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Third Edition

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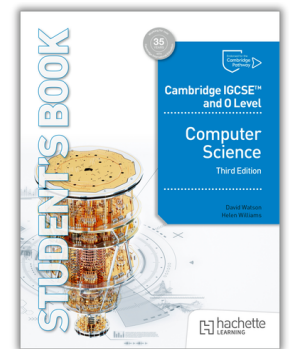
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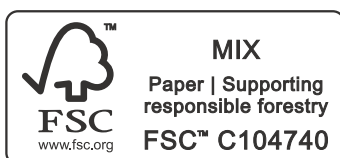
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Data transmission and networking

In this chapter, you will learn about:

- ★ packet switching:
 - how data is split up into data packets before transmission
 - the structure of data packets (header, payload and trailer)
 - packet switching (including the role of the router in the process)
 - how data packets are reconstructed at the recipient's computer
- ★ data transmission:
 - methods of data transmission (serial, parallel, simplex, half-duplex and full-duplex)
 - the advantages and disadvantages of the transmission methods
 - the purposes of network interface cards (NICs)
 - the format and purpose of media access control (MAC) addresses
 - the function of the switch in storing MAC addresses
- ★ internet protocol addresses:
 - the purpose and format of internet protocols (IPs)
 - the differences between IPv4 and IPv6
 - static IP addresses and dynamic IP addresses
 - functions of the router
- ★ the internet and World Wide Web (www)
 - the purpose and structure of URLs
 - the purpose and operation of HTTP and HTTPS
 - how web pages are located, retrieved and displayed using web browsers, IP addresses, domain names, web servers and hypertext markup language (HTML)
 - the role of the domain name system (DNS)
 - the role of cookies and the differences between session cookies and persistent cookies
 - features of cloud services
 - cloud storage models (public, private and hybrid)

This chapter considers how data is transmitted across networks (including the internet). It considers how data is split up into manageable chunks, and the protocols that have to be considered when sending and receiving data across a network.

3.1 Packet switching

3.1.1 Data packets

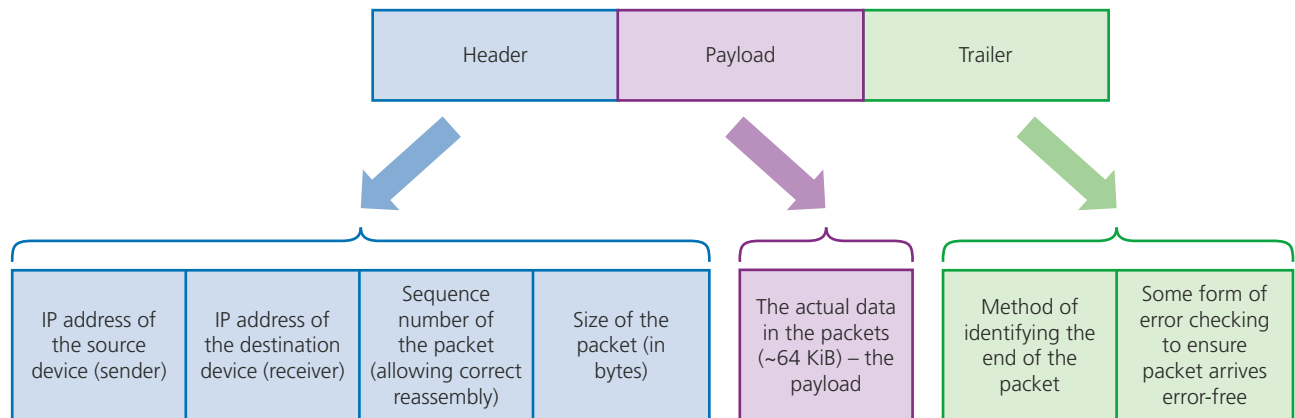
Data packets are usually referred to simply as 'packets'

Data sent over long distances is usually broken up into **data packets** (sometimes called datagrams). The packets of data are usually quite small, typically 64 KiB, which are much easier to control than a long continuous stream of data. The idea of splitting up data in this way means each packet can be sent along a different route to its destination. This would clearly be of great benefit if a particular transmission route was out of action or very busy. The only obvious drawback of splitting data into packets is the need to reassemble the data when it reaches its destination.

Structure of data packets

A typical packet is split up into:

- » a packet header
- » the payload
- » a trailer



▲ **Figure 3.1** Packet structure

Contents of data packets

For each packet, the **packet header** consists of:

- » the IP address of the sending device
- » the IP address of the receiving device
- » the sequence number of the packet (this is to ensure that all the packets can be reassembled into the correct order once they reach the destination)
- » the packet size (this is to ensure the receiving station can check whether all the packets have arrived intact)

Note: The header often also contains another value that indicates how many packets there are in total for this transmission.

