system. Hard disks are used to store large operating systems, databases, large number of graphics and images etc.

CD ROM

CD ROM is an optical storage device. It uses the reflection of a laser beam off a pitted surface to store data. CD ROM can be used to store data for direct access. Data storage capacity is high. CD ROMs are very portable. Access time to data is fast. The data stored in CD ROMs cannot be changed. Therefore CD ROM is used to store data such as operating systems, application software packages and large data files which should not be altered accidentally or purposely.

Rewritable CDs

Rewritable CDs have all the properties of CD ROMs and in addition to that the data stored in the rewritable CD can be changed or erased. Therefore rewritable CDs are used for storing backup copies of files and for archiving files.

Zip Drive

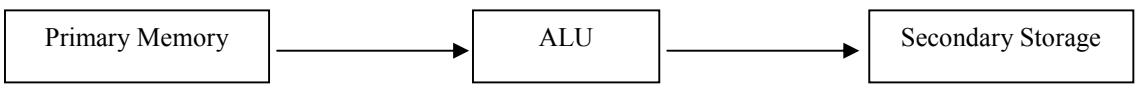
This is a more robust version of a floppy disk. Zip drive has a higher data storage capacity and a faster data access speed than a floppy disk. Zip drive is usually used as a backup medium.

DVD

This is an optical storage medium. The data storage capacity and the access speed are much higher than the CD. DVDs are used for storing large files such as music and movies.

Use of buffers and interrupts in the transfer of data from primary memory to the secondary storage

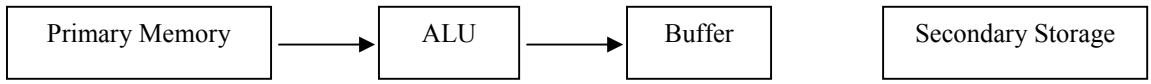
It is necessary to transfer data between the primary memory and the secondary storage. Because primary memory is part of the processor and that anything that goes in or out of the processor must go through the ALU. This is shown by the following diagram.



Primary memory operates at great speed because it is part of the processor. In comparison, secondary storage is slow at reading or writing data.

Buffer is an area of fast access storage which can be filled by the processor very fast and then emptied at a slower speed by the secondary storage device allowing the processor to continue with other tasks. Therefore a buffer is included between the ALU and the secondary storage. This breaks the exchange of data between the primary memory and the secondary storage into two stages.

Stage 1: Filling the buffer from the processor



Stage 2: Emptying the buffer to the secondary storage

When the secondary storage device has used up the contents of the buffer it needs to tell the processor that it requires more data. This is done by sending a message to the processor, which is called as an interrupt.

Definition of an interrupt: It is a signal generated by a process (a running instance of a software application) or a hardware device to get the attention of the processor.

Summary of the mechanism of data transfer between the processor and a secondary storage using buffers and interrupts

1. Processor transfers a whole block of data from the primary memory to the buffer at once

2. The buffer transfers data one by one to the backing store slowly

3. In the meantime the processor can attend to some other task in the computer

4. When the buffer becomes empty, the backing store sends an interrupt signal to the processor to
   signal the fact.

5. According to the priority of the job handling the interrupt, the processor decides whether to suspend the current job and to carry out the interrupt or to store the interrupt for execution later.

6. The processor sends another block of data to fill the buffer.

Peripheral devices

Hardware that is connected to the system unit from outside are called peripheral devices.

Examples of peripheral devices are:
Input devices such as keyboard, mouse, digital camera, microphone
Output devices such as monitor, printer, speaker

Storage devices such as external hard drive and flash drive
Communication devices such as external modem and ADSL adaptor

What are input devices?

This is a piece of hardware that allows data to be input to the processor.

What are output devices?

This is a piece of hardware that allows the processor to convey the results of processing (information).

What are communication devices?

This is a piece of hardware involved in transferring data between computers. Examples are modem, network interface card, router, bridge and ISDN adapter. The details will be covered in Chapter 6.

Input Devices

1. Keyboard

The common keyboard which contains all the ASCII keys is called the QWERTY keyboard because those are the first six characters on the top line. The keyboards of special devices do not contain all the keys of the common keyboard but only the keys that are needed for the operation of that device. Examples are ATM machine, washing machine, door-security systems etc. ATM machine needs only those keys for numbers to enter an amount of money and for “Enter” and “Cancel” commands. Washing machine needs keys only to execute a specific set of commands such as “Start”, “Stop”, “Hot Water”, “Cold Water” etc. Door-security systems need only the keys to enter numbers from 0 to 9 which are used enter the password.

Problems with normal keyboard are:

1. Prone to damage from dust, dirt and liquid because of the gaps between the keys.
2. Difficulty to keep the typist’s hands comfortably while using the keyboard because the keys are
   arranged in rigid rows.

Concept keyboard

This is a keyboard which has specialized overlays to perform functions with specialist software. After the keyboard is programmed, a sheet called an overlay, is placed overtop to identify each key. The overlay can consist of any combination of words, symbols or pictures. Usually this keyboard has its keys simply as areas of a continuous surface which are sensitive to touch. They are ideal for outdoor use because the rainwater will not damage them. Example: The keyboard of an ATM machine

Ergonomic keyboard

An ergonomic keyboard is a computer keyboard designed with ergonomic considerations to minimize muscle strain. Some ergonomic keyboards are a single board, with the keys separated into two or three groups, allowing the user to type at a different angle than the typical straight keyboard. Some ergonomic keyboards have the keyboard split into several independent pieces. Either of these types of keyboards may include elevated sections at various angles. This keyboard has its keys arranged in curves so that the palm of the hand can be supported on the keyboard comfortably while typing.

What is ergonomics?

Ergonomics is the science of adapting products and processes to human characteristics and capabilities in order to improve people's well being and optimize productivity. Ergonomics ensure that products and environments are comfortable, safe and efficient.

2. Mouse

A pointing device used to translate its movements on the desktop into digital information; this is fed to the computer, which in turn causes the cursor to move on the screen.
There are mechanical mice and optical mice. Mouse has two or three buttons used to make selections on the screens.

3. Tracker ball

A pointing device used in laptop computers.

4. Touch sensitive pad (track pad)

Used in notebook computers
Operate by moving a stylus or a finger across a pad which moves the cursor on the screen.

5. Touch-screen

A screen sensitive to touch
Used to select an item from a menu
Used in banks and restaurants
Input device useful for users who are not computer literate

6. Light pen

A light pen is a light-sensitive wand used in conjunction with the computer's CRT monitor. It allows the user to point to displayed objects, or draw on the screen, in a similar way to a touch screen, but with greater positional accuracy. A light pen can work with any CRT-based monitor, but not with LCD screens, projectors and other display devices.
Used in CAD systems.

7. Joystick

A stick, when moved, which makes the cursor move in the same direction

8. Scanner

Used to scan text or pictures into the computer's memory

9. OCR

1. Optical Character Reader

2. Used to scan documents such as data capture forms where it reads, translates, converts the printed and handwritten characters into computer characters and transfer those characters to the computer.

3. Light reflected off characters determines the shape of characters.

4. OCR uses a template of characters stored in it to compare with the characters in the source document in order to recognize them.

10. OMR

1. Optical Mark Reader

2. Used to scan paper documents containing marks at specified locations and to recognize them.

3. OMR uses a template document containing the marks at correct locations to compare with the marks in the source document in order to recognize the correct answers.

How the form and its contents can be affected by the need to use OMR?

1. The form used to mark data must have areas at identified locations to shade or mark.

2. Printing in the sensitive areas of the sheet is done using a special type of ink in a light color (such as light blue or pink which the OMR does not see.

3. Form should only be used in one side

4. Form should be restricted to one sheet

5. Form should not be folded

6. Form should be kept clean.

11. Barcode reader

Used to input data included in a barcode to a computer. The barcode consists of a series of alternating dark and light colored lines. The thickness of the line identifies a specific character.

12. MICR

Magnetic Ink Character Reader
Used to scan bank checks and input data printed with a special magnetized ink at the bottom of the check

13. Digital camera

Used to input photos taken and stored in its memory to the computer's memory

14. Web Cam

Used in video conferencing, weather stations and checking on children in nurseries.

15. Sensors

Used to input signals coming from sources in monitoring and control systems and data logging system

16. Microphone and Voice Recognition

Used as an input device in voice recognition systems by speaking directly to the computer

17. Graphic tablet or digitizer

A Graphics tablet consists of a flat surface upon which the user may "draw" an image using an attached stylus, a pen-like drawing apparatus. The image generally does not appear on the tablet itself but, rather, is displayed on the computer monitor.

This uses a cursor to trace over a technical drawing put on a flat surface called the tablet. When the user draws on the paper the tablet senses where the pencil is pointing and transfer the line to the screen.

18. Digitizer

This is an input device which can convert text, a picture or a drawing (which are considered as analog signals) to digital form when trace over them.

19. Smart card

Used as telephone cards to input the card number and the amount of the card
Used as credit cards to input the account number and the credit limit

20. Magnetic stripe reader

Used to input the data containing in the magnetic stripe of a credit card

21. Touch-tone telephone

Used to input responses to a voice-based menu system by pressing keys of the telephone

22. Kimball tag

This is a piece of card with holes punched in it which represents a code. When an item is purchased the card is removed and input to a computer. Used in clothes shop for stock control.

What is point of sale (POS)?

Point of sale is a terminal connected to a main computer.

The input devices used at a point of sale are:

1. Barcode reader – scans the barcode fixed to an item by recognizing the thickness of the bars to
   allow the interpretation of the item number.

2. Keyboard – allows the operator to input barcode, price and other details manually in case the barcode reader cannot read the barcode.

3. Swipe card reader or the smart card reader
   Allows reading data from a credit/debit/bank card or to send those details to the bank

4. Scales
   To measure the weight of an item

5. Customer keypad
   For the customer to input the PIN

The output devices used at a point of sale are:

1. Printer
   To print the till receipt

2. LCD
   To show purchase details and the cost of item

3. Buzzer
   To confirm the reading of the barcode

Output Devices

1. Visual display unit (standard TV, standard computer screen, Liquid Crystal Display)

A standard monitor includes a cathode ray tube (CRT). The resolution of the standard monitor is determined by the number of pixels in a given area on the screen.

2. Printer – Dot matrix, Laser, Ink Jet

Dot matrix printers are called impact printers because they print by striking the paper through a carbon ribbon. The letters are formed by a series of dots. Laser printer operates by heating the paper and making the toner particles fuse to the paper in those locations which make the contour of the letters. Ink jet printers operate by spraying liquid ink on the paper at identified locations to draw the letters and pictures.

3. Microfiche

This is a rectangular shaped film of plastic which is divided into tiny areas which can store a miniature image of a page of a document. A book with even 500 pages can be stored in a microfiche card.

4. Plotter

This is used to draw and output fine graphics such as maps and building designs. The advantages of plotter are:

1. Can produce hard copy output
2. Can produce large scale printouts
3. Can produce high quality and accurate output
4. Can produce the output as the data is inputted

5. Voice synthesis or speakers

6. Projector

Chapter 1.6 – Data Transmission and Networking

What is a network?

