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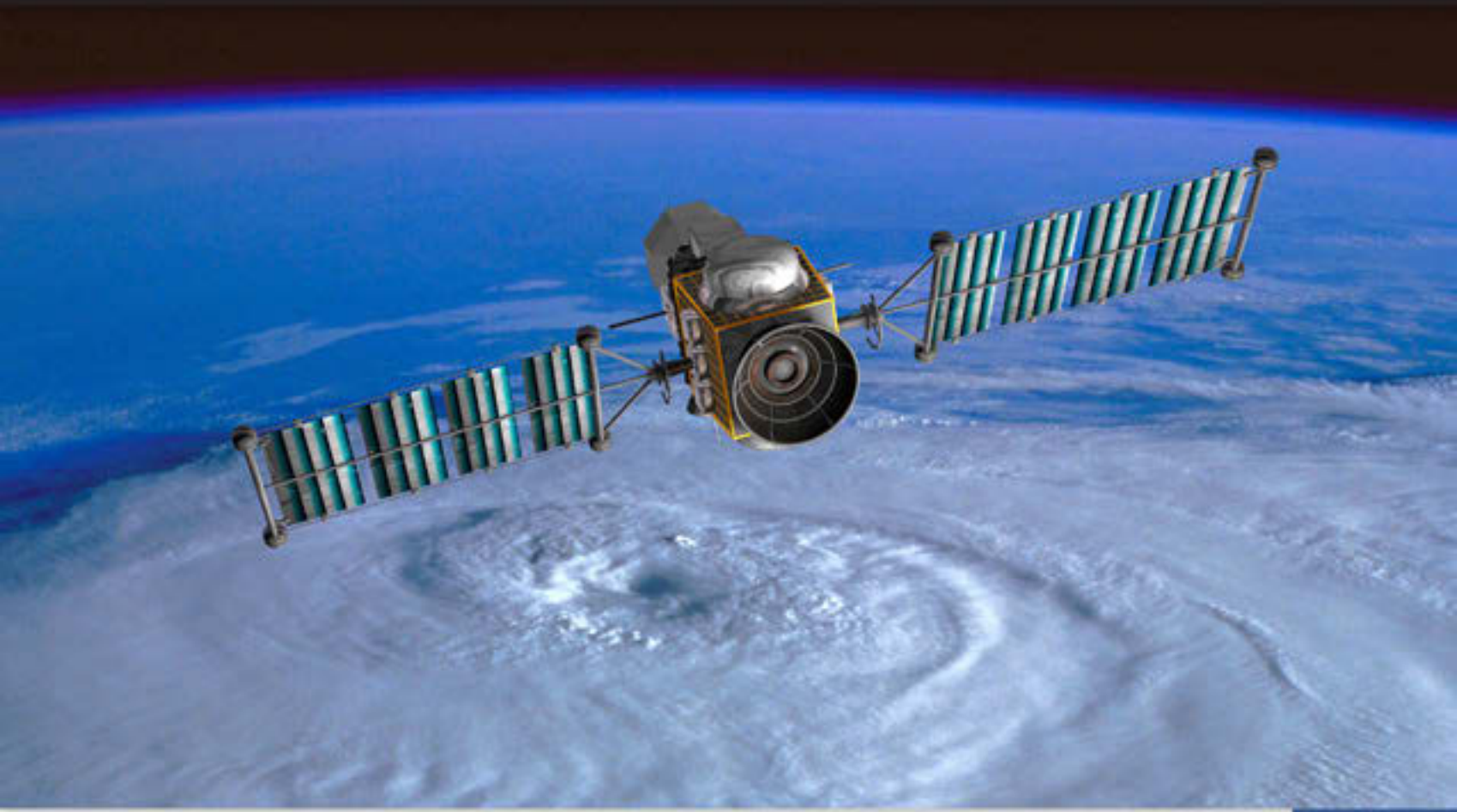

Cambridge International AS and A Level

Computer Science

Revision Guide

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Contents

Revision guidelines

Revision, by the nature of the word, implies re-visiting content and topics that you have studied throughout the year. What you already have in terms of resources to help you with your revision will largely determine the way in which you set about and plan your revision programme.

Key issues include:

- Have you got a copy of the textbook you have followed throughout your course?
- Did you use it as your course progressed to make your own notes?
- Has your teacher provided you with notes as each topic has been covered?
- Have you worked through worksheets prepared by your teacher?

All of these are a good starting point and your first revision task is to gather together all the materials you have produced and accumulated throughout the course. Organise them in the same way as the 9608 syllabus, that is, by section and subsection.

When should I start revising?

Start as early as possible. Examinations are generally a stressful time and so you need to do everything possible to make this a 'stress-free' experience.

A trawl through all the materials you have should establish:

- what topics you have clear notes for and where you do not
- topics where you can do lots of practice, for example, the number systems content in Part 1, 1.01
- topics about which you are definitely confident
- topics that you are not confident with – you probably 'put it off' when the content was covered in lessons.

Preparing for examination

You must not have large gaps in your understanding and you need the skills to apply your knowledge. Both are important. The trend generally for all advanced level examinations is away from questions which only ask you to reproduce basic knowledge, for example giving a basic definition. For a question about database design a knowledge question could be 'State what is meant by a primary key and a foreign key'. However, it is a much better assessment of your ability if you are able to apply this to a given simple practical scenario. The question style you are more likely to face is:

1 Which attribute would be the primary key for table X?

2 How is the relationship formed using a foreign key to table Y?

Computing is a practical subject – probably second only to engineering – and so it is reasonable that your computing examination papers should reflect this, with questions that require answers which apply your knowledge in the context of practical scenarios.

Past examination paper questions

Looking at as many previous questions as possible can be a very valuable part of revision. Many examples from Cambridge past papers have been carefully selected and included at the end of each section in the course textbook. (Cambridge International Examinations bears no responsibility for the example answers to questions taken from its past question papers which are contained in this publication.)

Your teacher will be able to supply you with further past papers and specimen papers and guide you to relevant questions for the topic you are revising.

So, you've trawled through and organised the materials you have produced throughout the course – what next?

Specific revision materials

Cambridge International AS and A Level Computing Revision Guide

This book should provide you with a helpful structure to plan your revision around. The organisation of this guide is similar to the course textbook and it has frequent 'test yourself ' questions as you work through each chapter.

Revision cards

These are a favourite with students and have the obvious advantage that you can carry them around with you and dip into them in any odd five minutes you can find. Cards are available in different colours and so you could easily develop a system to code cards on the same general topic in the same colour.

The figures below are for Chapter 8, on databases:

Database design **Card 1 (of 10)**

Attribute – Data item recorded as part of a database design.
Entity – In database design, something about which we record data, for example, a Customer. Entities are implemented as tables.
Primary key – An attribute (or combination of attributes) chosen to ensure that all the records in a table are unique.
Relationship – A link between two tables, which can be:

- One-to-one – uncommon
- One-to-many – the most common
- Many-to-many – cannot be implemented with relational database software

Database design **Card 2 (of 10)**

Foreign key – An attribute in a table which links back to the same primary key attribute in a second table.
Candidate key – Attribute(s) which are unique in a table and so are a 'candidate' to be used as the primary key.
Secondary key – An attribute other than the primary key for which an index has been created.