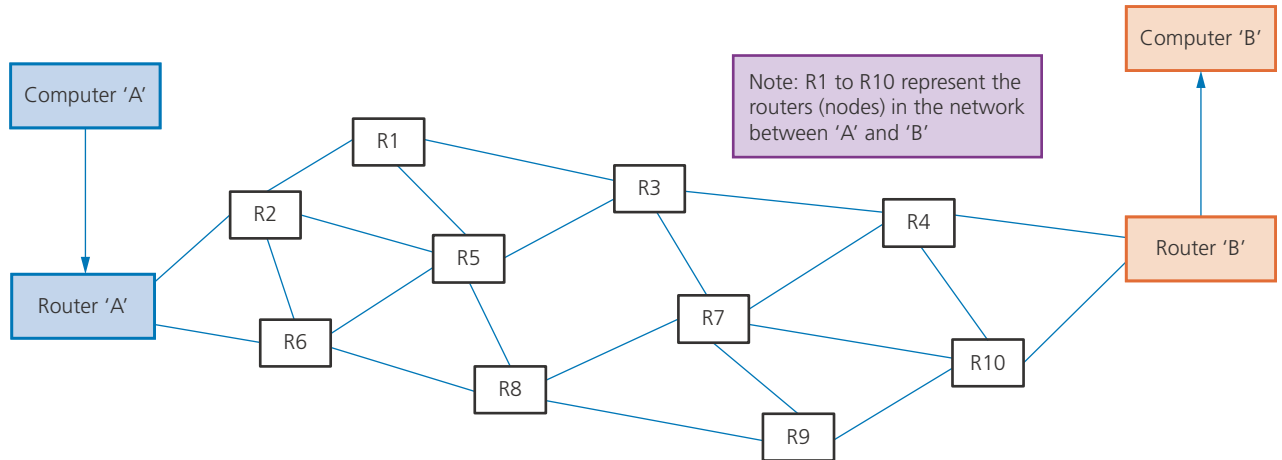
For each packet, the **payload** consists of the actual data being sent (this is usually about 64 KiB).

For each packet, the **packet trailer** consists of:

- » some way of identifying the end of the packet; this is essential to allow each packet to be separated from each other as they travel from the sending to the receiving station
- » an error-checking method; **cyclic redundancy checks** (CRCs) are used to check data packets:
 - this involves the sending computer counts all the 1 bits in the payload and storing this as a hex value in the trailer before it is sent
 - once the packet arrives, the receiving computer recalculates the number of 1 bits in the payload
 - the computer then checks this value against the one sent in the trailer
 - if the two values match, then no transmission errors have occurred; otherwise, the packet needs to be re-sent

Packet switching

Let us now consider what happens when a photograph, for example, is sent from computer 'A' to computer 'B'. The photograph is split up into a number of packets before it is sent. There are several possible routes for the packets between computer 'A' (sender) and computer 'B' (receiver). Each stage in the route contains a **router**. A router receives a data packet and, based on the information in the header, decides where to send it next, for example:



▲ **Figure 3.2** Typical network showing possible routes between 'A' and 'B'

Packet switching is a method of data transmission in which a message is broken up into a number of packets. Each packet can be sent independently from start point to end point. At the destination, the packets need to be reassembled into their correct order (using the information sent in the header). At each stage in the transmission, there are **nodes** that contain a router. Each router determines which route the packet needs to take to reach its destination (the destination IP address is used in this part of the process).

Suppose a photograph has been split up into five packets that have been sent in the order shown in Figure 3.3.

- » each packet follows its own path (route)
- » routers determine the route of each packet
- » routing selection depends on the number of packets waiting to be processed at each node
- » the shortest possible path available is always selected – this may not always be the shortest path that could be taken, since certain parts of the route may be too busy or not suitable
- » unfortunately, packets can reach the destination in a different order from that in which they were sent.

Figure 3.5 shows one possible scenario. Notice the different paths taken by each packet from computer 'A' to computer 'B'. Also notice that the packets have arrived in a different order compared to the way they were sent: the order shown in Figure 3.4.

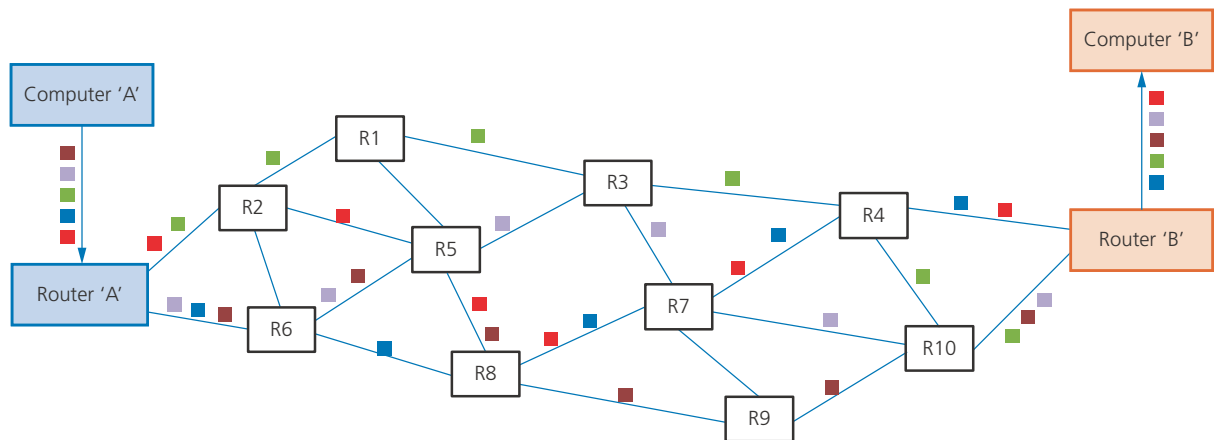
Computer 'B' now has to reassemble the packets into the original sequence.