A network is a collection of computers, printers, scanners, routers, bridges, switches and other devices which are connected to each other by some transmission medium. The devices connected in the network are called nodes of the network.

What is a network transmission medium?

Network transmission medium is the medium through which the data flow from one node to another in a network.

What are the types of network transmission media?

Network transmission media are of two types:
- Cable media – metal cables, fiber optic cables
- Wireless media – radio waves, microwaves, infra-red waves

What metal cables are used as network transmission media?

Coaxial Cables
Unshielded Twisted Pair (UTP) cables
Shielded Twisted Pair (STP) Cables
Fiber-Optic Cables

What is a local area network (LAN)?

A LAN is a network of computers in a small geographical area such as a school, a company, an office or a factory.

What is a wide area network (WAN)?

A WAN is a network of computers in a large geographical area such as several cities or even countries. The largest WAN is the Internet, which is global.

How LANs differ from WANs?

LAN	WAN
LAN exists in a small geographical area.	WAN exists in a wider geographical area.

LAN is usually hard-wired (uses cables to connect computers)	WAN requires other transmission media to connect devices except for cables
Data in a LAN is easier to keep secured	Data in a WAN is prone to hacking
Computers in a LAN can share hardware such as printers	Computers in a WAN cannot share hardware such as printers

What are the software and hardware needed for communication in a LAN?

1. Network operating system
   Needed by the computers to get connected to each other and communicate data and information

2. Hardware drivers for the network interface card and the modem
   Needed by the network interface card to convert data and information to a format that the processor of the communicating computer can understand

3. Network interface card
   Need by the computers to get connected to each other

4. Cables
   Used as the transmission medium

5. Hub
   Used to concentrate the cables connected to the computers

What are the software and hardware needed for communication in a WAN?

1. Dial up software
   To connect to a Web server or to access the telephone lines

2. Network interface card
   To communicate in a WAN

3. Modem/ISDN/ADSL adapter
   To access the telephone system

What are the advantages of using a network of computers over using a collection of stand-alone computers?

- It allows the sharing of hardware resources such as disk storage, printers, image scanners, modems and central servers.
- It allows sharing of data and information held in one computer accessible to many users.

- It is easier to store application programs on one computer and make them available to all users rather than having copies individually installed on each computer.
- It allows sharing of a centralized database.
- It allows electronic mail and messages to be sent between users.
- It allows the implementation of centralized security.
- It is easier to set up new users and equipment.
- It allows the connection of different types of computers which can communicate with each other.

What are the disadvantages of using a network of computers over using a collection of stand-alone computers?

- Users become dependent on them. For example, if the network file server develops a fault, then many users will be unable to run application programs. (On many sites, a back-up file server can be switched into action if the main server fails).
- If the network stops operating then it may not be possible to access various hardware and software resources.
- The efficiency of a network is very much dependent on the skill of the network administrator. A badly managed network might operate less efficiently than a set of stand-alone computers.
- It is difficult to make the system secure from hackers, novices and industrial espionage.
- As traffic increases on the network, the performance degrades unless it is properly designed.

What is meant by network topology?

The physical layout of network nodes is called the network topology.

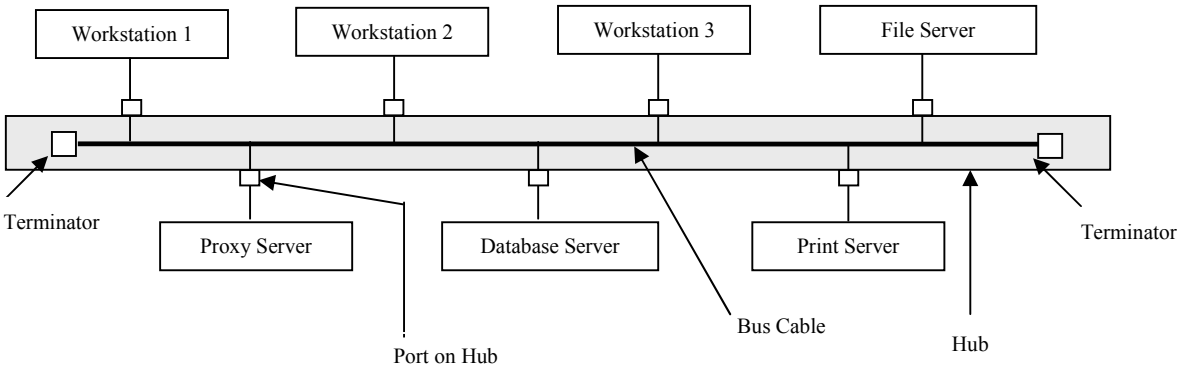
What are the widely used network topologies?

Bus topology, star topology and Ring topology

Bus Topology

Description of the bus topology

All the devices on the network share a single cable known as the bus cable. Each node is independently attached to the common bus cable. Data can be transferred from any computer to any other computer. The bus cable ends at a terminator, which absorbs electrical signals so they don't bounce or reflect back and forth on the bus. The bus cable is located inside a hub and each piece of cable connected to the bus cable has its other end connected to a port on the hub.



Advantages of bus topology

- Easy and inexpensive to set up as it requires the least amount of cables compared to other topologies.
- Easy to add nodes without disrupting the network.

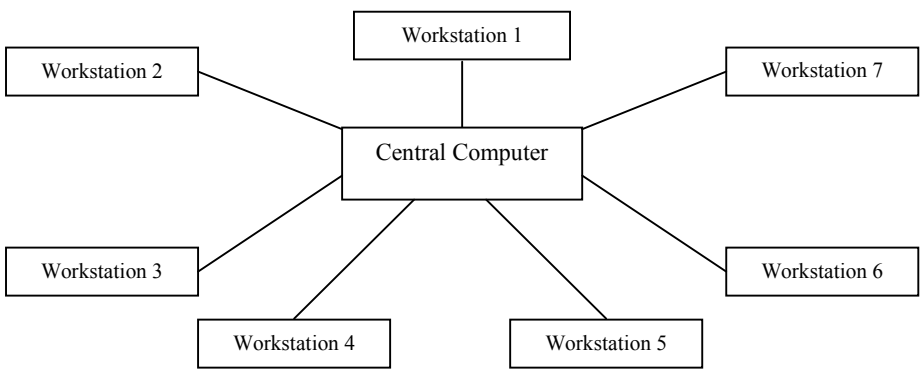
Disadvantages of bus topology

- The whole network goes down if the main bus cable fails at any point.
- Cable failure is difficult to isolate.
- Network performance degrades as the number of computers increase.

Star Topology

Description of the star topology

In star topology each node is connected to a central computer which controls the network.



Advantages of star topology

- If one cable fails the other nodes are not affected.
- Performs consistently even when the network is being heavily used.
- Reliable market-proven system.
- No problem arises with the collision of data since each computer has its own cable connecting to the server.
- Easy to add and remove nodes without disrupting the network.

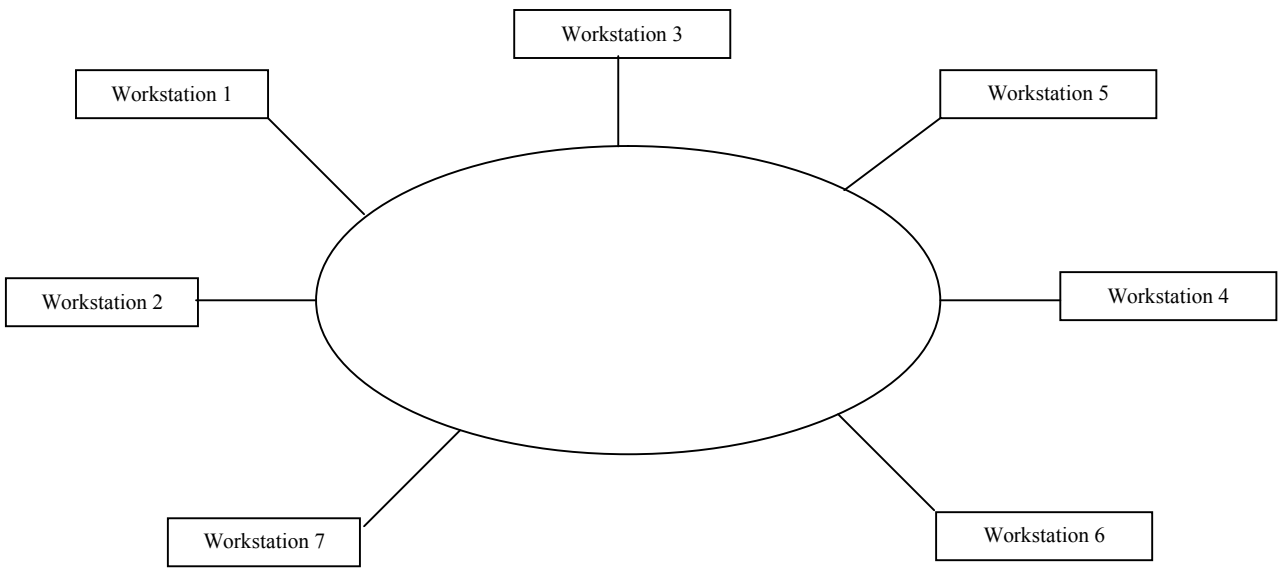
Disadvantages of star topology

- Costly to install because of the length of cables required.
- If the central computer crashes, the whole network goes down.

Ring Topology

Description of the ring topology

In a ring network, the two ends of the bus are joined up. This creates a loop so that data can be sent in both directions along the cable. If there is a break in the cable, the network will continue to operate because the data can go in the other direction.



Advantages of ring topology

- There is no dependence on a central computer or file server and each node controls transmission to and from itself.
- Can continue with a break in the network cable as the data can move in both directions along the cable
- High transmission rates are possible.

Disadvantages of ring topology

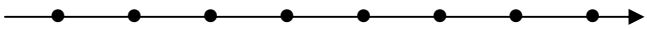
- If one node of the ring breaks down, transmission between any of the devices in the ring is disrupted.

Types of data transmission

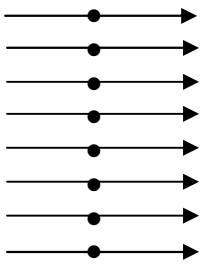
Data transmission can be divided into the following two types:

Serial transmission
Parallel transmission

Serial transmission is the transmission of data one bit behind another along a single wire.



Parallel transmission is the transmission of data along a set of several wires (usually a multiple of eight wires) where bits move simultaneously as a bit front.



Parallel transmission is faster than serial transmission.
Parallel transmission is less reliable than serial transmission because of the fine tolerances in the transmission as the bits can become muddled up.

Examples:

1. The Data transmission between the primary memory and the hard drive of the computer is parallel because the processor requires the data to be downloaded as quickly as possible.

2. The data transmission between the computer and the printer is parallel because the computer needs to send a big chunk of data to the printer's buffer quickly so that the processor will be free to attend to other tasks of the computer.