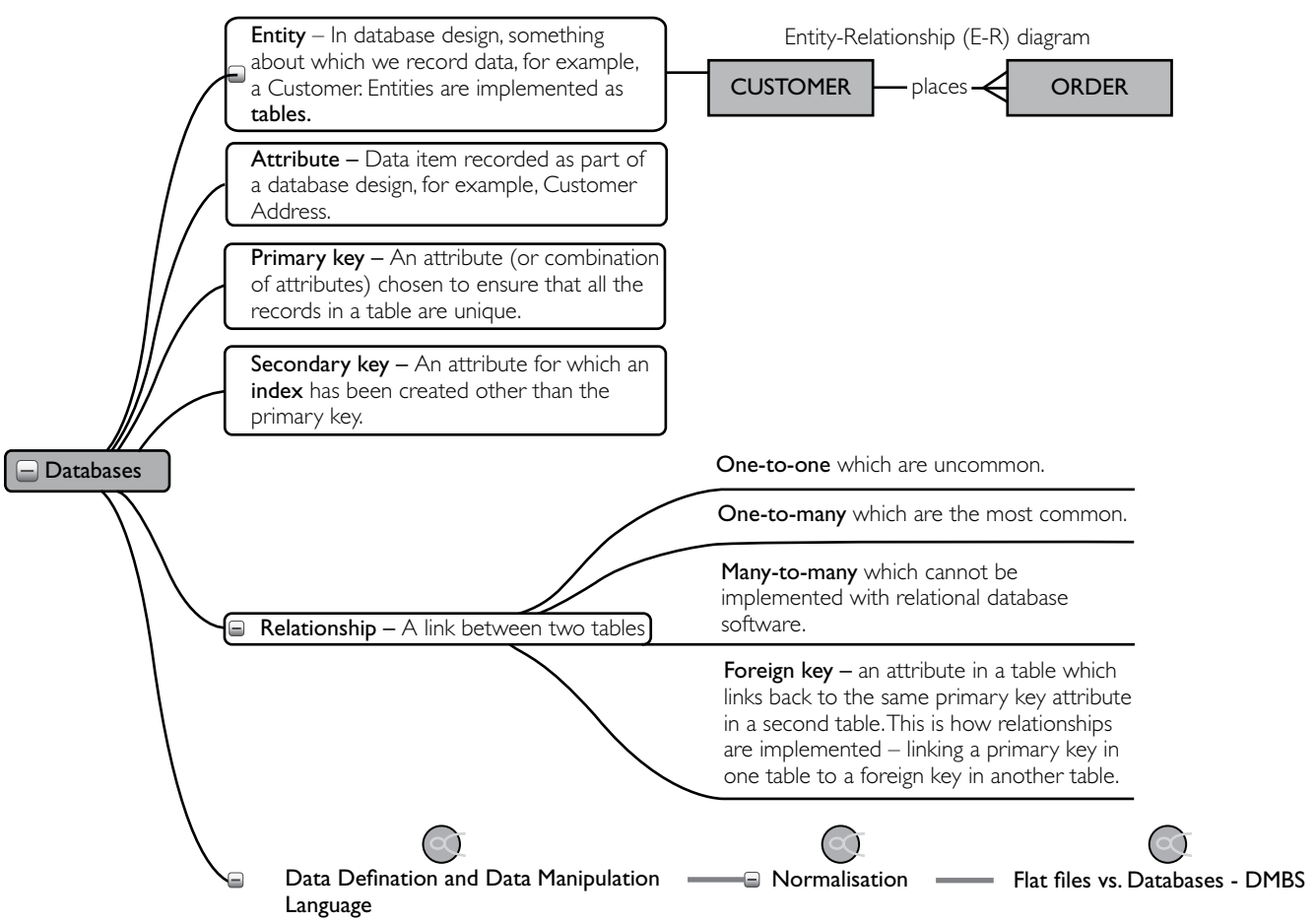
How will you organise the cards?

- a separate set for each section
- a separate set for each topic

There are some clear links between content in, for example, Part 1 and Part 3. Assembly language is introduced in Section 1 and then studied in more depth in Part 3. Can you have a system with your revision cards which allows for this?

Mind maps

Mind maps provide an effective way to break the content down into manageable amounts and if you are a person who 'thinks visually' then you will probably take to mind-mapping. My experience is that students tend to be polarised into 'I like using them' or 'I hate them' but I have found that students do agree they are a useful revision tool. A simple example for (some of) the database content for Chapter 8 is shown below:



Also there is available on the World Wide Web free mind-mapping software and this usually has features which are very appropriate for revision:

- the expansion of branches (to see detail)
- the collapsing of branches (to see the 'big picture')
- the inclusion of graphics.

How do I revise?

What time of day?

There are all sorts of conflicting evidence about when your brain is at its most receptive! You will need to decide what time of day seems to work best for you and how long each session should be.

Shall I revise on my own?

Maybe, but it will be much less daunting if you team up with a fellow student – a 'revision buddy' – and revise together. This could include:

- sharing the work of producing the revision cards or mind maps
- testing each other on some basic definitions and the factual knowledge of a topic.

I do lots of past examination questions

Consider carefully what 'doing examination questions' actually means for you. It is tempting to look at a question then, talking to yourself, recite the answer you would give – then move on to another question. That might be sufficient but, remember, the examination is a written paper; why not spend the extra time in writing out the answer on rough paper? That way when you read it back it may be clear that there are some points which you have omitted or some points where the meaning is unclear.

Seek advice

You need to be confident with all the syllabus content (remember, there is no choice of questions) so don't try to bury problems and topic areas about which you are unsure. Your revision buddy may be confident about it and after five minutes of him or her talking it through, something about which you have been unclear for six months, may become clear for the first time. Failing that, be honest that you are unsure and seek help from your teacher. Problems do not go away and solve themselves – you must be pro-active in plugging the gaps in your knowledge and understanding.

On the day – examination technique

Reading the paper

It is sensible to read the entire paper before you start to attempt any of the questions. This will give you a good idea as to the questions you are confident about and those which may need more time spent on them. The number of marks is a good indicator of how long you should spend on each question. Get used to planning how you will divide your time for questions through an examination paper using the marks as a guide. It is a good idea to read back through your answers once you finish.

Layout of the paper

Where questions are displayed in an answer booklet, the amount of space provided is an indicator of the length of answer the examiner is expecting.

Is it important to answer the questions in a paper in order? No, you can answer the questions in any order. As a general rule questions which are considered less demanding will be at the start of the paper.

Understanding the question command words

Some questions will have a short introduction (called the 'stem' of the question) and this will apply to all parts of the questions which follow. Specific questions will each have a keyword which is the indicator as to the style of answer expected.

Questions starting 'Define ...', 'State ...', 'Give ...' or 'Name …' all require an answer of only one or a few words giving a short and concise answer.

For example:

Give the attributes for the Loan table below, showing the primary key.

You should not create a `LoanID` for this table.

```
Loan (............, ............,
.............., ..............)
```
[2]

A question starting 'Describe ...' wants more detail. The indicator of precisely how much detail is the number of marks for the question: a three-mark question will usually require three different points to be made.

For example:

Describe how an assembly language program is translated into machine code. [2]

A question starting 'Explain ...' wants not only a description but an answer that contains some reasoning.

For example:

Explain why an interpreter has better diagnostics features than compiler software. [2]

A sample examination question is shown below:

(a) State what is meant by a real-time application.

.....

.....

.....

.....

There is no introductory statement.
The keyword is 'State' and what is wanted is the basic 'bookwork' definition of a real-time system.

[1]

(b) An air conditioning system is a real-time application.
Explain how sensors and actuators are used to control an air-conditioning system in an apartment.

.....

.....

.....

.....

.....

.....

.....

.....

The introductory statement applies to part (b) only
The keyword is 'Explain' and there are four marks.
The answer must make at least four clear points describing how a temperature sensor sends data values to the processor and how they are processed when an actuator is involved.

[4]

(c) Give ***one other*** example of a real-time application. Justify why your choice is a real-time application.

Example: .....

Justification: .....

.....

.....

.....

.....

The keyword is 'Give' but you are having to be more resourceful and come up with your own example of a real-time system.
The key requirements are the example and its justification. The paper makes it clear how you are to present them. You can assume there will be one mark for the example and one mark for the justification.

[2]

Cambridge International AS and A Level Computing 9691 Paper 31 Q4, June 2011

PART 1

THEORY FUNDAMENTALS

Chapter 1

Information representation

Revision objectives

By the end of the chapter you should be able to:

- ☐ show understanding of the basis of different number systems; use the binary, denary and hexadecimal number systems; and convert a number from one number system to another
- ☐ express a positive or negative integer in two's complement form
- ☐ show understanding of, and be able to represent, character data in its internal binary form
- ☐ express a denary number in binary coded decimal (BCD) and vice versa and describe practical applications where BCD is used
- ☐ show understanding of how data for a bitmapped image is encoded
- ☐ use the terminology associated with bitmaps: pixel, file header, image resolution, screen resolution
- ☐ perform calculations estimating the file size for bitmapped images of different resolutions
- ☐ show understanding of how data for a vector graphic is represented and encoded
- ☐ use the terminology associated with vector graphics: drawing object, property and drawing list
- ☐ show understanding of how typical features found in bitmapped and vector graphics software are used in practice and are therefore appropriate for a given task
- ☐ show understanding of how sound is represented and encoded
- ☐ use the associated terminology: sampling, sampling rate, sampling resolution
- ☐ show understanding of how file sizes depend on sampling rate and sampling resolution
- ☐ show understanding of how typical features found in sound-editing software are used in practice
- ☐ show understanding of the characteristics of video streams: frame rate (frames/second); interlaced and progressive encoding; video interframe compression algorithms and spatial and temporal redundancy; multimedia container formats
- ☐ show understanding of how digital data can be compressed, using 'lossless' (including run-length encoding, RLE) or 'lossy' techniques.