▲ **Figure 3.3** Data packets sent



▲ **Figure 3.4** Data packets received



▲ **Figure 3.5** Typical network showing possible paths taken by each packet



Find out more

Another method of sending packets is called circuit switching. Find out how this differs from packet switching, and then re-draw Figure 3.5 showing the route the packets take when using circuit switching.

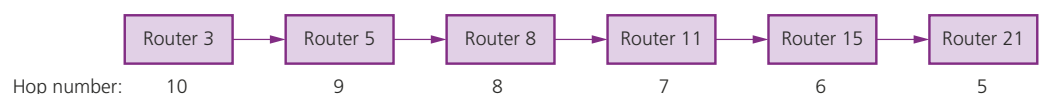
The **benefits** of packet switching are that:

- » there is no need to tie up a single communication line
- » it is possible to overcome failed, busy or faulty lines by simply re-routing packets
- » it is relatively easy to expand packet usage
- » a high data transmission rate is possible.

The **drawbacks** of packet switching include:

- » packets can be lost and need to be re-sent
- » the method is more prone to errors with **real-time streaming** (for example a live sporting event being transmitted over the internet)
- » there is a delay at the destination while the packets are being re-ordered.

Sometimes it is possible for packets to get lost because they keep 'bouncing' around from router to router and never actually reach their destination. Eventually the network would just grind to a halt as the number of **lost packets** mounts up, clogging up the system. To overcome this, a method called **hoppping** is used. A **hop number** is added to the header of each packet, and this number is reduced by 1 every time it leaves a router (Figure 3.6).



▲ **Figure 3.6** Hop numbers between routers

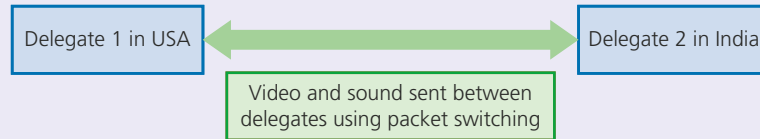
Each packet has a maximum hop number to start with. Once a hop number reaches 0 and the packet hasn't reached its destination, then the packet is deleted when it reaches the next router. The missing packets are then flagged by the receiving computer, which makes a request to re-send these packets.

Advice

You do not need to know about hopping, but it is included here for completeness (to help you understand how packets can get lost).

ACTIVITY 3.1

- 1 Suppose a video conference is taking place between delegates in two different countries. Packet switching is being used to send video and sound data between the delegates:



▲ **Figure 3.7** Video conference between delegates

Describe:

- a any potential problems with sound and video quality.
 - b how these problems could be caused.
- 2 Explain how packet switching could be used to download a large web page from a website.
 - 3
 - a The trailer in a packet will use one form of error checking. Explain what is meant by a *cyclic redundancy check*.
 - b The payload contains the following data:

11110000 10000011 00110011 00111111 11111110 11100011

Use this data to show how the receiving computer can verify that the received payload was error free.

- a Explain how it is possible for packets to be lost during their transmission across a network.
- b Describe how it is possible for a system to deal with lost packets and prevent them from slowing down the transmission process.
- c Explain why you think packet switching might improve data security.

3.2 Data transmission

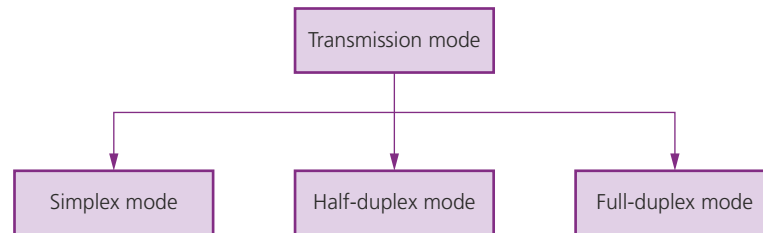
Data transmission can be either over a short distance (for example, a computer to a printer) or over longer distances (for example, from one computer to another in a global network). Essentially, there are three factors to consider when transmitting data:

- » the direction of data transmission (for example, can data transmit in one direction only or in both directions)
- » the method of transmission (for example, how many bits can be sent at the same time)
- » how data will be synchronised (that is, how to make sure the received data is in the correct order).

These factors are usually considered by a communication protocol.

3.2.1 Data transmission methods

Simplex, half-duplex and full-duplex



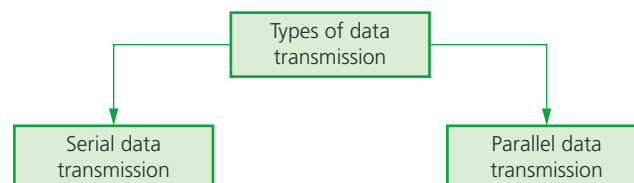
▲ **Figure 3.8** Transmission modes

Simplex mode occurs when data can be sent in **one direction only** (for example, from sender to receiver). An example of this is sending data from a computer to a printer.