Modes of data transmission

Data transmission can be divided into the following three modes:

- Duplex mode
- Half duplex mode
- Simplex mode

Duplex mode of transmission means passing data in both directions at the same time between two devices.

Half duplex mode of transmission means passing data in both directions between two devices but only one direction at a time.

Simplex mode of transmission means passing data only in one direction between two devices.

Examples:

1. The data transmission between the primary memory and the hard drive of the computer is half duplex.

2. The data transmission between the computer and the printer is half duplex because the computer transmit data files to the printer for printing and the printer passes messages to the computer such as error messages.

Bit rate

Number of bits that can be sent in one second is known as bit rate.

The unit used to measure the bit rate is Baud.

1 Baud = 1 bit per second

What is the relationship between the bit rate and the way that the data in the files are used?

1. When files containing only text data are transmitted in a network, they can be sent at a slower bit rate because the text data are not time sensitive.

2. When files containing pictures, graphics and animations are transmitted in a network, they have to be sent at a higher bit rate because those data are time sensitive.

3. When files other than the ones containing only text data is transmitted in a network, it is important to limit the amount of data that is being transmitted. This will increase the speed of data transmission and therefore the time it takes to download the file at the destination computer will decrease. Speeding up the transmission of a file by reducing the amount of data is known as compression.

Why bit rate is an important part of communication?

This is because it enables:

1. Standardization
2. One layer of the protocol to be altered without altering the entire protocol
3. Manufacturers to design hardware and software for a particular layer

Why bit rate is an important part of any protocol?

Because if one device sends data at a particular bit rate and the other device reads what it receives at a different rate, the message would never be received correctly.

Error checking and correcting

When data is transmitted in a network the bit stream can get affected due to various reasons, which makes the data at the receiving computer to contain errors. The methods that can be used for checking transmission errors are:

1. Echoing back
2. Check sum
3. Parity

What is echoing back?

The receiving computer sending back the data to the sending computer is known as echoing back.

How echoing back is used to detect transmission errors?

The data echoed back is checked against the data that was sent in the first place by the sending computer. If they match there has been no error in transmission. If they do not match there has been an error in transmission and the data will be sent again.

Disadvantages of echoing back

Takes a long time to transmit data as the data has to be sent twice
Can be implemented only in duplex or half duplex modes

What is check sum?

The sum of all the bytes in a block of data is called the check sum.

How check sum is used to detect transmission errors?

1. The check sum is calculated ignoring the carry out of the byte and is mentioned with the block of data that is being transmitted.
2. The check sum is then calculated again when it is received at the receiving computer
3. The check sum calculated is then compared with the value mentioned in the block of data.
4. If the two values match there has been no error in transmission. If they do not match there has been an error in transmission.

What is parity?

1. The sum of all the 1-bits in a byte of data is called the parity. Parity can be either odd or even.
2. The parity of each byte of data must be equal to the parity defined for that computer.
3. If the parity of a byte of particular piece of data is different from the parity of the computer, then the parity bit of the byte is changed so that the parity of the data will match the parity of the computer.

How parity check is used to detect data transmission errors?

1. The parity of each byte of data that reaches the receiving computer is checked against the parity of the sending computer.
2. If the two parities match there has been no error in transmission. If they do not match there has been an error in transmission.

What is circuit switching?

Circuit switching has a fixed path through the network between the sending computer and the destination computer is opened and held for the entire time duration of data transmission.

What are the advantages of circuit switching?

The message arrives at the receiving computer without having its data to be reordered.

What is packet switching?

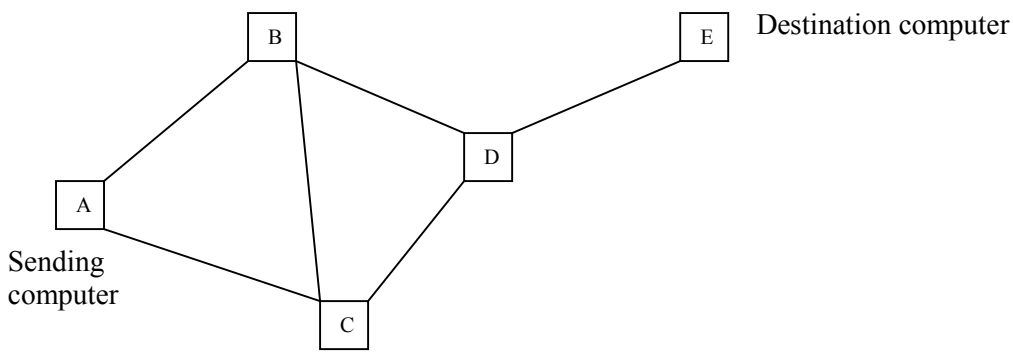
1. The message is split into a number of equal-sized packets.

2. Each packet is labeled with the destination address and the packet number.

3. Packet switching transmits individual data packets into the network to find their way to the destination computer independently of each other.

4. At each node the label is checked and the packet is redirected

5. At the destination computer the packets are reordered and reassembled according to their packet numbers.



What are the advantages of packet switching?

1. Large part of the network is not tied up for long periods of time.

2. Message is difficult to be hacked

What are the disadvantages of packet switching?

1. Transmits at the speed of the slowest packet

2. Packets must be reordered and reassembled at the destination

What is a protocol?

A protocol is a set of rules which control the data transmission in a network.

What are the features (or rules) of protocols?

1. Type of data transmission or whether the data transmission is serial or parallel. Errors would occur if one device has a serial connection and the other device expects a parallel connection.

2. Mode of data transmission or whether the data transmission is full duplex, half duplex or simplex

3. Bit rate – since both devices must talk and listen at the same number of bits per second. Otherwise bits may be missed or counted twice

4. Error checking – whether the parity is odd or even, whether echoing back is used, whether check sums are used

Why a protocol should be arranged in a layered fashion?

Individual layers of protocol can be altered without altering the other layers when hardware and software are changed.

Chapter 1.6 – Data Transmission and Networking

A network is a collection of computers, printers, scanners, routers, bridges, switches and other devices which are connected to each other by some transmission medium. The devices connected in the network are called nodes of the network.

Network transmission media

A network transmission medium is the medium through which the data flow from one node to another in a network.

Network transmission media are of two types:

- Cable media such as metal cables and fiber optic cables

  Metal cables used as network transmission media are: coaxial cables, unshielded twisted pair (UTP) cables, shielded twisted pair (STP) cables and fiber optic cables

- Wireless media such as radio waves, microwaves, infra-red waves

LANs and WANs

Networks are divided into two types based on the extent of geographical area covered by them. A network that covers a small geographical area is called a local area network or a LAN. Examples for local area networks are the networks in schools, offices, and factories. A network that that covers a wide geographical area is called a wide area network or a WAN. Examples for wide area networks are the networks in companies which have branches in many cities or countries. The Internet is the largest wide area network.

How LANs differ from WANs?

LAN	WAN
LAN exists in a small geographical area.	WAN exists in a wider geographical area.
LAN is usually hard-wired (uses cables to connect computers)	WAN requires other transmission media to connect devices except for cables
Data in a LAN is easier to keep secured	Data in a WAN is prone to hacking
Computers in a LAN can share hardware such as printers	Computers in a WAN cannot share hardware such as printers

Hardware and software needed for communication in a LAN?

- Network interface card which is needed by the computers to get connected to each other

- Cables which are used as the transmission medium
- Hub which is used to concentrate the cables connected to the computers
- Network operating system which is needed by the computers to get connected to each other and communicate data and information
- Hardware drivers for the network interface card and the modem which are needed to convert data and information to a format that the processors of the communicating computers can understand

Hardware and software needed for communication in a WAN?

- Network interface card which is used to connect computers by cables
- Modem, ISDN or ADSL adapter which is needed to access the telephone system
- Dial up software which is needed to connect to a Web server or to access the telephone lines

Advantages of using a network of computers over using a collection of stand-alone computers

- Allows sharing of hardware such as disk storage, printers, image scanners, modems and central servers
- Allows sharing of data and information held in one computer among the users of the network where their computers are connected.
- Allows sharing of application programs held in one computer and make them available to all users rather than having copies installed on each computer
- Allows sharing of a file server where all the users can save their files and have that one computer backed up instead of backing up all the computers
- It allows sharing of a centralized database
- It allows electronic mail and messages to be sent between users
- It allows the implementation of centralized security for computer files
- Allows having one proxy server to have the Internet connection and have the users of all the other computers in the network log in to the proxy server to access the Internet
- It allows different types of computers to communicate with each other

Disadvantages of using a network of computers over using a collection of stand-alone computers

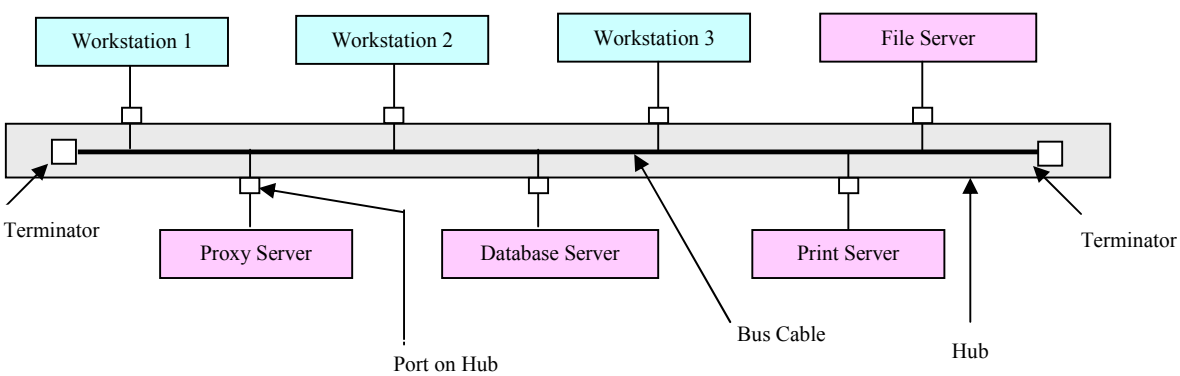
- Users become dependent on them. For example, if the network file server develops a fault, then many users will be unable to run application programs. (On many sites, a back-up file server can be switched into action if the main server fails)
- If the network stops operating then it may not be possible to access various hardware and software resources
- The efficiency of a network is very much dependent on the skill of the network administrator. A badly managed network might operate less efficiently than a set of stand-alone computers
- It is difficult to make the system secure from hackers, novices and industrial espionage
- As traffic increases on the network, the performance degrades unless it is properly designed

Network topology

Network topology is the physical layout of network nodes. Bus topology, star topology and Ring topology are the widely used topologies of local area networks.

Bus Topology

All the devices on the network share a single cable known as the bus cable. Each node is independently attached to the common bus cable. Data can be transferred from any computer to any other computer. The bus cable ends at a terminator, which absorbs electrical signals so they don't bounce or reflect back and forth on the bus. The bus cable is located inside a hub and each piece of cable connected to the bus cable has its other end connected to a port on the hub.