1.01 Number representation

We present any denary number with some combination of the digits 0, 1, 2, 3, 4, ..., 8 and 9.

Any number system is founded on the concepts of:

- a base
- that digits in certain positions each have a place value
- the number of possible digits used is the base.

Denary system

We were taught to use the **denary** (or **decimal**) numbering system – that is, using base 10 with possible digits 0, 1, 2, ..., 8 and 9.

TERMS

denary (decimal): numbering system using base 10 with possible digits 0, 1, 2, ..., 8 and 9

binary: numbering system using base 2

Binary system

The base 2 numbering (**binary)** system has possible digits 0 and 1.

This can be summarised as shown in Table 1.01.

System	Base	Possible digits	Place values
denary	10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	etc. | 10^3 | 10^2 | 10^1 | Units | 8 | 7 | 2 | 6
binary	2	0, 1	etc. | 2^3 | 2^2 | 2^1 | Unit | 1 | 0 | 1 | 1

Table 1.01 Denary and binary numbering systems

Intuitively we would read the denary number as "eight thousand, seven hundred and twenty six".

Appreciate that it is based on the place-value concept that we have:

$$(8 \times 1000) + (7 \times 100) + (2 \times 10) + 6 = 8726$$

Applying the same method to the binary pattern 10111, computes the pattern as binary number:

$$(1 \times 16) + (0 \times 8) + (1 \times 4) + (1 \times 2) + 1 = 23$$

Hexadecimal system

The base 16 numbering system can be summarised as shown in Table 1.02.

System	Base	Possible digits	Place values
hexadecimal	16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ~~10~~, ~~11~~, ~~12~~, ~~13~~, ~~14~~, ~~15~~ A, B, C, D, E, F	etc. | 16^3 | 16^2 | 16^1 | Units | | 1 | B | 5

Table 1.02 Hexadecimal numbering system

The Hexadecimal numbering system follows our three basic rules.

Since the 'digits' allowed in base 16 extend past 9 then we need a way to represent 10, 11, 12, 13, 14 and 15. The solution in hexadecimal is to use the characters A to F as shown.

TIP

If we did not do this, then the hexadecimal representation 13, could either be interpreted as 13 denary or (1 x 16) + 3 = 19 denary.

The number shown in Table 1.02 is:

(1 x 256) + (B x 16) + 5 = 256 + 176 + 5 = 437 denary

Conversion between different number presentations

We can now convert from binary to denary and vice versa and also from hexadecimal to denary and vice versa. What about conversion between binary and hexadecimal?

One approach would be to convert into denary first – but there is a more direct way.

Example:

Convert 0011110101010100 into hexadecimal

Divide the binary into groups of four binary digits:

0011 1101 0101 0100

Write the denary for each group

0011 1101 0101 0100

3 13 5 4

We can then convert each denary number to its hexadecimal equivalent:

3 D 5 4 = 3D54 hex

The method can be used in reverse to convert from hexadecimal to binary.

Example: Convert 4AE hex to a binary number stored as two bytes.

Hexadecimal:	4	A	E
Denary:	4	10	14
Binary:	0100	1010	1110

'Stored as two bytes' means this number will be stored as 16-bit binary pattern as shown in Figure 1.01.

0	0	0	0	0	1	0	0	1	0	1	0	1	1	1	0

Figure 1.01 A binary number stored as two bytes

Note the need to pack out the leftmost group of four bits with zero bits.

Numbers in the computer

All data in the computer must be represented in binary form.

Consider a single byte used to represent a positive integer.

- the most significant bit position has place value of 128
- the least significant position has place value of a 'unit', that is 0 or 1.

Progress check 1.01

1 What positive integer is this?

0	1	1	0	0	1	1	1

2 A positive integer is represented using a single byte. What is the denary value?

a 0100 0001 **b** 1010 1010 **c** 1111 1111

3 What is the eight-bit binary representation for these integers?

a 3 **b** 89 **c** 257

4 Convert these hexadecimal numbers to denary:

a 1A **b** 10B

5 Convert these hexadecimal numbers to 12-bit binary representations:

a 7D **b** 196 **c** AEC

Two's complement representation

We need to be able to represent both positive and negative integers.

One (simple) method would be to use the most significant bit to act as a 'sign' bit (1 for a negative integer and 0 for a positive integer) . This method is called 'sign and magnitude' but is not in our 9608 syllabus.

We shall use a representation – two's complement – which has a negative place value for the most significant

bit. For a two's complement presentation using a single byte the place values are as shown in Figure 1.02.

-128	64	32	16	8	4	2	u

Figure 1.02 Two's complement place values

Example:

Convert the following denary numbers to an eight-bit two's complement binary number.

1 56 = 32 + 16 + 8

-128	64	32	16	8	4	2	u
0	0	1	1	1	0	0	0

2 -125 = -128 + 3 = -128 + (2 + 1)

-128	64	32	16	8	4	2	u
1	0	0	0	0	0	1	1

3 -17 = -128 + 111 = -128 + (64 + 32 + 8 + 4 + 2 + 1)

-128	64	32	16	8	4	2	u
1	1	1	0	1	1	1	1

TIP

Note the method for a negative number. If its negative, we must have the '1 lot of -128' – we then need to work out what positive number to add to it.

Representing characters

All data – including characters – must be represented in main memory, saved in the backing store and processed by a program as a number value. A coding system such as ASCII or Unicode will be used.

LOOK FORWARD »

ASCII and Unicode are discussed in Chapter 10, section 10.01.

Binary-Coded Decimal (BCD)

Binary-coded decimal is a binary representation which can be used for a positive denary integer.

Each digit of the denary number is represented in sequence with a group of four binary digits.

Example: Represent the denary integer 859 in BCD.

8	5	9
1000	0101	1001

So, `859` denary is `100001011001` as a BCD representation.

Early computers stored date and time values in the BIOS of the operating system using BCD representation. Some later games consoles including Atari and Sony PlayStation did likewise. However in 2010, the PlayStation software interpreted the final two digits of the date '10' (stored in BCD) as the hexadecimal number 16. The resulting date of 2016 made the console inoperable!

1.02 Images

Bitmapped image

A bitmap graphic is a rectangular grid built up from a number of **pixels**. A pixel is the smallest addressable picture element which can be represented. The term bitmap comes from the concept that the bit patterns which make up the file are 'mapped' to an area in the main memory. Each pixel will be a particular colour. Each pixel's colour will be represented as a binary pattern. The contents of the bitmap file will be this sequence of binary colour codes.

TERMS

pixel: the smallest addressable picture element which can be represented.

There are several types of encoding and file formats for bitmap images:

- Monochrome: black and white pixels only
- 16 colour: 16 available colours for the pixels
- 256 colour: 256 possible colours
- 24-bit colour (or true colour) where millions of different colours are possible.

The encoding for each type can be worked out as shown in Table 1.03.

Bitmap encoding	Pixel representation	Explanation
Monochrome	1 bit	Only two colours needed (Black and white). One byte can store eight pixels.
16 colour	4 bits	Each byte can store two pixels.
256 colour	8 bits (1 byte)	Each byte stores one pixel.
24-bit colour	24 bits (3 bytes)	The number of different colours possible is 2^{24} (16, 777, 216).

Table 1.03 Encodings for bitmap images

TIP

These calculations are an application of the study of number systems in Chapter 1, section 1.01.

In addition to the pixel data, the bitmap file will have other data stored in a file header. The header data will give the size of the bitmap (width and height measured in pixels) and the type of bitmap (encoding)

Bitmaps have the drawback that they have a large file size. If an attempt is made to over-enlarge the bitmap with -editing software the individual pixels may become visible. This is called the staircase effect. Figure 1.03 shows an image of a mouse on the left and the same image after it has been enlarged – the individual pixels can clearly be seen.

Figure 1.03 A bitmap and its enlarged version

The clarity with which a bitmap image is viewed on a monitor screen will depend on two factors:

- resolution of the image: the number of pixels per centimetre. A small image size made up from a large number of pixels will produce a sharper display.
- screen resolution: the number of pixels which can be viewed horizontally and vertically on the screen. A typical PC screen resolution is 1680 pixels × 1080 pixels. This is a key factor to consider when purchasing a monitor – what is the highest possible screen resolution?

Vector graphics

A vector graphic is made up from a number of drawing objects. A vector graphic program such as Microsoft Visio or Corel Draw comes with a vast number of different objects organised into groups or 'shape libraries'.

