Chapter 3: Systems Software

In this chapter you will learn:

- ✪ what is meant by the term 'systems software'
- ✪ what is meant by an operating system
- ✪ why a computer needs an operating system
- ✪ about the different functions an operating system performs
- ✪ what is meant by the term 'utility software'
- ✪ about the different functions utility software performs

What is systems software?

> **OCR specification reference:**
> ☑ the purpose and functionality of systems software

There are two main types of software that are used on computer systems; these are **systems software** and **applications software**. Systems software controls the operations of **hardware** in a computer system.

Systems software also provides a platform to run applications software. Applications software is the everyday programs we use to create documents and carry out communication with each other using technology. Some examples of applications software include Internet Explorer, Paint and Microsoft Word.

There are a number of types of systems software, such as **device drivers**, **utility software** and the **operating system**.

Systems software – controls the operation of hardware in a computer

Applications software – the everyday programs that we use to create documents and perform tasks

Hardware – the physical parts of a computer system

Device driver – a program that controls a particular device connected to a computer system

Utility software – helps manage, maintain and control the computer's resources

What is an operating system and why does a computer need one?

> **OCR specification reference:**
> ☑ operating systems:
> - user interface
> - memory management / multitasking
> - peripheral management and drivers
> - user management
> - file management

An **operating system** (sometimes shortened to the initials OS) is software that is loaded by the computer after the initial boot-up. Once loaded, the operating system controls the operations of the hardware in a computer system and manages all other software.

Operating system – controls the operations of the hardware in a computer system and manages all other software

The operating system provides a number of important functions for the computer.

Without an operating system we would not able to use a computer. This is because we would not be able to command the hardware to carry out any processes or run any software to carry out tasks. The operating system provides us with the ability to interact with a computer system. The way a user interacts with the operating system is through the use of a user interface.
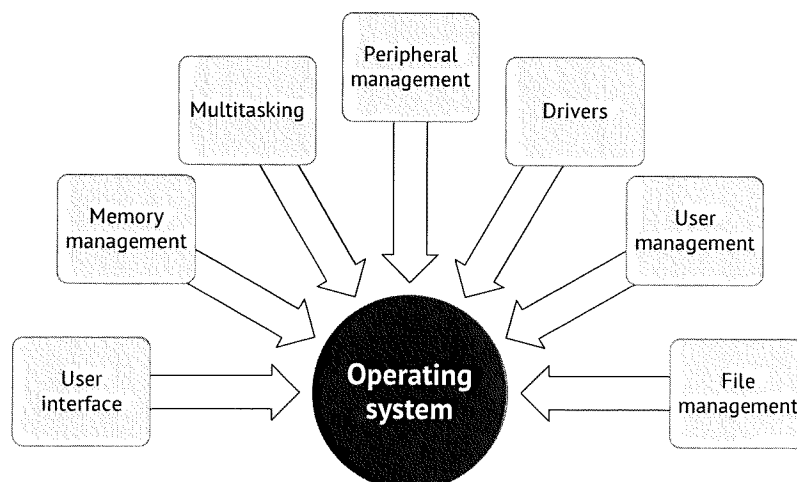
The range of different functions that are carried out by the operating system

User interface

The **user interface** is what we use to interact with a computer. There are three main types of user interface: graphical, command-line and natural-language.

> **User interface** – one of the ways we interact with a computer system

A graphical user interface (GUI) is the most common type of interface we use to interact with computers. This is the type of interface that has lots of icons, menus and windows for us to click and open. We use this type of operating system on many devices including our personal computers, smartphones and tablets. A GUI has lots of helpful guidance and clear items for us to interact with in order to carry out the daily tasks we use our computer for. We do not need to type in any commands to carry out tasks, just click the icons and menus to do so.