Advantages of bus topology

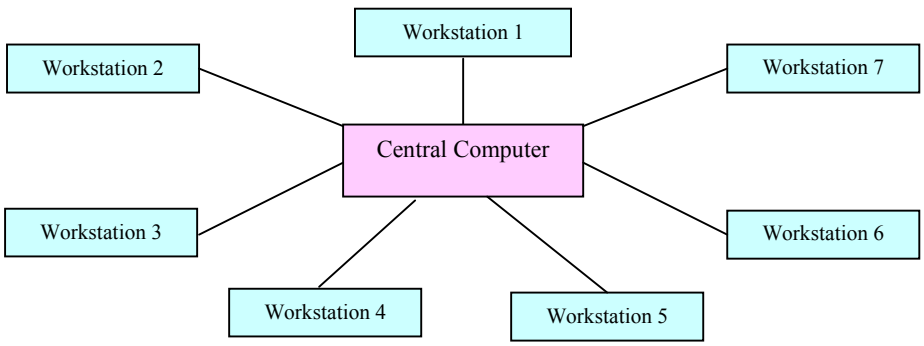
- Easy and inexpensive to set up as it requires the least amount of cables compared to other topologies
- Easy to add nodes without disrupting the network

Disadvantages of bus topology

- The whole network goes down if the main bus cable fails at any point
- Cable failure is difficult to isolate
- Network performance degrades as the number of computers increase and the network is heavily used

Star Topology

In star topology each node is connected to a central computer which controls the network.



Advantages of star topology

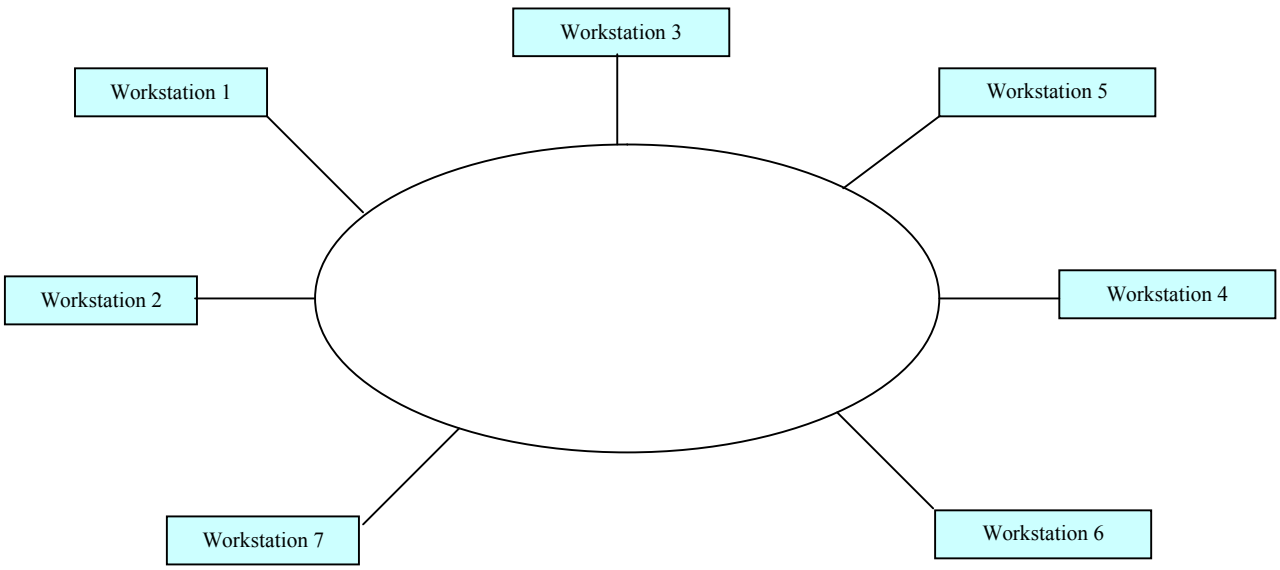
- If one cable fails the other nodes are not affected
- Network performance does not degrade as the number of computers increase and the network is heavily used because each computer has its own cable connecting to the server
- Reliable market-proven system
- Easy to add and remove nodes without disrupting the network.

Disadvantages of star topology

- Costly to install because of the length of cables required.
- If the central computer crashes, the whole network goes down.

Ring Topology

In a ring network, the two ends of the bus are joined up. This creates a loop so that data can be sent in both directions along the cable. If there is a break in the cable, the network will continue to operate because the data can go in the other direction.



Advantages of ring topology

- There is no dependence on a central computer or file server and each node controls transmission to and from itself.
- Can continue with a break in the network cable as the data can move in both directions along the cable
- High data transmission rates are possible.

Disadvantages of ring topology

- If one node of the ring breaks down, transmission between any of the devices in the ring is disrupted.

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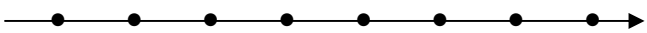
Types of data transmission

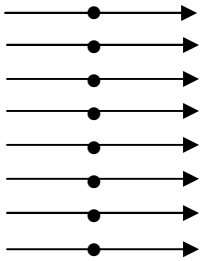
Data transmission can be divided into the following two types:

- Serial transmission
- Parallel transmission

Serial transmission is the transmission of data one bit behind another along a single wire.



Parallel transmission is the transmission of data along a set of several wires (usually a multiple of eight wires) where bits move simultaneously as a bit front.



Parallel transmission is faster than serial transmission.

Parallel transmission is less reliable than serial transmission because of the fine tolerances in the transmission as the bits can become muddled up.

Examples of different types of data transmission

- The data transmission in a network using cables is serial
- The Data transmission inside the computer using the bus system is parallel. This is because of the very high speed of data transmission needed by the computer's processor in order to process them. For example the data transmission between the primary memory and the hard drive of the computer is parallel because the processor requires the data to be downloaded to the memory as quickly as possible
- The data transmission between the computer and the printer is parallel because the computer needs to send a big chunk of data to the printer's buffer quickly so that the processor will be free to attend to other tasks of the computer

Modes of data transmission

Data transmission can be divided into the following three modes:

- Duplex mode
- Half duplex mode
- Simplex mode

Duplex mode of data transmission means passing data in both directions at the same time between two devices.

Half duplex mode of data transmission means passing data in both directions between two devices but only in one direction at a time.

Simplex mode of data transmission means passing data only in one direction between two devices.

Examples of different modes of data transmission

- The data transmission between the primary memory and the hard drive of the computer is half duplex.
- The data transmission between the computer and the printer is half duplex because the transmission of data files to the printer from the computer and the passing messages to the computer from the printer such as error messages happen at different times

Circuit switching

In circuit switching a fixed path through the network between the sending computer and the destination computer is opened and held for the entire time duration of data transmission.

Advantages of circuit switching

The message arrives at the receiving computer without having its data to be reordered and reassembled.

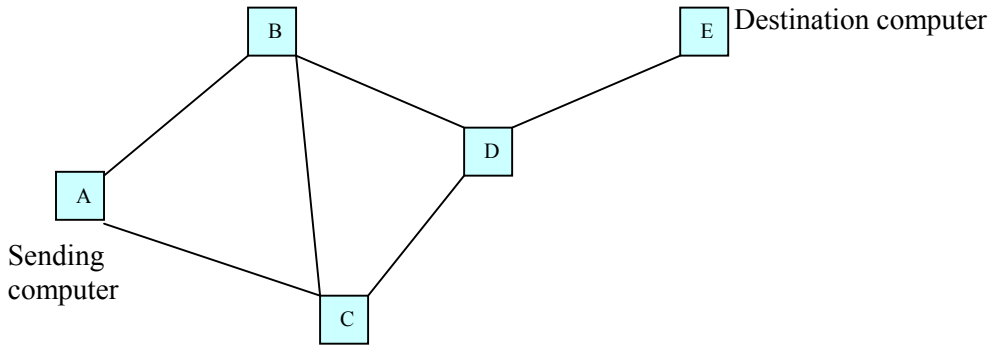
Disadvantages of circuit switching

Parts of the network are tied up for considerable periods of time

Packet switching

In packet switching the following things occur:

- The message is split into a number of equal-sized packets.
- Each packet is labeled with the destination address and the packet number.
- Packet switching transmits individual data packets into the network to find their way to the destination computer independently of each other.
- At each node the label is checked and the packet is redirected
- At the destination computer the packets are reordered and reassembled according to their packet numbers.



Advantages of packet switching

- Large part of the network is not tied up for long periods of time
- Message is difficult to be hacked

Disadvantages of packet switching

- Transmits at the speed of the slowest packet
- Packets must be reordered and reassembled at the destination

Protocol

A protocol is a set of rules which control the data transmission in a network.

Protocols specify the following requirements:

Type of data transmission i.e. whether the data transmission is serial or parallel. For example errors would occur if one device has a serial connection and the other device expects a parallel connection.

Mode of data transmission i.e. whether the data transmission is full duplex, half duplex or simplex

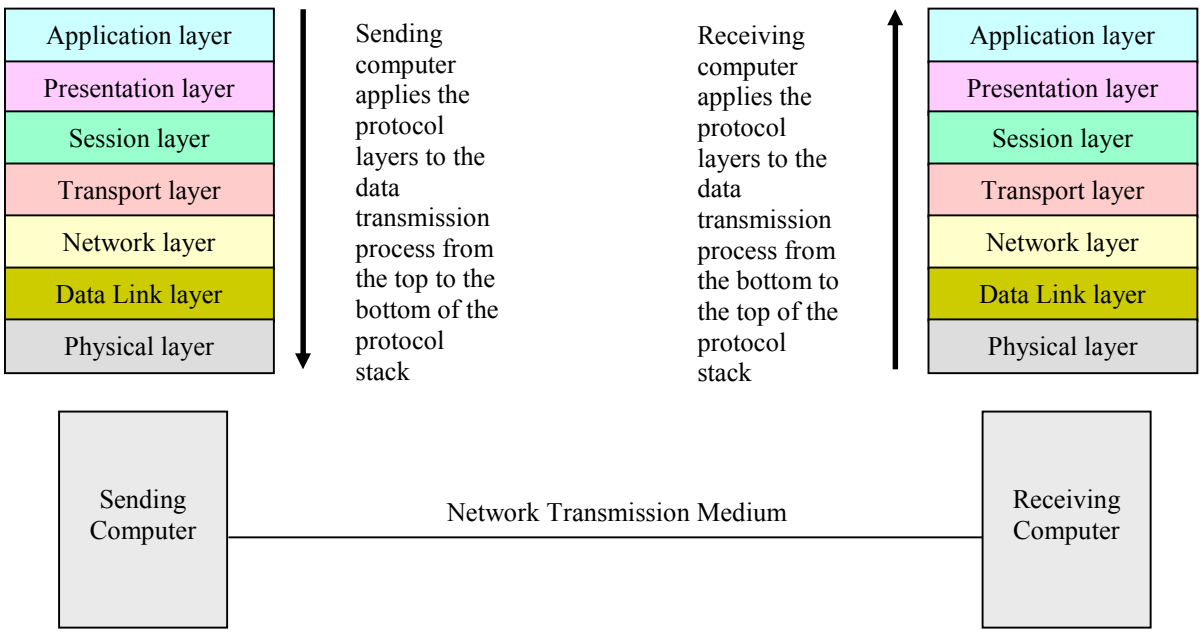
Bit rate – since both sending and receiving devices must send and receive data at the same number of bits per second. Otherwise bits may be missed or counted twice.