Objects are organised into groups of shapes – the creator has selected a straight line from the 'Connectors' group and an LCD monitor from the 'Computer' group.

Objects have properties. These properties determine the size and appearance of each object. If an object is re-sized its properties are simply recalculated.

An example could be a network topology diagram where a library of networking shapes exists containing objects for a computer, file server, printer, etc. The user could quickly construct a network topology diagram.

The advantage of vector graphics is that changing the size of any object will not affect the quantity of the drawing's appearance. That is, the objects are scalable.

Applications of bitmapped and vector graphics

Bitmapped graphics are used to:

- capture scanned images from a paper document.
- scan a photograph.

Vector graphics are used for:

- general line-drawing diagrams
- diagrams for specialist applications, such as flowcharting, object-oriented class diagrams, network topologies and any application where there is a specialist shapes library available.

A diagram using vector graphics software could be intended for inclusion in a word processor document. When completed it must be saved in one of the universally recognised file formats.

1.03 Sound

Sound is a key requirement for most software. Sound will be used for:

- sounding context-sensitive warning messages to the user
- the playback of music files, video and bit-streamed media content
- specialist applications, such as the reading of a text document to a visual impaired user.

A sound signal is an analogue signal. To be saved as data on the computer, the sound signal must be converted from an analogue to a digital signal. This will be done by some form of analogue-to-digital converter (ADC).

The sound will be sampled at a set time interval and these sample values form the binary values which form the sound file. The issues which affect the sound quality and the file size are:

- How many bits are used to encode each sampled value (the **sampling resolution**)
- How often the samples are taken, that is, how many values per second (the **sampling rate**)

The graph in Figure 1.04 illustrates the sampling rate. Samples are being taken every one millisecond; that is, 1000 samples will be taken every second.

This example used only eight bits to store each sample. Figure 1.05 shows the sampled data values stored in main memory from address 300 onwards.

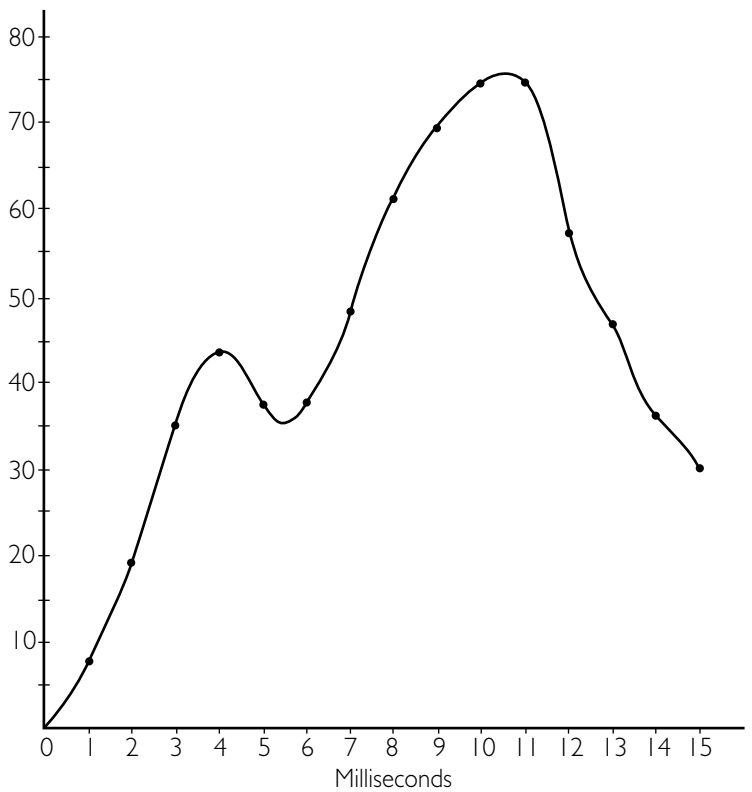


Figure 1.04 A graph of sound samples

300	301	302	303	304	305	306	307	308	309
8	20	35	44	38	38	48	61	69	75

310	311	312	313	314
75	57	45	36	29

Figure 1.05 Samples stored in memory

It should be apparent from Figure 1.05 that:

- If samples are taken more frequently, the quality of the sound wave will increase.
- If a larger number of bits is used to encode each sample, the sound resolution will increase.

Sound editing software is used for the recording of:

- Spoken word using a microphone
- The 'digitising' of an analogue sound source. An example could be the connection of a record turntable to the computer. The sound from a vinyl record is then recorded using the sound recording software

Editing features of the software would include:

- Cutting and pasting of sections of the recording
- Filtering out certain sounds. For example the 'clicks' on a scratched vinyl record
- Recording as a single (mono) channel or two channels (stereo)
- Normalising the recording level
- Export of the sound recording to a variety of file formats. For example MP3.

1.04 Video

Video is in widespread use on computers for recreational and educational use:

- YouTube is one of the most popular websites where users can post their own video content.
- Videos are an excellent medium for an explanation of the working of a piece of equipment or to provide a learning tutorial.

A video is a sequence of still photographic images which are displayed in sequence. The frequency with which they are displayed gives the appearance of continuous motion, and what is contained on individual frames is not apparent.

The frequency with which the frames are displayed is called the **frame rate**. A continuous effect to the human eye is achieved with a frame rate of 25 frames per second or higher.

TERMS

Frame rate: the frequency with which video frames are displayed

Progressive encoding

A system which stores the data for an entire frame and displays all the frame data at the same time is called 'progressive encoding'. This means the frame rate will be the number of pictures displayed per second. Traditional film uses progressive encoding.

Interlaced encoding

The problem is that some devices, such as a television, are not designed to display all the frame data at the same time. The data from a single frame is encoded as two separate fields; one containing the data for the even numbered rows and the second frame has the data for the odd numbered rows. The term interlaced comes from the concept that the image is rendered by switching between the even field and the odd field. It follows that the rate of picture display is twice the frame rate.

With increasing demand for the display of video content through DVD players, set-top boxes and other home electronic devices there is still a need for interlaced encoded video format files.

The picture frames that make up interlaced fields have a correct order relative to each other:

- The spatial order shows which should be the odd or even field.
- The temporal order refers to a field or frame and which field represents an earlier moment in time.

If either one or both of these orders is incorrect the result of the playback will appear as jerky motion or blurred edges to content.

1.05 Compression techniques

Both sound and video files tend to have large file size. Techniques used which encode the data in a way which results in less bytes for the file are highly desirable.

Compression is the technique of reducing the size of a file without a significant loss in the later quality in the use of the file.

Image compression techniques

Run-length encoding (RLE)

Consider a bitmapped file of a photograph where over half of the pixels are the same pixel value, representing the blue sky. An alternative to saving (say) the 300 consecutive pixel values on a row could be to save a single copy of

the pixel value followed by the number of occurrences of the value (300). This way we have reduced the number of pixels used to store this portion of the graphic from 300 to a very small number.

This technique would be appropriate for a monochrome image consisting of a black line drawing on a white background. This will contain 'runs' when horizontal or vertical straight line are drawn.

Consider a 256-colour image that is 30 x 4 pixels as shown in Figure 1.06. The image has four different colours, coded as w, b, r and g.

w	w	w	w	w	w	w	w	w	b	b	w	w	b	b	b	b	g	g	g	g	w	w	w	w	w	w	w	w	w
w	w	w	w	g	g	g	g	g	b	b	b	b	b	r	r	r	r	r	r	r	r	w	w	w	w	w	w	w	w
w	w	w	w	w	w	w	w	w	w	w	w	w	w	r	r	r	r	r	r	r	r	w	w	w	w	w	w	w	w
w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w

Figure 1.06 Representation of a 30 × 4 image

The first row of pixels could be encoded: 9w2b2w4b4g9w.

Assuming each 'run number' is stored as a single byte, the first line will be stored using 14 bytes (compared to the original 30). This is a very effective compression.

Progress check 1.02

Calculate the encoded RLE for rows 2, 3, and 4 of Figure 1.06.

Lossless encoding

We now have two alternatives for encoding a bitmapped image:

- Save the colour code for every pixel.
- Use run-length encoding.

Both of these techniques mean that the original bitmap can be re-created when the data is read from the bitmap image file and displayed on the output device.

For bitmap files several of the universal file formats are lossless. These include .bmp and the Portable Network Graphics (.png) format, which was intended as a replacement for the older .gif format.

Lossy encoding

Using a 'lossy' technique for encoding bitmap data has the objective of compressing the file size.