A GUI has icons and menus that we click to carry out tasks

A command-line interface (CLI) is another type of user interface. This type of interface does not have icons and menus to guide the user to perform tasks; it requires the user to type in the program commands for the tasks that they want to perform. This type of interface is what people had to use to interact with computers before GUIs were developed. Some people still use CLIs as they like to be able to have the freedom to command the computer as they wish, rather than having to use the pre-programmed commands that are available with a GUI. They need to have the knowledge of what the commands are to be able to do this, otherwise they would not be able to control the computer. If you have ever used a Raspberry Pi computer, you may have used a CLI as this is how the user interacts with the Raspberry Pi. Another example of a CLI is the command prompt, which can let you use your computer solely through the command line.

```
Command Prompt                                    _  □  ×
C:\Users> This is an example of a command line interface!
```
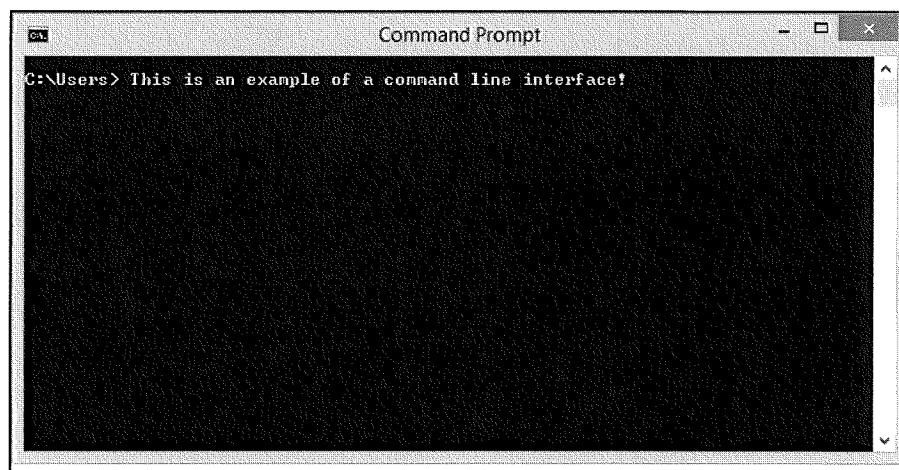
A CLI requires the user to type in the commands for the tasks they want to perform

The third main type of user interface is a natural-language interface (NLI). A user controls a natural-language interface through the use of linguistic commands that are often spoken. The user can make use of everyday words and phrases to interact with the computer and perform tasks. People make use of NLIs as they can potentially be a very quick and easy way of giving commands to a computer system.

However, in practice, the ability of a NLI to understand most commands can often be ambiguous and can frustrate the user. A common example of a NLI is Apple's Siri. This NLI makes use of natural-language processing to answer questions, perform tasks and make recommendations.
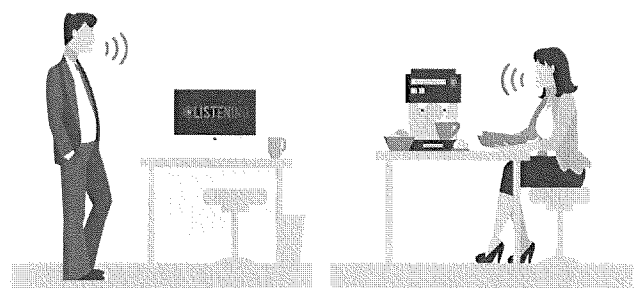
A natural-language interface allows a user to interact with a system by using linguistic commands. These commands are often spoken.

Memory management

Managing the memory of a computer is a function that is carried out by the operating system. Memory management refers to the managing of the computer's **primary memory**. The operating system keeps track of each and every memory location to see whether it is in use or available to be used in a process. It checks how much memory needs to be allocated to a process and decides which process will get memory allocated at any one time. If the operating system does not manage the memory effectively, this will slow down the computer's ability to perform tasks.

Multitasking

The multitasking function in an operating system allows a computer to run many applications at a time. It is multitasking that allows you to listen to music on your computer, while doing your homework and surfing the net all at the same time. The operating system is able to keep track of where you are up to with various applications, as you move from one to the other, without losing any data. There is a limit to how many applications an operating system can handle at any one time.