Error checking i.e. whether the parity is odd or even, whether echoing back is used or whether check sums are used

Network protocols are divided into layers. Protocols belonging to one layer carry out a specific function relating to data transmission. International Organization for Standardization (ISO)

released the OSI reference model in 1984. This standard divides the protocols into seven layers. The model containing the protocol layers is known as the OSI reference model.

The protocols are implemented in the computer through software. TCP/IP is the most commonly used protocol stack in data transmission. It is the protocol stack used in data transmission in the Internet too. HTTP and FTP are commonly used protocols which operate in the application layer of the OSI reference model. HTTP is used in the transmission of Web pages and FTP is used in the transmission of files.



Protocols are arranged in a layered manner because individual layers of protocol can be altered without altering the other layers when hardware and software are changed.

Importance of bit rate in data communication

Number of bits that can be transmitted in a network in one second is known as bit rate.

The unit used to measure the bit rate is Baud.

1 Baud = 1 bit per second

Bit rate is an important aspect of data communication because the bit rate of the sending device and the bit rate of the receiving device must be the same for data communication to be taken place properly.

Bit rate also enables the following:

- Standardization of the methods of data communication
- One layer of the protocol to be altered without altering the entire protocol

- Manufacturers to design hardware and software for a particular layer of protocols

When files containing only text data are transmitted in a network, they are sent at a slower bit rate because the text data are not time sensitive. When files containing pictures, graphics and animations are transmitted in a network, they have to be sent at a higher bit rate because those data are time sensitive.

Data compression

When files containing data other than text data is transmitted in a network, it is important to limit the amount of data that is being transmitted. Unlike text data, the graphics, videos and animations need a large amount of bits to be coded. This will decrease the speed of data transmission of files containing graphics, videos and animations and hence the time it takes to download the file at the destination computer. Speeding up the transmission of a file by reducing the number of bits in the file is known as data compression.

Reducing the number of bits in a file is done by encoding the data using fewer bits. The receiving computer must decode the data in order to understand it. Compressed data communication works only if both the sender and receiver understand the encoding scheme.

Compression is useful because it helps reduce the consumption of expensive resources, such as hard disk space and bandwidth of data transmission. The disadvantage of data compression is that the data must be decompressed to be used and this extra processing may be detrimental to some applications. For example, a video file that has been compressed may require expensive hardware to decompress it so that it is fast enough to be viewed.

Error checking and correcting in data transmission

When data is transmitted in a network the bit stream can get affected due to various reasons, which makes the data at the receiving computer to contain errors. The methods that can be used for checking transmission errors are:

- Echoing back
- Check sum
- Parity

Echoing Back

The receiving computer sending back the data to the sending computer is known as echoing back.

The data echoed back is checked against the data that was sent in the first place by the sending computer. If they match there has been no error in transmission. If they do not match there has been an error in transmission and the data will be sent again.

The disadvantages in echoing back are that it takes a long time to transmit data as the data has to be sent twice and it can be implemented only in duplex or half duplex modes

Check sum

Check sum is the sum of all the bytes in a block of data.

- Check sum is used by the computer to detect transmission errors as described below:
- The check sum is calculated by the sending computer ignoring the carry out of the byte and is mentioned with the block of data that is being transmitted.
- The check sum is then calculated again when it is received at the receiving computer
- The check sum calculated at the receiving computer is then compared with the value mentioned with the block of data.
- If the two values match there has been no error in transmission. If they do not match there has been an error in transmission.

Parity check

Parity is the sum of all the 1-bits in a byte of data. Parity can be either odd or even. The parity of each byte of data must be equal to the parity defined for that computer. If the parity of a byte is different from the parity of the computer, then the parity bit of that byte should be changed to match the parity of the computer before that byte is transmitted out of the sending computer. Parity check is used by the receiving computer to detect data transmission errors in the following manner

The parity of each byte of data that reaches the receiving computer is checked against the parity of the sending computer.

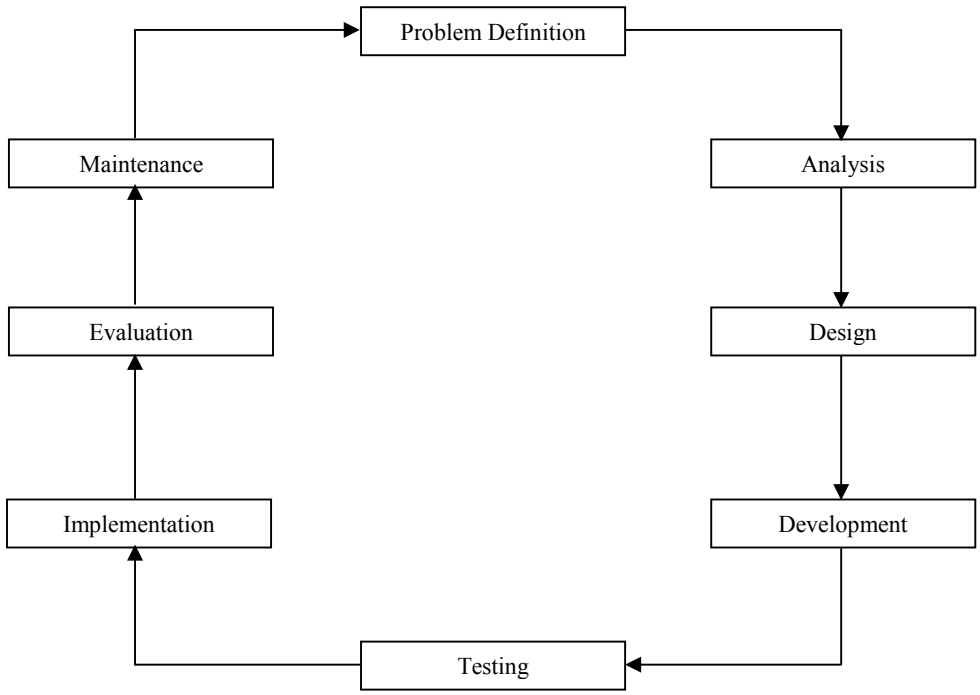
If the two parities do not match, the receiving computer reports that an error has occurred while the data is in transit. If the two parities match an error may or may not have occurred and the receiving computer is unable to report whether an error has occurred. This is because the parities would match even if a double error occurred where two bits may have changed.

Example:

Suppose that the parity of the sending computer is even. The bit pattern of the byte 1001011 can change to 1101111 while the data is in transit. Here both the second and fifth bits have changed from 1 to 0. But the parity of the byte still remains as even.

Chapter 1.7 – System Development Life Cycle

System development life cycle



System Development Lifecycle as an iterative process

1. Need for a change in the system once it has been developed has to be handled by defining and analyzing the requirements, which takes the development process back to the beginning of the life cycle.

2. The SDLC is an iterative process because each stage relies on the following stages as well as the previous ones.

Tasks performed in the SDLC

SDLC Phase	Things done
Analysis	Fact finding

	Analysis of facts using system flowcharts, DFDs, cause and effect diagrams
	Requirements specification
	Consideration of alternative solutions
Design	Describing the objectives
	Project plan and schedule
	Specification of the data input and output (data types and methods of input and output)
	Specifying the file structure
	Specifying the algorithms used for data processing
	Specifying the hardware and software
	Designing the test plan
Development	Coding the program or customizing a software package
Testing	Conducting tests to check the data validation routines
	Conducting tests to check functional requirements (black box testing)
	White box testing
Implementation	Plan for implementation or system changeover
	Acquiring the necessary hardware to implement the new system
	Installation of the new system
	Conversion of the data files – Involves transcription of data from manual files to the computer or importing data from the old computer files to the new computer files.
	Alpha testing
	Training the end users
	Beta testing
Evaluation	Discussion of the degree of success in meeting the original objectives
	Evaluate the user's response to the system
	Desirable extensions

Maintenance	Corrective maintenance
	Adaptive maintenance
	Perfective maintenance

Problem definition

It is important to define the problem accurately because otherwise a wrong problem may be solved.

It is important that the system analyst and the client must work together to define the problem accurately because:

1. Client is the expert in the problem
2. System analyst is the expert with computers and technology
3. Therefore the system analyst and the client need to pool resources to come up with a clear definition
4. Also the system analyst and the client need to agree on the outcomes so that when the system is implemented there is a set of criteria to judge it

Feasibility study

Feasibility study means considering the problem from the point of computerization and making a report to the organization saying whether a computerized solution is possible and sensible.

Feasibility study will consider the problem and the proposed solution from the following points of view:

1. Is the solution technically possible?
   If the hardware equipment and/or software tools do not exist to carry out the tasks, then it doesn't matter how good it would be, it cannot happen.

2. Is the solution economical to produce?
   If the cost of the computerized solution is so great that the company cannot recover the cost then the solution is not feasible.

3. Is the solution economic to run?
   If the cost of running the new solution is higher than the current system then the solution is not feasible.

4. Are there any social implications?
   If the human cost due to mass redundancy due to the introduction of the computerized solution is very high, the solution may not be considered as feasible.

5. Is the workforce skilled enough?
   If there are no skilled people to operate the equipment and the software the solution will not be

feasible.

6. Will the customer notice a difference?
   If the customer sees no difference in the price, quality and reliability in new solution and not get impressed then the solution will not be feasible.

7. Will the profits increase?
   If the profit won't increase due to the new solution, it would not be feasible.

8. Will the solution violate law?
   If the solution violate any laws of the country it is not feasible.

9. Will the solution take a long time to develop?
   If the solution takes too long to develop, the company may go out of business.

Information requirements of the system and fact finding

It is extremely important that the analyst finds out all the information about the requirements of the system.

Following are the methods of fact finding:

1. Interviewing key personnel
   Advantage of this method are that it allow
   (a) Questions to alter according to the answers given.
   (b) Employees to reveal confidential information

2. Questionnaires
   Advantage of this method are that it allow
   (a) A large number of people to give their views in a very short time period
   (b) Maintain the anonymity

3. Meetings
   Advantage of this method is that it allows
   (a) Discussion between people at the meeting

4. Inspecting documents
   Advantage of this method is that it allows
   (a) Obtaining the format of input and output

5. Observing the business operations
   Advantage of this method is that it allows
   (a) Obtaining first hand information of what actually happens in the system

Requirement specifications

1. Preparation of the list of tasks to be performed in system development arranged in the order of priority. This list of tasks is the basis for the system design.