Half-duplex mode occurs when data is sent in **both directions** but **not at the same time** (for example, data can be sent from 'A' to 'B' and from 'B' to 'A' along the same transmission line, but they can't both travel at the same time). An example of this is a walkie-talkie, where a message can be sent in one direction only at a time, but messages can be both received and sent.

Full-duplex (sometimes referred to as duplex) mode occurs when data can be sent in **both directions at the same time** (for example, data can be sent from 'A' to 'B' and from 'B' to 'A' along the same transmission line simultaneously). An example of this is a broadband internet connection.

Serial and parallel data transmission



▲ **Figure 3.9** Types of data transmission

Serial data transmission occurs when data is sent **one bit at a time** over a **single wire or channel**. Bits are sent one after the other as a single stream.

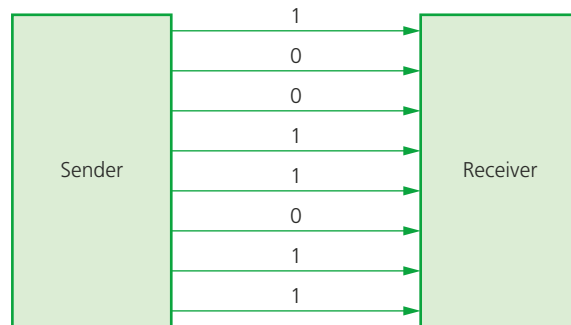


▲ **Figure 3.10** Serial data transmission

Note: Serial data transmission can be simplex, half-duplex or full-duplex.

Serial data transmission works well over long distances. However, the data is transmitted at a slower rate than parallel data transmission. Because only one channel or wire is used, data arrives at its destination fully synchronised (that is, in the correct order). An example of its use is when connecting a computer to a printer via a USB connection.

Parallel data transmission occurs when **several bits of data** (usually 1 byte) are sent down **several channels** or **wires** all at the same time. Each channel or wire transmits 1 bit.



▲ **Figure 3.11** Parallel data transmission

Note: Parallel data transmission can be simplex, half-duplex or full-duplex.

Parallel data transmission works well over short distances. Over longer distances (for example, over 20 metres), data can become **skewed** (that is, the data can arrive unsynchronised) and bits may arrive out of order. The longer the wire, the worse this can become. It is, however, a faster method of data transmission than serial. The internal circuits in a computer use parallel data transmission, since the distance travelled between components is very short and high-speed transmission is essential.

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For more on data transmission within the CPU, refer to Chapter 2.

ACTIVITY 3.2

- 1 Explain what is meant by:
 - a serial, half-duplex data transmission
 - b parallel, full-duplex data transmission
 - c serial, simplex data transmission.
- 2 Which types of data transmission are being described?
 - a data is sent 1 bit at a time in one direction only
 - b data is being sent 8 bits at a time in one direction only
 - c data is being sent 16 bits at a time in both directions simultaneously
 - d data is sent 1 bit at a time in both directions simultaneously
 - e data is sent 16 bits at a time in one direction only

3.2.2 Applications of transmission methods

Parallel data transmission

Parallel data transmission is used in the following applications:

- » Internal computer components (for example, the CPU and RAM) use parallel data transmission via data buses and address buses (refer to Section 2.2). This is the most applicable method since the distance between components is very short and high-speed data transfer is essential.
- » Some older devices (for example, early printers) used parallel data ribbon cables to enable data transfer from computer to printer.

Serial data transmission

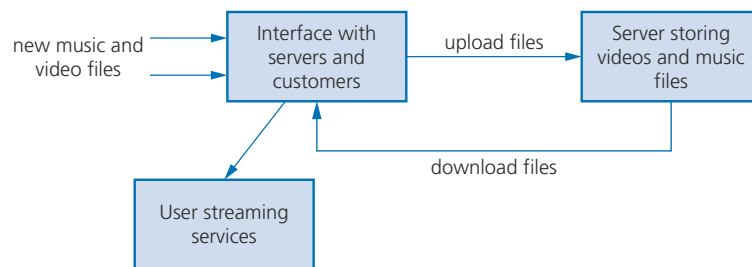
Serial data transmission is used in the following applications:

- » The universal serial bus (USB) is used to connect devices such as printers and keyboards to a computer. More information about USBs can be found after this section.
- » Long-distance networks (for example, wide area networks [WANs]) make use of serial data transmission. This is because of the long distances involved. With parallel data transmission, there would be a serious risk of data skewing and 'cross talk' (interference caused by the electromagnetic signals being carried by the wires).
- » Industrial automation and robotics often make use of serial data transmission; this is often down to costs (serial is generally cheaper to implement than parallel) and the distances involved in the processes.

Note on simplex, half-duplex and full-duplex

Simplex requires less complex hardware than duplex and is consequently usually cheaper. Duplex is the most applicable method to use when bi-directional communication is required. However, if there is a large amount of data being transmitted in both directions, then half-duplex wouldn't be suitable and full-duplex would need to be used.

Consider this example: A company stores videos and music on a server permitting customers to stream videos and music to their devices on request. The company uploads videos and music to their server and customers download the video and music files. The equipment to control the uploading of files is sited in the same room as the server. The company decides to use parallel data transmission using half-duplex mode. Figure 3.12 shows the setup.