Lossy techniques are based on two concepts which exploit the limitations of the human eye:

- An image which has a large background could encode the background pixels with a lower resolution.
- Colours such as blue, to which the human eye is less sensitive, could be encoded at a lower resolution.

The popular .jpeg file format is lossy.

Video compression techniques

Since a video is made up of a number of frames, we are interested in applying various compression techniques to a video frame or a frame sequence.

Spatial redundancy

This is the similar to the concern over 'redundancy' in a bitmap file. Is there a sequence of the same pixels within a single frame which could be encoded or effectively compressed?

Temporal redundancy

Is there a sequence of similar pixels in the same position in consecutive frames? In which case, we do not need to repeat them in each frame. It will depend entirely on the content. A room full of people disco-dancing will not compress as well as a panoramic view of a beauty spot.

Interframe coding addresses the issue of temporal redundancy. The encoding method is based on the idea of **key frames**, which store data for all the picture, and intermediary frames which store only the differences from the next intermediary frame or key frame.

File formats

Over the years standards in the computing industry have emerged for image files (we have already mentioned .BMP., .PNG, .GIF and .JPEG) and sound data. Popular sound formats include .WAV, .MPEG and .MP3.

Video – which is a combination of moving pictures and sound – requires its own industry standards. The detail about encoding methods used for this is outside the scope of our syllabus. The key issue is that there is correct synchronisation between the picture display and the accompanying sound commentary.

The current popular multimedia container formats include:

- AVI (standard Microsoft Windows container)
- MOV (standard QuickTime container)
- MP4 (standard container for MPEG-4 multimedia)
- Matroska (not standard for any codec or system, but it is an open standard).

The differences between container formats arise from issues such as:

- popularity: is the container format widely supported? This is the reason that the AVI format is still the most popular format.
- overheads: This refers to the difference in file size between two files with the same content in a different container. For a two-hour film, an AVI file may be up to 10 MB larger than a file in Matroska format.
- support for advanced codec functionality: Older formats, such as AVI, do not support new codec features, such as streaming media.

Summary

- Numbers can be written using a binary, denary or hexadecimal base.
- Two's complement is a representation which allows both positive and negative integers to be represented.
- Binary-coded decimal (BCD) is a coding system used for positive integers.
- Images can be encoded as a bitmap, made up of a rectangular grid of pixels. The file header will contain data about the image: its height, width and the type of bitmap. Bitmap resolutions are monochrome, 16 colour, 256 colour and true colour. From the resolution and the dimensions, the file size can be calculated.
- Vector graphics are constructed using drawing objects selected from shape libraries provided by the software. Each object has a set of properties which are stored as part of the vector file.
- Sound is encoded as samples taken from the analogue source with a set sampling rate. The number of bits used to encode each sample (the sampling resolution) determines the sound quality.
- Video is made up of a sequence of image frames with an accompanying sound track. The encoding can be interlaced or progressive. Various multimedia formats are used commercially. These formats may uses compression techniques to address spatial and temporal redundancy.
- Compression techniques use either 'lossy' or 'lossless'. One lossless technique is run-length encoding (RLE).

Exam-style questions

1 Binary representation is used for many different data values.

Consider the binary pattern 1010 0110

What is its value if it represents:

a an 8-bit two's complement integer? [1]

b an 8-bit sign and magnitude integer? [1]

c a hexadecimal number? [1]

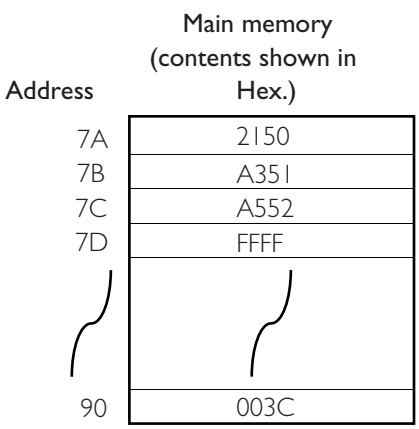
Cambridge International AS and A Level Computing 9691 Paper 33, Q2 a Nov 2012

2 a i Convert the hexadecimal number 7A to denary. [1]

ii Convert the binary number 0101 1100 to hexadecimal. [1]

iii Why do computer scientists often write binary numbers in hexadecimal? [1]

b The diagram shows a program loaded into main memory starting at memory address 7A Hex.



How many bits are used for each main memory location? [1]

Cambridge International AS and A Level 9691 Paper 31, Q3 b & c (i) Nov 2013

Chapter 2

Communications and Internet technologies

Revision objectives

By the end of the chapter you should be able to:

- ☐ explain the client–server model of networked computers and give examples of applications
- ☐ describe what is meant by the World Wide Web (WWW) and the Internet
- ☐ explain how hardware is used to support the Internet: networks, routers, gateways, servers
- ☐ explain how communication systems are used to support the Internet: the Public Service Telephone Network (PSTN), dedicated lines, cell phone network
- ☐ explain the benefits and drawbacks of using copper cable, fibre-optic cabling, radio waves, microwaves, satellites
- ☐ show understanding of bit streaming (both real-time and on-demand) and the importance of bit rates and broadband speed
- ☐ explain the format of an IP address and how an IP address is associated with a device on a network
- ☐ explain the difference between a public IP address and a private IP address and the implication for security
- ☐ explain how a uniform resource locator (URL) is used to locate a resource on the World Wide Web and the role of the Domain Name Service
- ☐ describe the sequence of events executed by a client computer and a web server when a web page requested and displayed by a browser
- ☐ recognise and identify the purpose of some simple JavaScript code
- ☐ show understanding of the typical use of client-side code in the design of an application
- ☐ recognise and identify the purpose of some simple PHP code
- ☐ show understanding that a web application for accessing database data makes use of server-side scripting

2.01 Networks

Most networks used for business applications are server based.

In a server-based network, a dedicated server provides for the administration of users, security and resources. There may be a single server which carries out all tasks.

The server is a computer which provides the administrative tools and resources which are shared by all computers on the network.

Client–server model

A client computer application will access various resources and services provide by a server.

There are many types of server, all named after the service they perform. For the most common network applications required by users, this will include:

- File server: All software and user data files could be stored on the server. Alternatively the application software can be installed on the client, then requests to the server are for data files only.
- Domain controller server: This server is used for the management of user accounts – IDs and passwords. The client computer software will send a log-on request to the server, which processes it and grants the request if the user ID and password are recognised.
- Email server: This server is used for sending, receiving and storing emails. A 'sent email' is sent to the server for processing and forwarding to the Internet Service Provider. When the client computer requests 'receiving email', the email server sends the request to the server of the email provider.
- Print server: This server manages print jobs from network client computers.
- Database server: This server manages a database management system such as mySQL or SQL Server.

- Web server: This server manages pages available from a website.

LOOK FORWARD »

Database management systems are discussed in Chapter 8.

The tasks done by a server are varied, but they all have in common:

- The client computer makes a request to the appropriate server.
- The processing of the request is carried out on the server.
- The server packages the results in a form which is displayed by the client computer's software.

The Internet and the World Wide Web

The Internet

The Internet is a global communication infrastructure which links together computers and networks.

It forms a collection of connected internets and is a packet-switched network. All network traffic is made up of packets of data with a source address and destination address. There will be a large number of available paths for the transmission of any data packet.

The communications methods used are various, including wired, radio and satellite communications.

The Internet is an open network. Access to it is provided by a company called an Internet Service Provider (ISP). The Internet protocol used is TCP/IP where all devices which connect to the Internet are identified by an IP address.

LOOK FORWARD »

IP addresses are discussed in Chapter 2, section 2.02.

The Internet is also a transit network that moves data. The Internet allows anyone to access, retrieve, process and store all manner of information (e.g. voice, video, documents, images) in a digital format.

The World Wide Web (WWW)

The World Wide Web consists of content organised as web pages made available across the Internet from web servers. The WWW was the invention of computer scientist Tim Berners-Lee in 1989 and uses three key concepts: **HyperText Markup Language (HTML)**, **Uniform Resource Identifier (URI)**, **Hypertext Transfer Protocol (HTTP)**.

TERMS

HyperText Markup Language (HTML): the publishing format for all web content; it provides for formatting documents and links to other documents or resources

Uniform Resource Identifier (URI): a unique address for a resource on the WWW

Hypertext Transfer Protocol (HTTP): a protocol to allow for the retrieval of linked resources from across the WWW

The WWW has changed the way we teach and learn, research information, buy and sell products and communicate globally with others.

TIP

The terms 'Internet' and 'World Wide Web' are loosely used and are often thought to be the same – they are not.