2. Determination of the requirement specifications for data:

(a) Type of data
This helps to determine the form that the data will be stored (whether ASCII, JPEG etc.) and the amount of storage space required for each set of information.

(b) Data structures to be used
Whether arrays, linked lists, stacks, queues or binary trees are required to organize and handle data depending on the situation to be handle

(c) Data access methods
Whether the data are supposed to be accessed individually one at a time or they all are supposed to be accessed in one run.

(d) Whether the data is static (do not change frequently) or change frequently

3. Determination of the requirement specifications for input

(a) Nature of the data to be inputted i.e. whether graphical, textual or physical

(b) Is the data already in existence or whether they have to be collected?

(c) The skill level of the data entry operator

(d) Design of the user interface

4. Determination of the requirement specifications for output

(a) Nature of the information to be outputted, whether on-screen, printed, sound, light or mechanical

(b) Color codes to be used for on-screen output

(c) Dialog boxes used to display error messages and alerts

(d) Specific type of printer to be used in the case of printed output

5. Jackson structure diagram

The solution is gradually divided into modules which are more manageable. Jackson structure diagram is the representation of these modules in a hierarchical diagram.

Example:

A hotel needs to computerize its room booking system. The system needs to have the following functionalities:

(a) Add a record of a new customer to the system.

(b) Make changes in the data of an existing customer and save those changes to the system

(c) Delete a customer's record from a system

(d) Clear the data of a customer displayed on the user interface

(e) Capability of browsing to the first record

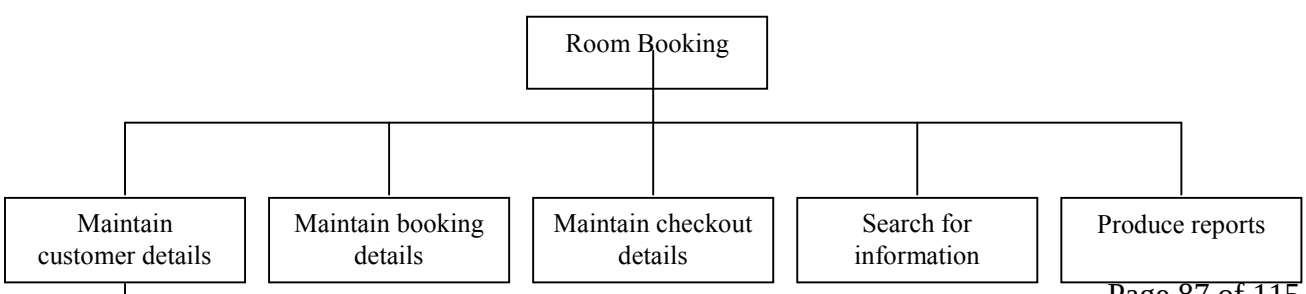
(f) Capability of browsing to the previous record

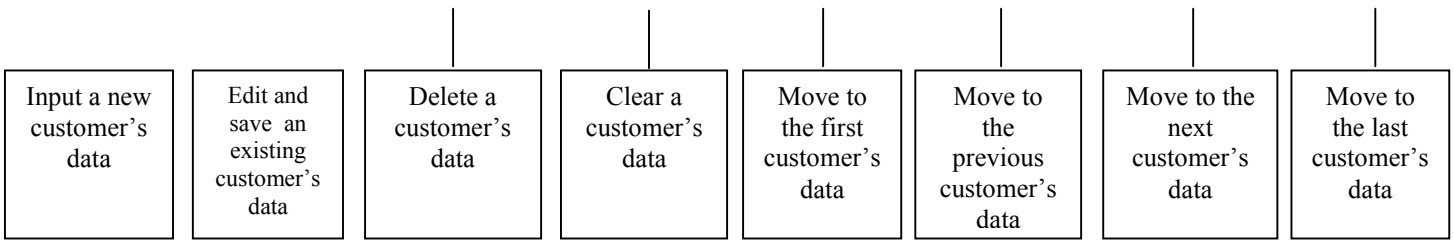
(g) Capability of browsing to the next record

(h) Capability of browsing to the last record

(i) Validating the customer name by performing the character type check

The Jackson structure diagram drawn to reflect the above system requirements are given below:

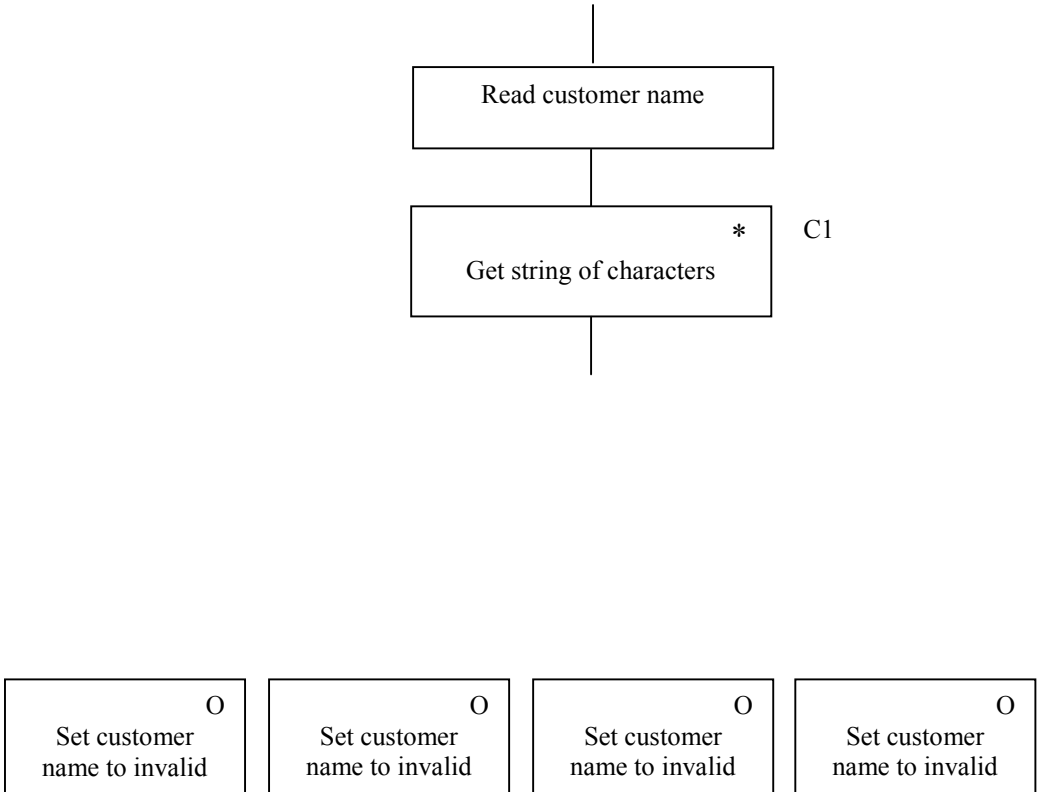




C1 Else C2 Else C1 Else C2 Else

Condition List
C1 – Valid customer name
C2 – Valid telephone number

Validate customer name

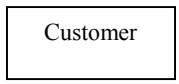


Condition List
C1 – Until number of characters = 1
C2 – ASCII value is between 0 and 31
C3 – ASCII value is between 33 and 64
C4 – ASCII value is between 91 and 96
C5 – ASCII value is between 123 and 127

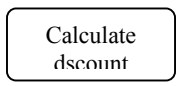
6. Data flow diagram

Data flow diagrams are used to model an information system in terms of the data, data flows, processes and data stores. It also shows the entities from where the data originate and to where the data flows in.

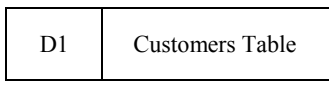
The following symbols are usually used when drawing the data flow diagrams:



External Entity



Process

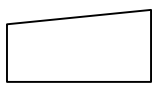


Data store

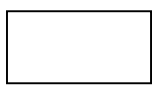
Data flow

7. System flowchart

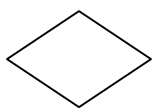
This is the diagram which shows the sequence of the business operations of an information system. The following symbols are used when drawing system flowcharts:



Manual input (example: keyboard)

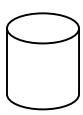


Process



Decision

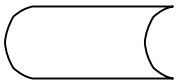
Visual display unit



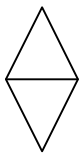
Magnetic disk

Magnetic tape

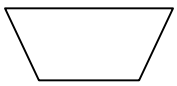
Document or printout



Computer data file



Sort data



Manual operation (done by hand) such as operating the OMR

Page connector

System evaluation against the initial specifications

1. Why evaluating the new solution against the initial specifications, is important to the end user?

2. Why evaluating the new solution against the initial specifications, is important to the end user?

System documentation

System documentation explains

1. How to use the system
2. How the system has been developed and
3. How to maintain the system

System documentation is done at several stages of the system development life cycle. Following are the different types of system documentations:

1. System requirement specification

This documentation contains the list of the requirements that the customer needs to have in the the new system (which have been described under the system requirement specification section).

(a) List of tasks to be performed

(b) Specifications of data

(c) Input specifications

(d) Output specifications

(e) Structure diagrams

2. System design specification

This documentation describes how the system would be developed. This includes:

(a) Specifications of the hardware (specifications of input devices, output devices, data storages, computers and other equipment)

(b) Specifications of the software used (whether it needs a database management system, a programming language tool, a user interface design tool etc.).

(c) Design of the data files and databases

(d) Development methodologies used

(e) Testing strategy

3. Program specifications

This documentation describes the method of developing the program

(a) Detailed algorithms used represented by pseudo-code and/or program flowcharts

(b) Programming language used

(c) Data structures used

(d) Library routines and components used

4. Technical documentation

This documentation describes anything that will be helpful for a technician to maintain the system. Therefore it is also known as the system maintenance document.

Technical documentation contains:

(a) System design specifications and

(b) Program specifications

5. User documentation

This documentation describes the things that would be helpful for a person who will be using or operating the system.

Why technical documentation is necessary?

Because a technician can alter the system or correct the system when necessary

Why user documentation is necessary?

It provides instructions for users about how to use the system and what to do when something goes wrong

What are the items to be included in the user manual?

1. Details of how to enter data

2. Details of how to use the system illustrated with screen shots

3. Help facilities and frequently asked questions

4. Troubleshooting guide for errors

What are the items to be included in the technical manual?

1. Details of installation and start up procedure

2. Minimum system specifications of the computer on which the software is to run

3. Algorithms

4. Database design

Testing and implementation planning

When implementing the new system, the analyst

1. Must ensure that the correct hardware is available

2. Must train the staff to use the new system

3. Must input the data to the data files, either manually or by importing them from the original System

Following are the four system implementation (changeover) methods:

1. Parallel running

The old and new systems are run side by side until it is made sure that the new system is fault free. This method of implementation is adopted where a system failure is not affordable.

The advantages of this method are that

(a) The results of the two systems can be compared to ensure that there is no fault with the new system

(b) The staff training on the new system can be carried out effectively

(c) Always have a fall-back system in case of a system failure

The disadvantage of this method is that it is very expensive as the things have to be done twice.