The more applications a user has open, the slower the operating system will be as it handles all of them.
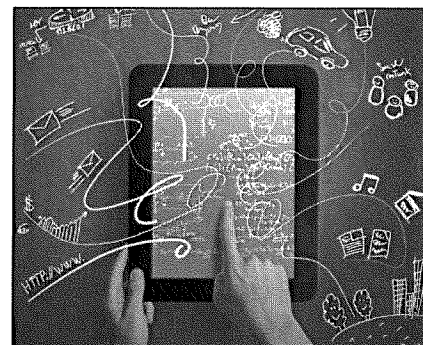
A multitasking operating system allows a user to run many different applications at a time

Peripheral management and drivers

The peripheral management function of an operating system controls the computer's interaction with all the peripheral devices that are linked to the computer system. Example peripheral devices are a keyboard, a mouse and a printer. The operating system handles the input from and the output to each of the peripheral devices by sending and receiving commands from them in their programmed language. Each peripheral device that is attached to a computer system has a software routine that manages the interaction; this is called a driver. The operating system needs these drivers to be able to control the interaction with the peripheral device. Drivers are often preloaded into peripheral devices and downloaded onto a computer system when the device is first connected to the computer system.
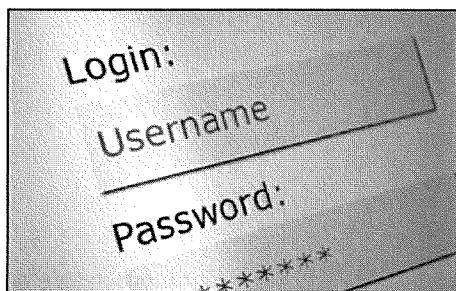
The operating system allows different users to be given a username and password to log on to a computer system

User management

The user management function of an operating system allows multiple users to be able to log on to a computer system. It allows each user that logs into the system to do so with a username and password. It also manages the data and applications a user should have access to; these are normally identified from their username.

File management

File management is the function that the operating system uses to organise and keep track of files stored on a computer system. As far as a computer is concerned, all that exists in the computer's memory is blocks of data. It is the file management function that allows the user to see the data in the secondary storage (either a magnetic hard drive or a solid-state drive) in the form of structured files and folders.

The operating system allows the user to see and organise the data they save in the form of files and folders

What is utility software and what do we use it for?

Utility software is a type of systems software. It helps manage, maintain and control the computer's resources. Most utility software is designed to carry out a singular task, or very small number of tasks. It is generally built into the operating system, but it can also be installed as a separate program, if a user would prefer an alternative to the one offered by the operating system.

Tasks that utility software may be responsible for include:

- File conversion
- File repair
- Encryption
- Defragmentation
- Data compression
- Backing up data
- Antivirus

Encryption software

Encryption software is used to encrypt data. When text based data is in its original form it is referred to as **plain text**. The encryption software uses an encryption algorithm and an **encryption key** to scramble the plain text. When the data has been encrypted it is referred to as **cipher text**. The cipher text can only be decrypted and viewed using the correct encryption key. People mostly encrypt data to store it or transmit it securely. For example, when we send any details to our bank, the data is encrypted before transmission.

There are two main types of encryption: symmetric and asymmetric. In symmetric encryption, the same encryption key is used to encrypt and decrypt the data. Symmetric encryption is a very fast way to encrypt data, but the key needs to be sent with the data for the receiver to decrypt the data, this can pose a security issue. If the encrypted data is intercepted during transmission, the interceptor will have the key to decrypt the data.