Hardware to support the Internet

Networks

A local area network (LAN) is made up of a set of computers which can communicate across the network. For example, a computer can communicate with a file server device, a print server or a user using email. Network users will want to use the Internet to access content available from the WWW.

Routers

A router is used on a packet-switched network. Data is organised into packets for sending between the various devices. The common protocol used is TCP/IP and the routing of packets is done by giving each packet a destination address.

LOOK FORWARD »

IP addresses are discussed in Chapter 2, section 2.02.

TCP/IP is discussed in Chapter 14.

Gateways

A gateway is the hardware device need to allow two networks which use different protocols to communicate. A network gateway can be implemented completely in software, completely in hardware, or as a combination of both.

Because a network gateway, by definition, appears at the edge of a network, related capabilities such as firewalls tend to be integrated with it. On home networks, a broadband router typically serves as the network gateway providing access to the Internet.

Servers

A list of the typical servers used by various computer systems were given earlier.

Progress check 2.01

Explain the difference between the World Wide Web and the Internet.

Communication systems to support the Internet

The Public Switched Telephone Network (PSTN)

The Public Switched Telephone Network (PSTN) was designed for two-way voice communication. The concept was to create a dedicated line or circuit between two end-points.

Over time, the telephone network has grown to support more users and end-points through a network of switches; thus the concept of circuit switching was born. This revolutionised voice communications and telephone network design, creating the PSTN architecture that is still in place today.

This established a system in which each usage of the network required a 'call setup' stage, in which a connection or circuit was established between the two end-points.

Dedicated lines

A business may prefer to use a communication line which is dedicated for use by its computers only. It will purchase a dedicated line from a telephone company under some leasing agreement. This contrasts with the shared resources of the PSTN and Internet.

Typical business uses include:

- linking corporate offices to the Internet.
- connecting the LANs of several corporate offices to form a wide area network (WAN) that allows offices to communicate and share IT resources.

Dedicated lines have major advantages which impact on the applications which are possible:

- consistent data transfer speeds.
- high and consistent bandwidth: the bandwidth available to most Internet users drops at peak times, when other customers of the same ISP are attempting to connect.
- high data throughput and fast upload speeds.

Dedicated lines offer major speed advantages compared to broadband. A UK broadband connection offers around only 12 Mb/s downstream and 1 Mb/s upstream. In contrast, a high-capacity dedicated line can provide a connection speeds of up to 10 000 Mb/s (10 Gb/s) for both uploads and downloads.

This enables a dedicated line to:

- carry phone calls
- allow lots of staff to connect simultaneously to their work computers from home
- carry video transmission without buffering and signal degradation.

Cell phone networks

The name come from the land mass being divided into areas called 'cells'. Each cell is served by at least one transceiver or base station. The cells are usually hexagonal in shape and the base station for each cell uses a different frequency range to that of any of its neighbouring cells.

The large capacity using a cellular network is made possible because the same frequency can be used:

- by multiple callers in any cell
- in non-adjacent cells.

The most common usage of a cell network is a mobile phone network which provides for communication from a portable mobile phone to the base station with radio waves. Since radio waves travel in straight lines a large land mass is divided into smaller cells, where necessary, to avoid a 'line-of-sight' signal interruption.

Radio waves have the longest wavelength and the lowest frequencies. The ability to focus a beam decreases with increasing wavelength. Radio waves broadcast in all directions and are least affected by obstacles.

Progress check 2.02

1 What do the initials PSTN stand for?

2 A business is based on a number of UK sites. List advantages to the company of using dedicated lines for all its digital communications.

Communication media

Copper cable

Copper cabling comes in different forms.

TERMS

Twisted-pair cable: a pair of copper cables, twisted together

Coaxial cable: a cable with a central single strand wire

Twisted-pair cable is a pair of copper cables, twisted together. This is designed to cancel out electromagnetic interference.

Twisted-pair cable is available in several specifications – the simplest is made up of two insulated copper wires surrounded by the external insulation. One of the Ethernet networking standards uses a cable with four twisted-pairs (called 'Cat-5') which supports a maximum cable segment length of 100 metres.

All forms of copper wiring suffer from a loss of signal strength proportional to the cable length. The shielding screen is used either as a return path for the signal or as a form of screening to eliminate forms of electro-magnetic interference.

Coaxial cable has a central single strand wire which is insulated from the outer multi-strand wire mesh braided around the central insulation. Coaxial cable is also available in a number of specifications.

The most widely used bus networking standard for the physical layer is called Ethernet. This has developed standards based on the transmission speeds called 10BASE-T (transmits at 10 Mb/s), 100BASE-TX (100 Mb/s) or 1000BASE-T (1000 Mb/s, i.e. 1 Gb/s).

LOOK FORWARD »

Protocols are discussed in Chapter 2, section 2.02.

Uses of coaxial cable include:

- connecting a radio or television receiver/sender and an aerial
- computer network connections
- cable television connections.

An advantage of coaxial cable is that the signals are unlikely to be affected by electro-magnetic interference from other metal objects in close proximity.

A bus network uses either twisted-pair or coaxial cabling.

Fibre-optic cable

Up to 24 glass strands are grouped into a single fibre-optic cable. Pulses of light are used to transmit a signal along a single strand as a modulated light beam. Because the medium for communication is light – rather than electrical signals – the data should be free of interference and also less susceptible to unauthorised access.

Fibre-optic cable has many advantages over copper wire:

- The signals will be free of any interference.
- Signals do not suffer from a loss of strength (attenuation).
- The cabling does not suffer from corrosion.

Typical applications include any form of long-distance communication including:

- telephone communication
- Internet communications
- networking.

Telecommunications and the electro-magnetic spectrum

All forms of telecommunications include some form of electro-magnetic wave, acting as the signal carrier, and a form of modulation for the signal when the carrier wave is made to change to represent different signals and hence different data.

If two humans communicate by talking, the carrier is a sound wave and the range of frequencies possible with a sound wave will limit the possible signals. The same is true for electro-magnetic communication. Each form will have a range of frequencies which are possible with corresponding benefits and drawbacks which make them suited to particular applications.

Radio waves

Radio waves have the largest range of wavelengths and include AM radio (around 400 m), television (40 m) and FM radio (around 4 m).

Radio waves are used for:

- domestic antennae receiving television signals sent from the TV broadcaster radio mast
- sending/receiving of mobile phone communications.

Microwaves

Microwaves have wavelengths measured in centimetres.

Unlike infrared and visible light, microwaves can penetrate haze, light rain and snow, clouds and smoke. For this reason, satellites which capture pictures of the earth use microwave communication.

Infrared waves

Infrared waves occupy the range of wavelengths between microwaves and visible light. The range of wavelengths varies from the size of a pin-head to the size of a cell; they are measured in a unit called a 'micron', which is one millionth of a metre.

The shorter infrared ranges are the wavelengths used for remote control signals between a controller and a device such as a television.

Satellite communication

Artificial satellites orbiting the earth provide telecommunications between the satellite and receiving/sending stations.

Applications are numerous and varied:

- satellite radio and television broadcasting
- photography of the earth
- satellite-based Internet
- satellite phones
- military communications.

Wireless

Communication can use any of the wavelengths: radio, microwave or infrared. The term 'wireless' has come to be used to describe any form of data communication which is 'without wires'.

Wi-Fi is the term for the industry standard IEEE.802.11. Wi-Fi hotspots are now popular, for example, as a way of attracting custom to a cafe.

The range of applications of wireless communication is now widespread and includes:

- communication for a local area network
- smartphones and other portable devices.

Progress check 2.03

State two advantages of using fibre-optic cabling rather than copper cable.

Bit streaming

A bitstream is a sequence of bits, representing a stream of data. The sequence of bits will be transmitted continuously over a single channel. The bits are transmitted serially, one after the other. The bits probably originated from software as a sequence of bytes and so the terms byte stream or octet are also used. The bytes could represent any form of digital data – a sequence of text characters, pixels from a picture or video clip, or a sound file.

TERMS

bitstream: a sequence of bits, representing a stream of data

Real-time bit streaming

The Sky satellite channel in the UK now has the facility to allow a subscriber to watch live television on a device such as a personal computer, tablet or smartphone.

The device needs the appropriate software or app. The communication channel will be a wireless connection for a PC, smartphone or tablet or a 3G or 4G connection for a smartphone or tablet.

The BBC in the UK provides a similar facility – called BBC iPlayer – for the viewing of (some) live television programmes and a service for listening live to its radio broadcasts.