Examples of systems which are ideal for implementing with parallel running are:
Exam marks processing system

Examples of applications for which parallel running is not suitable are control system such as traffic light systems and process control systems

2. Pilot running

The new system is implemented initially only in a certain part of the company such as a branch.

The advantages of this method are that

(a) If there is a fault in the new system, it would affect the organization only in a relatively small area of data processing.

(b) It allows the analyst to test how the system would perform with a smaller amount of data.

The disadvantage of this method is that it is not possible to check how the system would perform with a large amount of data, which is the actual case when it is implemented at the organization level.

3. Phased implementation

The system is implemented by replacing the parts of the old system gradually with the corresponding parts of the new system while the rest of the system is still running with the old system.

The advantages of this method are that

(a) Can repair a faulty module without affecting the other modules

(d) It allows staff to be trained gradually

The disadvantage of this method is that one or many part(s) of the old system and the part that has been computerized may not be compatible. It would also take relatively a long time to fully implement the new solution.

Examples of systems which are ideal for phased implementation are:

Example 1: Process control system of a chemical plant

1. One phase can be the computerization of the mixing of raw materials, monitoring and controlling the conditions such as the temperature and pressure involved with one reaction

2. Another phase can be the computerization of the packing process of the final product

Example 2: ATM machine system

1. One phase can be the development of the withdrawing process of money

2. Another phase can be the development of the depositing process of money

Example 3: Computerized ticketing machine system

1. One phase can be the issuing of the printed ticket and returning the balance money only when the coins are put into a till.

2. Another phase can be the capability of using a magnetic swipe card or smart card to pay the bus fare

Example 4: Point of sale system

1. One phase can be the capability of using the barcode scanner as the device to input the product ID

2. Another phase can be the capability of using magnetic swipe card or smart card facility to pay the bill by a credit card or a debit card

Example 5: Pay phone system

1. One phase can be the capability of taking a call by inserting coins or bills to the system

2. Another phase can be the capability of using a prepaid phone card to pay and take the call

Example 6: Proximity card system

1. One phase can be where the data entry to the system is done by using a concept keyboard i.e. the user types in the pin number using the keyboard of the machine

2. Second phase can be where the data entry to the system is done by swiping a magnetic card

3. Third phase can be where the system uses a finger print scanner for data entry

4. Direct Conversion or "big bang"

The new system replaces the old system immediately and completely.

The advantages are that

(a) The cost of implementation is less.

(b) No confusion to the staff

The disadvantage is that it is risky. If the new system has a fault and malfunctions there will be a loss of data and even the loss of customers. Allows no time for training and finding errors in the system.

Explain what implementation method is suitable for a new POS system developed for a supermarket

Parallel running is not feasible as customers would not put up with the delays

Pilot running can be done by implementing the new system only in some of the checkout counters. It would cause no problems even if it fails because the customers can be moved to other counters which run the old system. Also it is ideal for training the cashiers to the new system.

Direct conversion is risky because if the new system fails all the counters have to be closed which means that the store must be shut down.

System maintenance and the software lifespan

The three kinds of system maintenance and the reasons for the system maintenance are:

1. Corrective maintenance

This kind of maintenance is performed to correct bugs found in the system after the system has been commissioned.

2. Adaptive maintenance

This kind of maintenance is performed to make changes in the system because of the changes that have taken place in way that the organization works (for example due to the changes in tax rates, due to the changes in law etc.)

3. Perfective maintenance

This kind of maintenance is performed to improve the performance of the system.

Chapter 1.9 – Handling of Data in Information Systems

What is manual data collection?

Manual data collection involves the following three stages:

1. Collecting data
2. Preparation of data suitable for computer use
2. Inputting data to the system

What is automatic data collection?

Automatic data collection involves the following two stages:

1. Collecting data
2. Inputting data to the system

Methods and devices used for automatic data collection

1. Barcode reader
2. OMR
3. OCR
4. MICR
5. Voice recognition
6. Magnetic stripe card
7. Smart card
8. Data logging
9. Touch screen
10. Digital camera

Methods and devices used for manual data collection

1. Keyboard
2. Mouse

Examples of situations where manual data collection is used

1. Obtaining data from data capture forms

2. Obtaining data contained in turnaround documents

What is data verification?

This is the method of checking whether the data entered to the computer is same as the source data.

In the case where the data are contained in a source document the verification can be performed by using the following two techniques:

1. Proof reading method
   Here the operator manually checks each and every piece of data entered to the computer against the corresponding piece of data in the source document to see whether they are same.

2. Double entry method
   Here two operators enter the same set of data separately to the computer. Then a computer program will be used to compare the corresponding pieces of data in each of the two sets of data files.

What is data validation?

This is the method of checking whether the data inputted to the system is reasonable and accurate. There are several methods of data validations:

1. Length check
2. Character type check
3. Format check
4. Range check
5. Presence check
6. Check digit – When a piece of data consists of numbers, one number is designated as the check digit. The value of the check digit can be obtained by applying an algorithm to the rest of the numbers. If the data is entered to the computer incorrectly or if the order of the numbers in the data were not correct the value calculated by applying the algorithm to the number will not be equal to the value of the check digit.

Methods of data entry used under given circumstances

Situation	Method of data entry
1. Entering data in the checks received at a bank	MICR
2. Taking a photo to print on a sweatshirt	Digital camera
3. Recording of an event taking place to display on the computer screen	Video camera
4. Processing answers to an MCQ test	OMR
5. Maintaining temperature inside a room using a Thermostat	Temperature sensor
6. Burglar alarm	Pressure sensor, motion sensor, light sensor
7. To pass pictures and video sequences between computers in a LAN	Using a digital camera and compressing the images using JPEG technology

8. To find the arrival time of the next bus at a bus Halt	Touch screen

What are the common methods of output?

1. Text
   Example: Text information displayed on a form-based user interface such as the total cost of an order

2. Graphs
   Example: Temperature variation during a month

3. Charts
   Example: Annual sales figures of a company on a monthly basis

4. Reports
   Example: Marks and grades obtained by the students of a class in a school

5. Interactive presentations
   Example: CEO of a company participating in a videoconference

6. Sound
   Example: Voice synthesis for reporting to blind people
   Burglar alarm system

7. Video
   Example: Demonstration of performing an experiment in the chemistry lab

8. Images
   Example: An online album containing the picture of cars at a car dealer
   A database of criminals

9. Animations
   Example: Used in a slide-based presentation to eliminate boredom.

Method of output according to the target audience

Target Audience	Method of output
1. A nurse working in an intensive care ward	Sound of an alarm, flashing light, monitor screen showing a scrolling graph about the state of a patient's heart rate.
2. A doctor who needs to diagnose whether a patient has diabetes	Fasting blood glucose level data of the patient tested over several days.
3. A manager of a business	Graphs – Ideal for showing trends Reports in text form – Gives exact details or

	figures Reports in tabular form – Arranges exact details to make them simpler to interpret Interactive presentations – Allows the manager to tailor the output required Sound – Can inform while the manager is attending to some other task

What is timeliness?

This is the concept that the data changes over time and that data is only a part of a sensible solution for a short period of time before it becomes outdated.

The data on heart rate 3 hours ago is not of any importance to the nurse looking after a patient. But that data is very important to the doctor in providing a clue as to the reason for the sudden change in the heart rate.

What is relevance of data?

This means that the data has a bearing or use, in a particular application.

For example, the date of birth of a customer of a food catering company has no relevance to the system.

Chapter 1.10 – Designing the User Interface

Why good user interface design is an important part in system design?

1. It avoids ambiguity in data entry

2. It allows the user to input all the data

3. It presents the output in an easily understandable way

Factors that the analyst should consider when designing an HCI for data input

1. Who will be using the interface?

2. What experience or knowledge the user has with data entry?

3. Under what circumstances the interface must be operated?

4. Are data to be entered time sensitive?

Factors that the analyst should consider when designing an HCI for information output

1. What is the information needed to be outputted?

2. How much information is needed to be outputted?

3. What is the best way to present the information required?

4. Colors that should be used and should not be used

5. Visual perception

6. What are the alternative forms of output?

7. What technology is available?

8. What layout is needed?

9. The content of the information presented

10. Whether the information is for short term or long term memory

Form Based User Interface

Description of form-based user interface

1. It mirrors a data capture form

2. It contains spaces to insert data

3. Drop down lists and option buttons are used to limit the choices for answers

Example: Interface used at the appointment counter of a doctor's office

Advantages of form based user interface

1. Written instructions can be provided for the user to understand what data to enter

2. Can force the user to answer required questions and ensure that all the data is inputted

3. It makes the operator input the data in correct order

4. Easy to implement data validation rules

5. Can be used to provide restricted views for different users

Disadvantages of form based user interface

1. User needs training to understand how to use the program

2. User needs training to understand what data to be inputted

Menu Based User Interface

Description of menu-based user interface

1. It contains a series of options from which the user selects

2. The selection of an option may lead to a sub menu

3. It is usually used with touch sensitive screens

Examples: The interface of the ATM machine and the interface at restaurants like McDonalds

Advantages of menu based user interface

1. The system is self understandable and the user does not need training

2. This can be used in situations where the operator tends not to know what options are available.

3. No need to implement data validation rules as the system can make the user always input correct data by restricting choices for the user

4. Menu based interface can be used with touch screens to implement systems in very busy environments or where many people are waiting to use the system such as in factories, restaurants, railway stations and airports.

5. Menu based interface is used with touch screens to facilitate many computer illiterate people who would use them.

Disadvantages of menu based user interface

1. The system takes time to find information as the user has to go through many screens before the system outputs the results

Example of a menu based system: system at a railway station in a popular holiday location

The first screen may ask for the general area of interest such as accommodation, trips, shopping, entertainment etc. Once the choice of accommodation has been made, the next screen may offer different standards of hotels. Once the choice of hotel type is made the next screen may offer different price bands. Once the choice of price band is made, the final screen will display the hotel or the list of hotels that matches all the requirements of the customer.

Command Line User Interface

Description of command line user interface

1. User types in a command at a command prompt which appears on the screen. A command prompt is a character or a group of characters which the computer displays in order to let the user know that a command can be input.

   Examples: C:\ >
   C:\ My folder >

2. User must ensure that the syntax is correct

3. User must learn the commands

4. The interface allows access to the whole system

Example: Interface used by a system administrator looking after a network

Advantages of command line user interface

1. Fast to operate as it is done through the keyboard

2. Can access the whole system

Disadvantages of command line user interface

1. The user needs to understand the way that the data and files are stored in the computer system

2. Difficult to understand and learn the commands

3. Difficult memorize the commands

4. Can only be used by computer literate people.

Graphical User Interface

Description of GUI

1. It contains windows, icons, menus and uses mouse pointer to interact with the computer.

2. The GUI is used by selecting options from menus of choices and from a set of small pictures, which represent the different options available.