▲ **Figure 3.12** Setup using half-duplex parallel data transmission

Why is the choice of data transmission acceptable in this application? Parallel data transmission is the correct choice since the upload and download processes involve the transfer of considerable amounts of data. Also, the transmission speeds for streaming need to be very fast. Half-duplex permits upload and download to occur, but they rarely need to be at the same time, which makes it acceptable in this scenario.

3.3 Universal serial bus (USB)

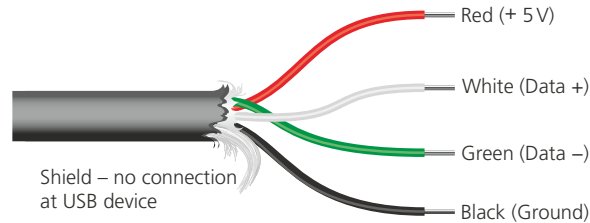
As the name suggests, the **universal serial bus (USB)** is an example of serial data transmission.

USB is now the most common type of input/output port found on computers and has led to a standardised method for the transfer of data between devices and a

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Refer to Section 5.1.6 on software drivers regarding devices plugged into USB ports.

computer. It is important to note that USB allows both half-duplex and full-duplex data transmission.



▲ **Figure 3.13** Typical USB cable

As Figure 3.13 shows, the USB cable consists of a four-wire shielded cable, with two wires for power (red and black). The other two wires (white and green) are for data transmission. When a device is plugged into a computer using one of the USB ports:

- » the computer automatically detects that a device is present (this is due to a small change in the voltage on the data signal wires in the USB cable)
- » the device is automatically recognised, and the appropriate device driver software is loaded up so that the computer and device can communicate effectively
- » if a new device is detected, the computer looks for the device driver that matches the device; if this is not available, the user is prompted to download the appropriate driver software (some systems do this automatically and the user sees a notice asking for permission to connect to the device website).

We will now consider the advantages and disadvantages of using the USB system.

▼ **Table 3.1** Advantages and disadvantages of USB systems

Advantages	Disadvantages
devices plugged into the computer are automatically detected and device drivers are automatically loaded up	standard USB supports a maximum cable length of only 5 m; beyond that, USB hubs are needed to extend the cable length
connections can fit only one way, preventing incorrect connections being made	even though USB is backwards compatible, very early USB standards (V1) may not always be supported by the latest computers
it has become an industry standard, which means considerable support is available	even the latest version 3 (V3) and version 4 (V4) USB-C systems have a data transfer rate that is slow compared to e.g. ethernet connections (note: USB V2 has a maximum data transfer rate of 480 Mbps)
it can support different data transmission rates (from 1.5 Mbps to 5 Gbps)	
there is no need for an external power source since the cable supplies +5 V power	
USB protocol notifies the transmitter to retransmit data if any errors are detected; this leads to error-free data transmission	
it is relatively easy to add more USB ports if necessary, by using USB hubs	
USB is backwards compatible (i.e. older versions are still supported)	

A new type of USB connector, referred to as USB-C, is now becoming more common in laptops, tablets and phones. This is a 24-pin symmetrical connector, which means it fits into a USB-C port either way round. It is much smaller and thinner than older USB connectors and offers 100 watt (20 volt) power connectivity, which means full-sized devices can now be charged and it can carry data at 10 gigabits per second (10 Gbps); this means it can support 4K video delivery.

USB-C is backwards-compatible with USB 2.0 and 3.0, provided a suitable adaptor is used, and is expected to become the new industry standard (universal) format.

3.3.1 Advantages and disadvantages of transmission methods

▼ **Table 3.2** Comparison of serial and parallel data transmission methods

Serial	Parallel
less risk of external interference than with parallel (due to fewer wires)	faster rate of data transmission than serial
more reliable transmission over longer distances	works well over shorter distances (e.g. used in internal pathways on computer circuit boards)
transmitted bits don't risk being skewed (i.e. out of synchronisation)	since several channels/wires are used to transmit data, the bits may arrive out of synchronisation (skewed)
suitable if the amount of data being sent is relatively small, since transmission rate is slower than parallel (e.g. USB uses this method of data transmission)	the preferred method when speed is important
suitable for sending data over long distances (e.g. telephone lines)	the most appropriate transmission method if data is time-sensitive
less expensive than parallel due to fewer hardware requirements	parallel ports require more hardware, making them more expensive to implement than serial ports
	makes it easier to program input/output operations

▼ **Table 3.3** Comparison of simplex, half-duplex and full-duplex transmission modes

	Simplex	Half-duplex	Full-duplex
Data transmission	data can travel in one direction only	data can travel in both directions but not at the same time	data can travel in both directions simultaneously
Transfer speed	has the lowest performance of the three modes	faster than simplex, but there is a wait time between changing directions of data travel	has the highest performance of the three modes; uninterrupted data flow
Bandwidth	uses the entire bandwidth for a single transmission	conserves bandwidth as communication takes place in one direction only	doubles the utilisation of available bandwidth
Uses	keyboards, monitors, printers	walkie-talkies, CB radio	telephones, internet, Bluetooth

ACTIVITY 3.3

Ten statements are shown in the table. Each of these statements is either true or false. For each statement, write the number and indicate which statements are true and which are false.