On-demand bit streaming

Both Sky and the BBC offer the facility to 'catch up' on broadcasts that the user has missed. The user can select programmes which have already been broadcast.

The bitstream is saved to the device's secondary storage and can be watched by the user when convenient. Other providers, such as Netflix, offer a large selection of films which can be provided 'on demand'.

Issues with bit streaming

On-line forums are awash with queries about bit streaming. The most common problems are about the connectivity of various devices, the software to provide the service and the quality of the service.

The content may be subject to a pause in the delivery of the picture or sound before it resumes. The reasons for this is that the bitstream will be directed into a storage area on the device called a buffer. The data stream is processed by the viewing software and appears as a sequence of picture frames.

The factors which determine if this results in a satisfactory experience for the user are:

- Can the communication channel deliver the bitstream at a sufficiently high rate? Broadband providers suggest this requires a download speed of 3 Mb/s or higher.
- Can the software process and display the content of the buffer at a high enough speed? The two key factors here are the speed at which data is retrieved from the hard disk and the specification of the processor inside the device.

2.02 IP addressing

Using the Internet Protocol (IP), networks are joined into a network of networks through interconnected gateways or routers that use the standard protocol suite – Transmission Control Protocol/Internet Protocol (TCP/IP) for interworking.

Most Internet traffic is still using Internet Protocol version 4 for addresses. This uses 32 bits for an IP address – expressed as four numbers in the range 0–255, separated by full stops.

The original addressing for networks used the first byte for the Network ID and the other bytes for the host identifier. This quickly proved inadequate and lead to a system of defined **classes**, where a variable number of bits is used for the network identifier. The system defined five classes (A, B, C, D and E). Classes A, B and C use different bit lengths for network identification.

The Class formats impose some restrictions on the available addresses; for example, a Class C address is not allowed to use host numbers 0 or 255.

LOOK FORWARD »

The network class identifiers are discussed in Chapter 14.

The TCP/IP protocol suite is also studied in Chapter 14.

Internet traffic has no dedicated path; there is no single interconnection point or fixed network hierarchy as used by the PSTN. Individual data packets may take different routes over separate networks as they travel to their final destination to be reassembled and delivered to the requesting computer and application program. This is unlike circuit switching which relies on physical, point-to-point connections. On the Internet, data is placed in packets with an IP address for the packet's destination and an IP source address.

An IP address is a four-byte number usually written in denary, for example, 192.168.4.7. This is called the 'dotted decimal' notation. The address can also be written as 'dotted hexadecimal' or 'dotted binary'.

Internet Protocol Version 6

In 2011, the IP version 4 address space was finally exhausted – all 4 billion Version 4 IP addresses had been allocated. However, the ever-increasing number of Internet users had given concerns about 'address space exhaustion' earlier. This gave rise to a new standard, Internet Protocol Version 6 (IPv6), which was adopted for the first time in 2006.

IPv6 increases the address length to 128 bits, providing a vastly greater address space.

The immediate issue is that host devices which only recognise IPv4 addresses cannot directly communicate with IPv6-only hosts. Migration to IPv6 is in progress but completion is expected to take some considerable time.

LOOK BACK «

This is an application of the number systems studied in Chapter 1.

Progress check 2.04

1. How many bits are used to encode an IPv4 address?
2. Write the denary value for the following IP address: 11111111.10101000.00000100.00001101.
3. Explain why 259.168.7.8 cannot be a valid IP address.

Domain name service

A web browser requests a resource using the known URI. What is usually not known by the user is the matching IP address for this resource. Therefore, somewhere on the Internet, the IP address must be 'looked up' from the URL. This is the role of the Domain Name Service (DNS).

Once the IP address is known, it is the function of hardware called **routers** to route the data packets to the receiving device.

Because maintaining a central list of domain names and IP addresses mapping would be impractical, the lists of domain names and IP addresses are distributed throughout the Internet in a hierarchy of authority. The DNS database resides on a hierarchy of special database servers.

At the top level of the hierarchy, **root servers** store a complete database of Internet domain names and their corresponding IP addresses. The Internet employs 13 root servers that have become somewhat famous for their special role. Maintained by various independent agencies, the servers are aptly named A, B, C and so on up to M. Ten of these servers are sited in the United States, one in Japan, one in London and one in Stockholm.

Most lower-level DNS servers are owned by businesses or Internet Service Providers (ISPs). For example, Google maintains various DNS servers around the world for management of google.com, google.co.uk and other Google domains. Your ISP also maintains DNS servers as part of your Internet connection setup. There is probably a DNS server within close geographic proximity to your access provider that maps the domain names used in your Internet requests or forwards them to other servers in the Internet.

When a client web browser requests a resource with a URI, a piece of software called the DNS resolver (usually built into the network operating system) first contacts a DNS server to determine the server's IP address. If the DNS server does not contain the mapping, it will forward the request to a different DNS server at the next higher level in the hierarchy. Further forwarding of the request may be needed before the URI is resolved.

LOOK FORWARD »

If you are running the Windows operating system, key into a command prompt window 'ipconfig' to see all the settings on your computer for Internet access.

An IP address can be thought of as a private or public IP address. Any device on a Local Area Network will have a private (or non-routable) IP address allocated by the Network Administrator. This is sufficient if the only communication is between host devices on the LAN. If however a computer needs to access a resource using the Internet, the device needs to know the public address of the server holding the resource. Every resource on the Internet must have a globally known and unique IP address. As there is a shortage of IPv4 addresses, devices on the LAN are allocated a private IP address.

The three ranges used for private addresses are:

10.0.0.0/8
172.16.0.0/16 to 172.31.0.0/16
192.168.0.0/24 to 192.168.255.0/24

This will be a requirement for any of the devices on the LAN; they will communicate to the Internet through a proxy server and firewall which has a single public (or routable) IP address. All data packets whose destination in a device on the LAN will arrive using the LAN's public IP address. It is then the role of the proxy server to route the data to the appropriate device.

2.03 Client-side and server-side scripting

Before we start talking 'scripting' (that is 'programming'), let's get clear what the web server and the computer on which it is running must do.

The web server must be 'hosted' on a host computer. The web server uses the HTTP protocol to:

- receive request messages from client computers
- deal with each request
- send a response message back to the client.

The web server will continually listen for 'request messages' and then respond to the client computer with a 'response message'.

The host computer must have an operating system which supports the TCP/IP communications protocol. It deals with all the communications between the web server and the client.

–Requesting data from a database server

Users working with a database send requests to the server for information, as shown in Figure 2.01.

For example, a user will create and run a query which is held on the client computer. The query is turned into an SQL request which is sent to the server.

1 The client web browser application requests the page using the URI.

2 The DNS directs the request to the appropriate domain.

3 The server retrieves the page.

4 The server sends the page content, consisting of HTML tags and text content only, to the client.

5 The client web browser software 'renders' the page and displays it.

However, the content may need to change each time the page is requested; that is, the page has dynamic content. For example, a web page may display today's date or may be used for data entry.

The inclusion of dynamic content requires that the webpage contains a 'script', that is, program code, which determines some or all of the final content displayed on the page.

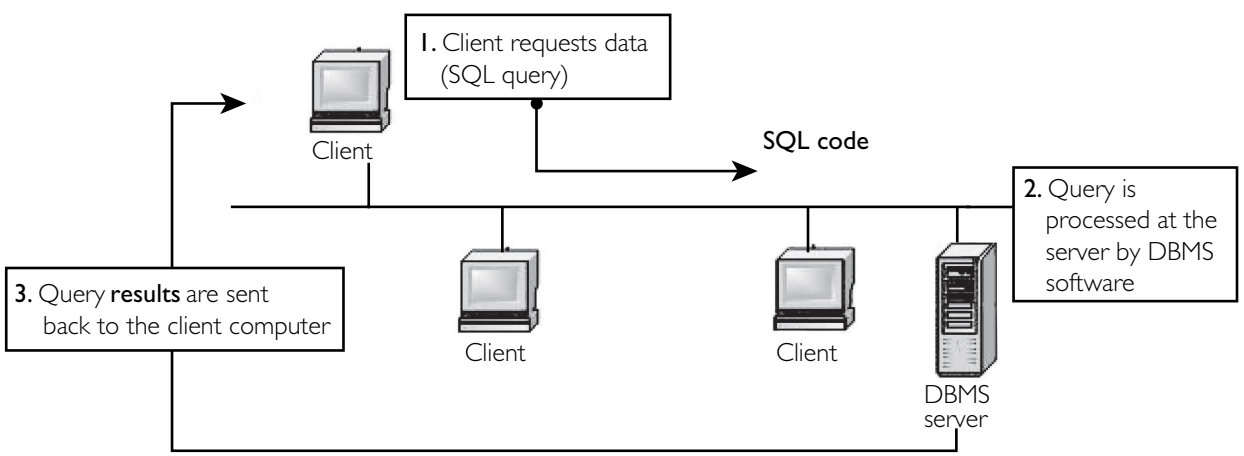


Figure 2.01 Request to a database server

The server processes the SQL request received and the results of the processing are then sent back to the client computer.