In asymmetric encryption, a different key is used to encrypt and decrypt the data. The two keys are called a public key, which everyone can see, and a private key, which only you have access to. The main idea is that for Alice to send Bob an encrypted message, she must first encrypt her message with Bob's public key (that everyone can see), so only he can decrypt it using his private key (that only he can see).
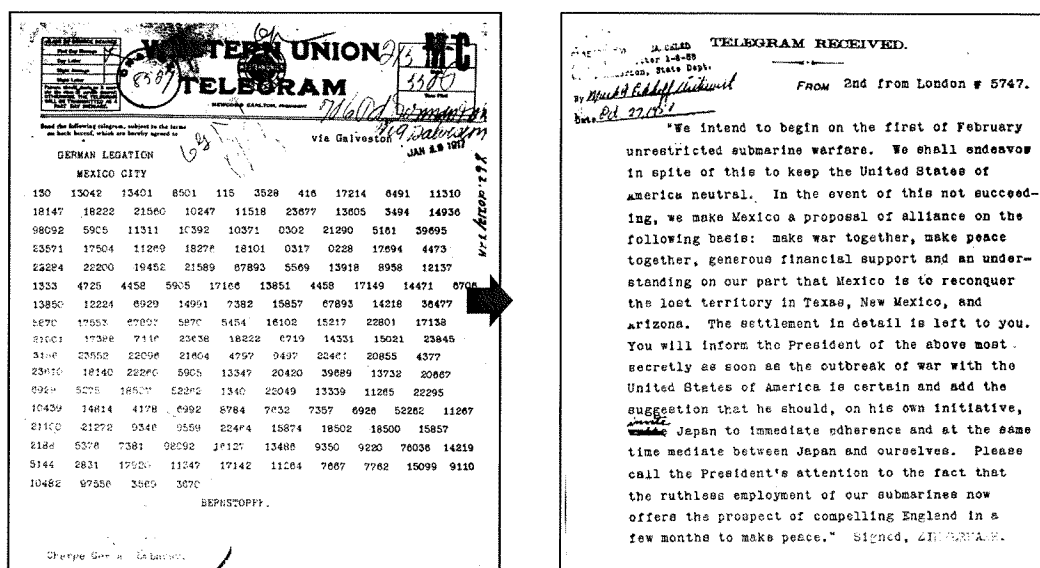
Zimmermann Telegram issued from the German Foreign Office in January 1917. Left shows the encrypted message (cipher text). Right shows the message after it was intercepted and deciphered by the British and sent to the US government.

Defragmentation

When data is stored on a computer's hard drive, the computer doesn't look for the next space available in which the data can be stored in full and continuously. It breaks the data up and stores it in the available spaces on the hard drive. Available space on a hard drive is often as a result of changing files or file deletion. For example, Alice has six files stored on her hard drive. These are a letter, three piece of homework and two music files. Her hard drive looks like this:

L	E	T	T	E	R	M	U	S	I
C	H	O	M	E	W	O	R	K	M
U	S	I	C	H	O	M	E	W	O
R	K	H	O	M	E	W	O	R	K

Alice decides that she no longer needs the music files, so she deletes them:

L	E	T	T	E	R				
	H	O	M	E	W	O	R	K	
				H	O	M	E	W	O
R	K	H	O	M	E	W	O	R	K

This leaves Alice with some free space on her hard drive. Alice now needs to save her video project for school. The computer will find the next available spaces on the hard drive to save this file:

L	E	T	T	E	R	V	I	D	E
O	H	O	M	E	W	O	R	K	P
R	O	J	E	H	O	M	E	W	O
R	K	H	O	M	E	W	O	R	K
C	T								

The video project file was broken up into fragments to be stored in the available space and Alice now has a fragmented hard drive. She can run defragmentation software that will help to rearrange her hard drive and bring together any fragmented files. To do this the software will move around blocks of data on the hard drive to join together any fragmented files. When files are not fragmented, it makes them quicker and easier to open as the computer does not have to search for the fragmented parts of the file.

After running defragmentation software, Alice's hard drive might look like this:

L	E	T	T	E	R	H	O	M	E
W	O	R	K	H	O	M	E	W	O
R	K	V	I	D	E	O	P	R	O
J	E	C	T	H	O	M	E	W	O
R	K								

All the file fragments have been joined together and the hard drive is no longer fragmented.

Data compression

When we compress a data file we reduce the number of bits needed to store the file. This reduces the overall size of the file. Compression software uses a compression algorithm to reduce the file size. There are two main types of compression algorithm: lossy and lossless.

Lossy compression

Lossy compression reduces the size of a file by permanently removing some of the data in the file. The data that is removed is often thought to be redundant or would make only a small difference to the quality of the file. When the file is restored after compression, the data that was removed during the compression process cannot be restored.

Lossy compression is mainly used for audio, video and image files. It is mostly used to reduce the size of these files when streaming or transmitting them – however, there might be times where information cannot be lost; this exactly the purpose of lossless compression.