Number	Statement	True	False
1	Packets have a header that contains the IP address of the sender and the receiver.		
2	Packets don't require any form of error checking.		
3	USBs use a protocol that allows for error-free data transmission between device and computer.		
4	Serial data transmission suffers from data skewing.		
5	The longest cable length supported by USB is 5 metres or less.		
6	Simplex data transmission occurs when data is transmitted 1 bit at a time.		
7	Full-duplex data transmission involves sending 8 bits of data at a time.		
8	USB uses serial data transfer.		
9	Packet switching prevents loss of any data packets.		
10	USB connections can transfer data using half-duplex or full-duplex.		

3.4 Network hardware

3.4.1 Network interface cards (NICs)

A **network interface card (NIC)** is needed to allow a device to connect to a network (such as the internet). It is usually part of the device's hardware and contains the **media access control (MAC)** address generated at the manufacturing stage.

Wireless network interface cards/controllers (WNICs) are the same as NICs in that they are used to connect devices to the internet or other networks. However, they use wireless connectivity utilising an antenna to communicate with networks via microwaves. They would normally plug into the USB port or be part of an internal integrated circuit.

3.4.2 Media access control (MAC) and types of MAC address

A MAC address is made up of 48 bits, which are shown as six groups of hexadecimal digits with the following general format:

NN – NN – NN is the manufacturer's code

NN – NN – NN – DD – DD – DD

DD – DD – DD is the device serial number

Types of MAC addresses

There are two types of MAC address: the **universally administered MAC address (UAA)** and the **locally administered MAC address (LAA)**.

The UAA is by far the most common type of MAC address and is the one set by the manufacturer at the factory. It is rare for a user to want to change this MAC address.

However, there are some occasions when a user or organisation wishes to change their MAC address. This is a relatively easy task to carry out, but it can cause significant problems if the changed address is not unique.

There are a few reasons why the MAC address needs to be changed (using LAA):

- » Certain software used on mainframe systems needs all the MAC addresses of devices to follow a strict format. Because of this, it may be necessary to change the MAC address of some devices to ensure they follow the correct format.
- » It may be necessary to bypass a MAC address filter on a router or firewall. Only MAC addresses with a certain format are allowed through; otherwise, the devices will be blocked if their MAC address does not adhere to the correct format.
- » To get past certain types of network restrictions, it may be necessary to emulate unrestricted MAC addresses, hence it may require the MAC address to be changed on certain devices connected to the network.

3.4.3 Uniqueness of NIC MAC addresses

In the MAC address 00 – 1C – B3 – 4F – 25 – FF, the first six hex digits identify the device manufacturer, for example, Apple and the second set of six hex digits identifies the device itself and is unique. If the NIC card is replaced, the MAC address also changes.

3.4.4 Function of a switch

Local area networks make use of a device called a switch. When a data packet arrives via the local router, the data packet is sent to a switch. The switch contains a table of MAC addresses relevant to the network it is serving. The MAC address in the data packet is compared to those stored in the table and, if it is found, the data packet is routed to the correct device. Every time a data packet is received, its MAC address is compared to those stored in the table and it is consequently updated. Refer to Section 3.3.5 to learn how the router and switch work together.

EXTENSION

For those students considering the study of this subject at A Level, this section gives some insight into further study of computer hardware and wireless networks.

Topic 1: Computer ports

Input and output devices are connected to a computer via ports. The interaction of the ports with connected input and output devices is controlled by the control unit.



A summary of some of the more common types of ports found on modern computers follows.

USB ports

The **universal serial bus (USB)** is an **asynchronous serial** data transmission method. It has quickly become the standard method for transferring data between a computer and a number of devices.



▲ **Figure 3.22** USB cable

Essentially, the USB cable consists of a four-wire shielded cable. Two of the wires are used for power and the earth; two of the wires are used for data transmission.

When a device is plugged into a computer using one of the USB ports, the computer:

- automatically detects that a device is present (this is due to a small change in the voltage level on the data signal wires in the cable)
- automatically recognises the device, and loads up the appropriate device driver so that computer and device can communicate effectively
- looks for the device driver that matches the device if a new device is detected; if this is not available, the user is prompted to download the appropriate software.

Even though the USB system has become the industry standard, there are still a number of advantages and disadvantages to using this system.

▼ **Table 3.8** Advantages and disadvantages of using USB

Advantages	Disadvantages
devices plugged into the computer are automatically detected; device drivers are automatically loaded up	the present transmission rate is limited to less than 500 megabits per second
the connectors can fit only one way; this prevents incorrect connections being made	the maximum cable length is presently about 5 metres
USB has become the industry standard; this means that considerable support is available to users	the older USB standard (1.1) may not still be supported in the near future
several different data transmission rates are supported	
newer USB standards are backwards compatible with older USB standards	

High-definition multimedia interface (HDMI)

High-definition multimedia interface (HDMI) ports allow audio and visual output from a computer to an HDMI-enabled monitor or other device. It supports high-definition (HD) signals (enhanced or standard). HDMI was introduced as a digital replacement for the older VGA analogue system. Modern HD televisions have the following features, which are making VGA a redundant technology:

- they use a widescreen format (16:9 aspect ratio)
- the screens use a greater number of pixels (typically 1920 × 1080)
- the screens have a faster refresh rate (for example 120 Hz or 120 frames a second)
- the range of colours is extremely large (some companies claim up to 4 million different colour variations!)