3. Choices are selected by using some sort of pointing device such as a mouse.

Example: Interface of the Microsoft Windows Desktop program and the Control Panel program

Advantages of GUI

1. Easy to understand the interface as it includes pictures and graphics

2. Easy to learn the system as it has no commands to memorize

Disadvantages of GUI

1. Some icons on the GUI may be unfamiliar and confusing

Natural language user interface

The computer asks questions which elicit a response which gives the user the impression that he is talking to the computer.

Chapter 1.11 – Characteristics of Information Systems

What is a passive information system?

This is an information system from which information can be obtained but where the data cannot be changed.

An example for a passive information system is a computerized dictionary. Here the user can search to find the meaning of a word but he cannot change the contents of the dictionary.

What is an interactive information system?

This is an information system where the user can alter the data as well as can obtain information from.

An example for an interactive information system is an exam marks processing system from which the user (teacher) can obtain information by producing reports and can alter the data by changing or entering marks to the system.

What is management information system (MIS)?

This is an information system that a manger of a company can access to obtain information about the performance of the business.

What are the two types of management information systems?

1. Condition driven (or operational) management information systems and
2. Strategic management information system

What is condition-driven management?

This is performing the day to day management functions.

Examples: Ensuring that the business has enough stock
Ensuring that enough employees are available to operate a production line

What is strategic management?

This is the performing of management functions which involves making decisions which are long term in nature and are related to the policies and objectives of the company.

What is condition-driven management information?

This is information such as decisions, reports and responses produced as a result of meeting some parameter.

Examples: The stock level has fallen below the reorder level
Sending a secretary working at the HR department to the reception counter of the company because one of the two receptionists is absent on that day

What is strategic level management information?

This is information such as decisions, reports and responses related to the policies and objectives of the company.

Examples: Stop producing a particular product
Start producing a new product
Qualifications required for the post of accountant in the organization

Examples of applications for which batch processing is suitable

1. Processing payroll using hours worked data

2. Updating the customer accounts master file using the daily transaction file

3. Producing and printing monthly utility bills such as electricity bills, telephone bills, gas bills and water bills

Examples of applications for which real time processing (rapid response processing) is suitable

1. Airline seat reservation system
   Immediately after a particular seat is booked for a particular passenger the database must be updated so that another booking agent would see that the seat is already booked. This avoids double booking.

2. Process control system of a food products manufacturing company
   The variations in temperature, viscosity, color, pH value must be controlled immediately.

3. Missile control system must launch the missile as soon as signal is inputted to the system about detecting an enemy aircraft

What is an expert system?

This is a computer program which mimics a human expert on some specialized field of knowledge. Expert system also:

1. Can reason with uncertain data (where the human expert might respond "Don't know")

2. Delivers advice

3. Explains reasoning to the user

Components of an expert system

1. Knowledgebase – Contains storage of facts collected and provided by number of experts in the related field

2. Rule base – Contains algorithms used to interpret the information in the knowledgebase

2. Inference engine – Computer program which applies rules in the rule base on the facts in the knowledgebase to extract information

3. User interface – Interface used by the user to interact with the expert system

Examples of expert systems

1. Oil exploration system

2. Navigation system to find the most appropriate route to a given destination

3. Diagnosis system for medical conditions, vehicle defects and faults in pipelines etc.

How an expert system is set up?

1. Knowledgebase is created by collecting facts from number of experts

2. Rule-base is created by experts in the field

3. Inference engine is developed by programmers

4. User interface is developed by the programmers to suit the users

How an expert system is used?

1. The system tries to match data or patterns with the knowledgebase

2. The system uses rules to interpret the matching data and the patterns found

3. The system produces reasons and advices

Chapter 1.12 – Implications of Computer Use

State the advantages gained by the employees of a company by using computers

1. Employees can work faster
2. Messages can be sent faster to coworkers and customers through email
3. Can keep the working environment neat and clean
4. Can work from home
5. Can search and find information quickly by using computerized dictionaries and encyclopedia
6. Can transfer files easily to other employees
7. Get more leisure time
8. New jobs are created which helps the employee in advancing his career

State the disadvantages gained by the employees of a company by using computers

1. Less social interaction with the coworkers
2. Health is affected
3. Confidential data getting hacked
4. Getting addicted to computer games
5. Inability to work when the electricity is gone
6. Need to get skills and training in new technology
7. Some employees who are not skilled in technology might lose their jobs

State the advantages gained by the management of a company by using computers

1. Can get done the work faster and thereby attract a bigger customer base
2. Can occupy a smaller office as the file storage space is reduced
3. Can make the staff work at home thereby reducing the expenses on s electricity
4. Can use new technologies to cut down on labor cost such as robots

State the disadvantages gained by the management of a company by using computers

1. Has to invest a big amount of money in hardware and software

2. Has to spend money to maintain the software and hardware

3. Has to hire additional staff to maintain the computers

What are the health and safety issues that a worker who work with computers can get by working and how can they be overcome?

1. Stress – Take regular breaks

2. RSI – Use ergonomic keyboards and take regular breaks

3. Muscle or back strain – Use well-designed chairs, keyboards and position correctly when work in the computer

4. Eyestrain – Use glasses, anti-glare screens and look away from the computers

5. Poorly designed environment such as trailing wires – Use a purpose-built area and that the wires are properly concealed.

6. Extremely low-frequency radiation – Use of low radiation monitor, limit time spent at terminal

How can using the computers cause stress in an employee at his work place?

- The fear he or she will not be able to learn the computer skills
- The fear that their position of seniority will be undermined by younger and junior employees with a high level of competence in ICT
- Impossibility of getting away from work since pagers, mobile phones, laptop computers and modems even after leaving the office there is no need to stop work.
- Managers are bombarded with far more information than they can assimilate, producing "information anxiety".

What are the results of computer related stress at someone's workplace?

- Failing personal relationships
- Loss of appetite
- Addiction to work
- Potential alcohol abuse

What is Repetitive Strain Injury or RSI?

RSI is a collective name for a variety of disorders affecting the neck, shoulders and upper limbs. It can result in numbness or tingling in the arms and hands, aching and stiffness in the arms, neck and shoulders and an inability to lift or grip objects. Some who suffer from RSI cannot pour a cup of tea or type a single sentence without excruciating pain.

How can using the computers cause eyestrain in an employee at his workplace?

Computer users are prone to eyestrain from spending long hours in front of a screen. There is no evidence that computer use causes permanent damage to the eyes. But glare, improper lighting, improperly corrected vision (through not wearing the correct prescription glasses), poor work practices and poorly designed workstations all contribute to temporary eyestrain.

What ergonomic environment should be supplied by an employer to his employees?

Ergonomics refers to the design and functionality of the environment and encompasses the entire range of environmental factors. Employers must give consideration to:

1. Lighting
   The office should be well lit. Computers should neither face windows nor back onto a window so that the users have to sit with the sun their eyes.

2. Furniture
   Chairs should be of adjustable height, with a backrest which tilts to support the user at work and at rest and should swivel on a five-point base. It should be at a correct height relative to a keyboard on the desk.

3. Work space
   The combination of chair, desk, computer, accessories (such as document holders, mouse and mouse mats, paper trays and so on), lighting, heating and ventilation all contribute to the worker's overall well-being.

4. Noise – Noisy printers, for example, should be given covers to reduce the noise or located in a different room.

5. Hardware – The screen must be tilt and swivel and be flicker-free. The keyboard must be separately attached.

6. Software – Software is often overlooked in the quest for ergonomic perfection. The EEC directive made a clear statement about the characteristics of acceptable software, requiring employers to analyze the tasks which their employees performed and to provide software which makes the tasks easier. It is also expected to be easy to use and adaptable to the user's experience.

Social and ethical effects of the Internet

1. Chat rooms have created a new type of social circle

2. Generally inappropriate sites such as pornographic sites emerge

3. Danger to the structure of the society because of the emergence of abnormal views

4. Religion is undermined

5. Exposes people to new contradictory views

6. Sites that encourage breaking of law emerge

7. Sites giving incorrect information appear

What are the advantages of having unrestricted access for the students to the Internet?

1. Allows communication with classmates and friends

2. Allows access to a large amount of educational material

3. Allows students to learn at their own speed

4. Allows students to learn at own times

What are the disadvantages of having unrestricted access for the students to the Internet?

1. Many sites give inaccurate information

2. Many sites contain inappropriate material such as pornography

3. Many sites encourage breaking laws

4. Sites available to buy coursework

5. Sites available that teaches how to cheat at exams

6. Allows hackers enter the system

7. Allows downloading viruses

What are the benefits to the worker in working from home?

1. Quality of life improves

2. Can work around other commitments

3. More time can be spent with family

What are the disadvantages to the worker in working from home?

1. Loses social interaction

2. Distractions from family members such as children

3. May need training in the use of technology

What are the benefits to the businesses due the workers working from home?

1. No need of large and expensive office space

2. Will have lower utility bills such as gas, water and electricity

3. Can have a happy work force

4. Can have world wide workforce

What are the disadvantages to the businesses due to the workers working from home?

1. Greater security issues relating to the data and information

2. Difficult to monitor what workers are doing

3. Difficult to make sudden decisions about work

4. Incur costs in training programs

5. Group work becomes difficult

What are the advantages to the society due to the workers working from home?

1. Less traffic on the roads

2. Implies less need for infrastructure

3. Less pollution

4. Creates closely knit families

5. Can provide work for disabled

What are the disadvantages to the society due to the workers working from home?

1. Creates a society with less social ties

2. Non-availability of trade unions which leads to dictatorship by the employers

Why legislation is needed to protect the personal data of customers in a business?

1. Data may become incorrect
2. Some information is confidential in nature
3. Some data may be misused
4. Customers may lose financially
5. Customers may not be willing to provide data
6. Business may lose potential customers

What are the data protection principles mentioned in the Data Protection Act of 1998?

1. Data must be fairly and lawfully obtained
2. Data must be processed only for specified purposes
3. Data obtained must be adequate, relevant and not excessive
4. Data obtained must be accurate and kept up to date
5. Data must not be kept longer than necessary
6. Data must be processed according to the data subject's rights
7. Data must be kept securely against unauthorized access and accidental loss or damage
8. Data must not be transferred to countries outside the European Economic Commission without adequate protection

Mention the measures included in the Data Protection Act of 1998 to keep personal data confidential

1. Make sure that the data is obtained lawfully
2. Provides the right to see the data held to ensure that it is correct
3. Allows checking whether the data held is relevant to the purpose
4. Ensures that out of date information is destroyed
5. Limits personnel who are able to see the data

Implications on employees of using an expert system

1. Employees need not be trained

2. Employees may not be able to learn new skills

3. Employees may lose skills because of the reliance on the system

Implications of computer use by the staff at a computerized manufacturing company

1. Some jobs will be lost

2. More jobs will be created in some areas

3. Demands more training programs

4. Older workers may not be able to retrain

5. Training leads to extra qualifications

6. Training leads to extra responsibilities

7. More highly paid jobs will be available

8. Deskilling

9. Health and safety issues