> **Example**
>
> *James has an audio file that he wants to send to Sabina for her to add to their homework project. James wants to reduce the size of the file so that it is small enough for him to attach to an email. James chooses to compress the file into an MP3 format. MP3 uses lossy compression to reduce the size of the audio file. It does this by removing background noise and any sounds that would not be heard by the human ear from the track. This reduces the size of the file, but it will be difficult to tell when listening to the audio file that anything has changed, as it will still be a very close representation.*

Lossless compression

Unlike lossy compression, lossless compression does not remove any of the original data from the file to reduce the size of it. When lossless compression is used to reduce the size of a file, the file can be restored to the original form. Lossless compression is used when it is vital that the file is restored to its original form and that no data is lost. There are many different lossless algorithms that work in different ways.

> **Example**
>
> *Marcus has a text file that he is using to store the following quote: 'Ask not what your country can do for you, ask what you can do for your country'. Marcus wants to compress the file so it takes up as little room on his hard drive as possible, but he does not want to lose any data from the file to do this. He uses lossless compression to do this.*
>
> *Excluding spaces and punctuation, the message has 61 characters. Each character requires 1 byte of storage. That means we would need 61 bytes of storage to store this quote.*
>
> *If we look at the quote it has repeating words in it. We could store the words used and store the position in which they occur in a lookup table:*
>
> | Word | Position |
> | --- | --- |
> | ask | 1, 10 |
> | not | 2 |
> | what | 3, 11 |
> | your | 4, 16 |
> | country | 5, 17 |
> | can | 6, 13 |
> | do | 7, 14 |
> | for | 8, 15 |
> | you | 9, 12 |
>
> *When we compress data in this format we need 1 byte to store each character in each word and 1 byte to store each position of the word. This means the quote in the format would be 49 bytes. The original file size was 61 bytes so we have saved 12 bytes of storage space. This may not seem a great deal, but when storing large text files, the saving would be much greater.*

Methods of backup

Backing up is the process of making and storing copies of files in case of equipment failure or other damage that could cause loss of data. Files are backed up in the event that the data is lost so that they can be restored at any time.

In a full backup, all the files and folders selected for backup will be backed up. This type of backup is normally carried out as an initial backup of files, as all of the files will need to be copied. This kind of backup can take a long time to be completed, especially when there are lots of files to be backed up.

For this reason, once an initial backup has been carried out, people may want to just back up the files that have changed since their last backup. This type of backup is called an incremental backup. This type of backup will only back up the files that have changed since the last backup was carried out. This can make the process of backing up on a regular basis much quicker.
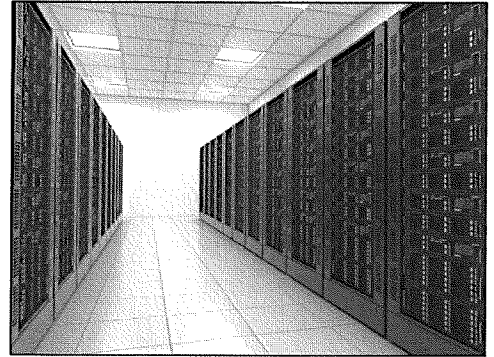
Large companies may have a great deal of storage space dedicated to the backing up of data

Chapter Summary

- There are two main types of software that are used on computer systems: systems software and applications software.
- Systems software controls the operations of hardware in a computer system. Systems software also provides a platform to run applications software.
- Applications software is the everyday programs we use to create documents and carry out communication with each other using technology.
- An operating system is software that is loaded by the computer after the initial boot-up. It controls the operations of the hardware in a computer system and manages all other software. We interact with the operating system through a user interface.
- The operating system performs a number of functions including memory management, multitasking, peripheral management, user management and file management.
- Utility software is a type of systems software. It helps manage, maintain and control the computer's resources. There are a number of different types, including encryption software, defragmentation software, data compression and methods of backups.

Practice Questions

1. Memory management is one of the main functions of an operating system. Explain how the operating system manages a computer's memory. [2]

2. State three other functions of an operating system. [3]

3. Explain the difference between a GUI and a CLI. [2]

4. Explain two benefits of lossy compression. [4]

5. Explain the difference between an incremental and a full backup. [4]