▲ **Figure 3.23** HDMI cable

This all means that modern HD televisions require more data, and this data has to be received at a much faster rate than it would be by older televisions (for example, 10 Gbps). HDMI increases the bandwidth, making it possible to supply the necessary data to produce high-quality sound and visual effects.

Topic 2: Wired and wireless networks

Wireless

Wi-Fi and Bluetooth

Both Wi-Fi and Bluetooth offer wireless communication between devices. They both use electromagnetic radiation as the carrier of data transmission.

Bluetooth sends and receives radio waves in a band of 79 different frequencies (known as channels). These are all centred on a 2.45 GHz frequency. Devices using Bluetooth automatically detect and connect to each other, but they don't interfere with other devices since each communicating pair uses a different channel (from the 79 options).

When a device wants to communicate, it picks one of the 79 channels at random. If the channel is already being used, it randomly picks another channel. This is known as spread-spectrum frequency hopping. To further minimise the risks of interference with other



devices, the communication pairs constantly change the frequencies (channels) they are using (several times a second). Bluetooth creates a secure wireless personal area network (WPAN) based on key encryption.

Essentially, Bluetooth is useful:

- when transferring data between two or more devices that are very close together (less than 30 metres distance)
- when the speed of data transmission is not critical
- for low bandwidth applications (for example, when sending music files from a mobile phone to a headset).

Wi-Fi is best suited to operating full-scale networks since it offers much faster data transfer rates, better range and better security than Bluetooth. A Wi-Fi-enabled device (such as a computer or smartphone) can access the internet wirelessly at any wireless access point (WAP) or 'hot spot' up to 100 metres away.

As mentioned, wireless connectivity uses electromagnetic radiation: radio waves, microwaves or infrared. Table 3.9 shows the scale of frequency and wavelength of electromagnetic radiation.

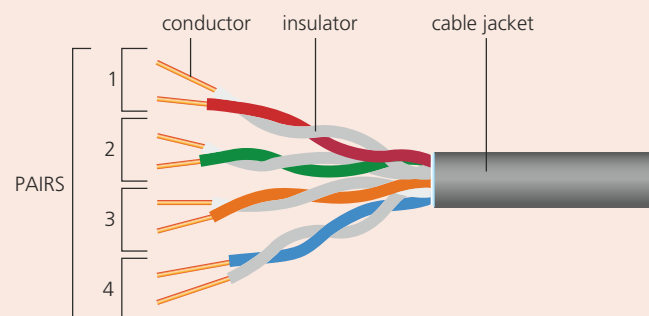
▼ **Table 3.9** Scale of frequency and wavelength of electromagnetic radiation

	Radio waves	Microwaves	Infrared	Visible light	Ultra violet	X-rays	Gamma rays
Wave length (m)	10 ²	10 ⁻¹	10 ⁻⁵	10 ⁻⁵	10 ⁻⁷	10 ⁻⁹	10 ⁻¹¹
Frequency (Hz)	3 MHz	3 GHz	300 GHz	30 THz	3 PHz	300 PHz	30 EHz

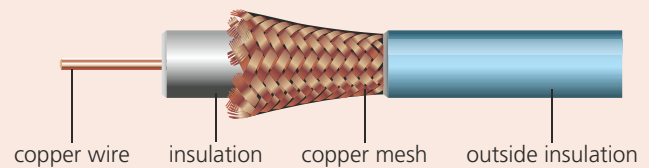
Wired

There are three main types of cable used in wired networks:

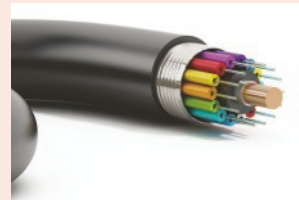
- twisted pair
- coaxial
- fibre optic



▲ **Figure 3.24** Twisted pair cable



▲ **Figure 3.25** Coaxial cable



▲ **Figure 3.26** Fibre optic cable

Wired versus wireless

Table 3.10 shows the factors to consider when deciding whether a network should use wired or wireless connectivity.

▼ **Table 3.10** Wireless versus wired networking

Wireless networking	Wired networking
easier to expand the networks and it isn't necessary to connect the devices using cables	produces a more reliable and stable network; wireless connectivity is often subject to interference
gives devices increased mobility provided they are within range of the WAPs	faster data transfer rates, without 'dead spots'
increases the chance of interference from external sources	cheaper overall setup in spite of the need to buy and install cable
data is less secure than with wired systems; it is easier to intercept radio waves and microwaves than cables; it is essential to protect data transmissions using encryption (e.g. WEP, WPA2)	however, cabled networks lose the ability for devices to be mobile; they must be close enough to allow for cable connections
slower data transmission rate than for cabled networks, although it continues to improve	having lots of wires can lead to a number of hazards such as tripping hazards, overheating of connections (leading to potential fire risk) and disconnection of cables during routine office cleaning
possible for signals to be stopped by thick walls (e.g. in old houses) and there may be areas of variable signal strength leading to 'drop out'	

3 DATA TRANSMISSION AND NETWORKING

In this chapter, you have learned about:



- ✓ data packets and packet switching
- ✓ data transmission methods, including serial, parallel, simplex, half-duplex and full-duplex
- ✓ network interface cards (NICs)
- ✓ media access control (MAC) addresses
- ✓ internet protocol (IP) addresses including IPv4 and IPv6
- ✓ static and dynamic IP addresses
- ✓ functions of a router
- ✓ uniform resource locators (URLs)
- ✓ HTTP and HTTPS
- ✓ how web pages are located, retrieved and displayed
- ✓ session cookies and persistent cookies
- ✓ cloud storage (private, public and hybrid).

Practice questions

- 1 Explain each of the following computer terms:
- a packet switching
 - b cyclic redundancy check
 - c data skewing
 - d universal serial bus
 - e parity bit
- [10]

- 2 A file server is used as a central data store for a network of computers. Rory sends data from his computer to a file server that is approximately 100 metres away. It is important that the data is transmitted accurately. Rory needs to be able to read data from and write data to the file server at the same time.

- a i Use ticks (✓) to identify the most suitable data transmission methods for this application. [2]

Method 1	Tick [✓]	Method 2	Tick [✓]
serial		simplex	
parallel		half-duplex	
		duplex	

- ii Explain why your answer to a i is the most suitable data transmission method. [4]

- b Identify and describe **two** methods of error checking that can be used to make sure that the data stored after transmission is accurate. [6]

*Cambridge O Level Computer Science 2210,
Paper 12 Q4, Oct/Nov 2017*

- 3 Maisy purchases a new router and attaches it to her computer. The connection she sets up uses duplex data transmission.
- a Five statements are given about duplex data transmission. Tick (✓) to show whether each statement is true or false. [5]

Statement	True [✓]	False [✓]
duplex data transmission can be either serial or parallel		
duplex data transmission is when data is transmitted both ways, but only one way at a time		
duplex transmission is always used to connect a device to a computer		
duplex data transmission is when data is transmitted both ways at the same time		
duplex data transmission automatically detects any errors in data		

3 DATA TRANSMISSION AND NETWORKING

- b Maisey's computer uses an integrated circuit (IC) for data transmission that sends multiple bits at the same time.
State whether the IC uses serial or parallel data transmission. [1]
- c Maisey purchases a new printer and connects it to her computer using a USB port.
Explain two benefits of using a USB connection. [4]

*Cambridge O Level Computer Science 2210,
Paper 12 Q9, Oct/Nov 2019*

- 4 a What is meant by a cookie? [1]
b Describe the difference between a session cookie and a persistent cookie. [2]
c Give three uses of persistent cookies. [3]
- 5 HTML can be used to create the structure and presentation of web pages.
a Describe what is meant by HTML structure. [2]
b Gloria writes a paragraph as an answer to an examination question about accessing a website.
Use the list given to complete Gloria's answer by inserting the correct four missing terms. Not all terms will be used.
- browser
 - cookies
 - hypertext markup language (HTML)
 - hypertext transfer protocol (http)
 - hypertext transfer protocol secure (https)
 - internet protocol address (IP address)
 - media access control address (MAC address)
 - web server

The user enters the URL of the website. The _____ uses the DNS server to look up the _____ of the website. The browser sends a request to the _____ to obtain the website files. The website files are sent as _____ that is interpreted by the browser. [4]

*Cambridge IGCSE Computer Science 0478,
Paper 11 Q9, Oct/Nov 2019*

- 6 A pharmaceutical company manufactures medicines for sale to the general public. They manufacture the medicines in their own factory. Information and data regarding the status of the manufacturing process is sent to a central computer. This computer controls the process.
- a The data is sent to the central computer using serial transmission in full-duplex mode. Explain why this transmission method would be most suitable. [3]
- b Confidential data about clients, the manufacturing process and financial data are stored using cloud storage. Product advertising is non-confidential.
- i Which mode(s) of cloud storage would be most suitable for data storage? [3]
 - ii Give reasons for your choice for part i. [3]
- c Give one advantage and one disadvantage of using cloud storage. [2]

- 7 Data packets are transmitted across a network from one computer to another.
- a Describe the structure of a data packet. [3]
 - b Packet switching is used to transmit the data packets across the network. Identify the device that controls which path each data packet takes. [1]
 - c Serial data transmission is used to transmit the data packets across the network. Explain why serial data transmission is used to transmit the data packets. [3]

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Paper 11 Q4, May/June 2024*

- 8 a Describe the differences between media access control (MAC) addresses and internet protocol (IP) addresses. [2]
- b Explain the purpose of the network interface card (NIC). [2]
 - c IPv6 is an improved version of IPv4.
 - i Explain why it was necessary to develop IPv6.
 - ii Describe the main differences between IPv4 and IPv6. [2]
- 9 The table contains terms and descriptions about the internet. Complete the table with the missing terms and descriptions. [6]

Term	Description
_____	the collective name for all the web pages available
_____	a small text file, stored by the web browser, that can store a user's personal data
uniform resource locator (URL)	_____
webserver	_____
_____	the language used to create a website; example tags are <head> and <body>
_____	a protocol that is used to request and send web pages

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