Note, all processing is done at the server.

–Requesting web pages from a web server

Web pages are constructed using the HTML markup language. This is not a programming language but – as it says – the HTML tags 'mark up' the text and graphics content to determine how it will appear to the user.

For many pages the content is only HTML tags, so the request sequence is:

Progress check 2.05

State the sequence of steps when a client web browser requests a page which contains no program code from a web server.

Client-side scripting

Using client-side scripting, the dynamic content is processed when the web page is received by the client web browser. The popular languages used for client-side programming are JavaScript (the Microsoft version is called JScript) and VBScript.

The use of client-side scripting assumes that the client web browser is configured to support this. The ability to interpret JavaScript code is a feature of all the popular web browsers – Internet Explorer, Chrome, Opera and Firefox.

JavaScript is a third-generation programming language. The code is embedded in a web page with all the HTML tags which determine the page's format and content.

All programming languages must be either compiled or interpreted. JavaScript program code statements are interpreted, either when the web page is loaded or later, in response to some event taking place (e.g. the user clicks on a button on the page).

Figure 2.02 shows an example of a web page containing JavaScript.

```
1
2  <html>
3  <head>
4  <title>LAB 1</title>
5
6  </head>
7
8  <body>
9  This is some text
10
11 <Script Language = "JavaScript">
12 alert("First script block");
13 document.bgcolor = "RED";
14 alert("Second alert pop up");
15 </Script>
16
17 </body>
18 </html>
```

Figure 2.02 Simple JavaScript code

Study Figure 2.02 and you should be able to deduce:

- The JavaScript program statements are lines 12, 13 and 14.
- The `alert` keyword causes a dialogue box to appear to the user.
- This code uses no variables.
- This code does not contain any structures such as 'if' statements or a loop.
- The `alert` keyword causes a dialogue box to appear to the user.

TIP

You are not expected to learn JavaScript or any client-side scripting language or a server-side language such as PHP in preparation for the examination.

You should, however, be able to study a JavaScript program and understand its construction. You will need to use the skills you have learnt from Section 2 to understand some JavaScript and PHP program code: using variables, sequence, selection and iteration.

The JavaScript code in Figure 2.03 illustrates the dynamic nature of a web page. It includes the four basic high-level language constructs.

The program in Figure 2.03 produces the sequence of interactions with the user shown in Figure 2.04.

Progress check 2.06

State the sequence of steps when a client web browser requests a page which contains JavaScript program code from a web server.

JavaScript code is used for:

- interacting with the user
- accepting data input from the user
- validating data input and other actions: for example, if an important field has been left blank, we need to address this before 'posting' the data to the server for processing or storage
- manipulating images, for example, changing the image displayed when the mouse does a 'roll over' on an image.

The code in Figure 2.03 is a simple example of validation of a number entered by the user.

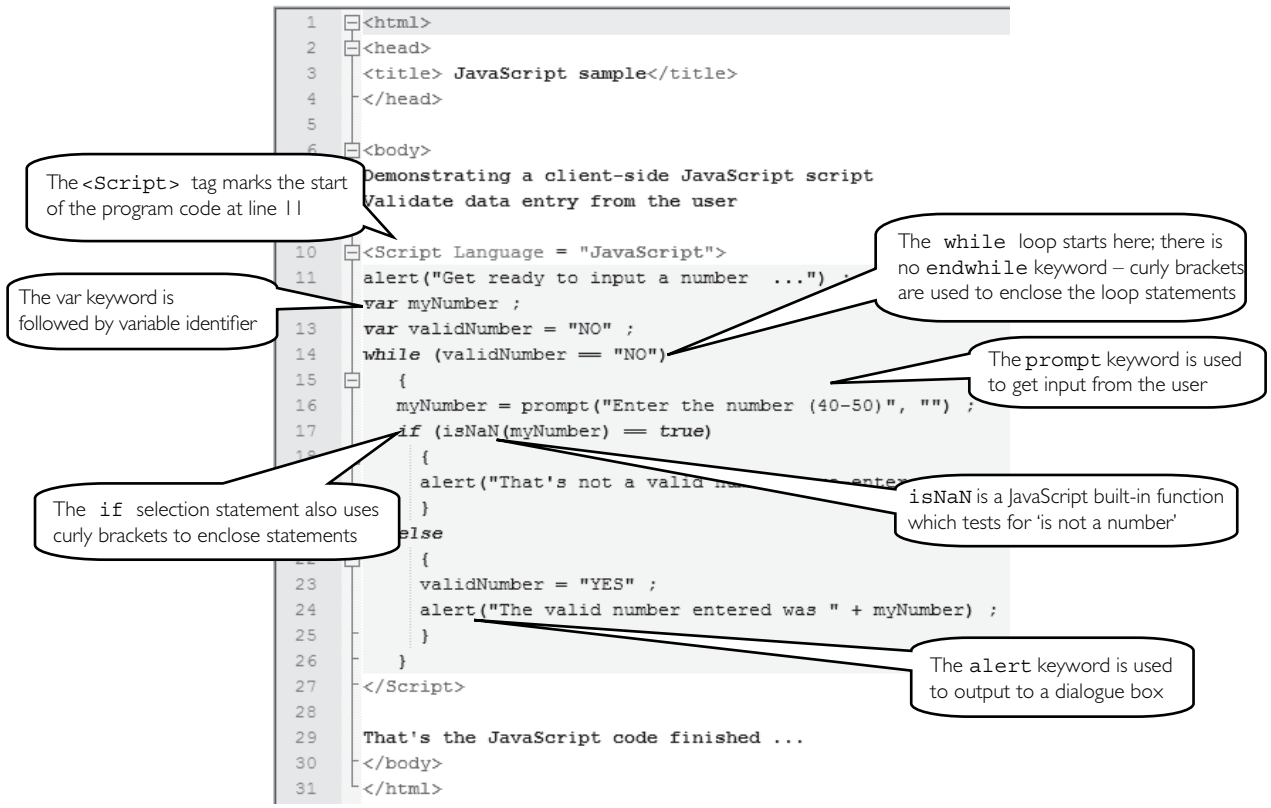


Figure 2.03 Client-side JavaScript code

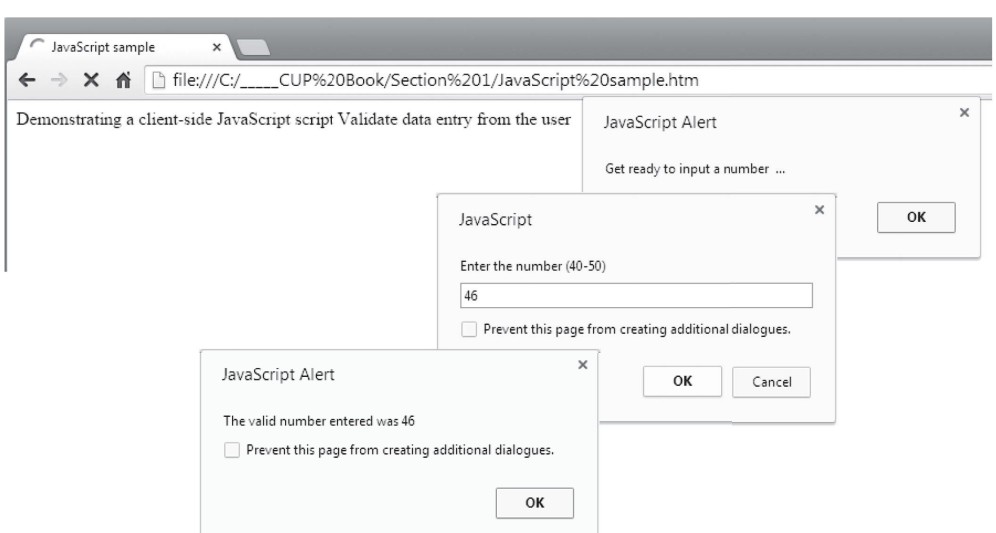


Figure 2.04 The dialogue from the code in Figure 2.03

Progress check 2.07

Study the script in Figure 2.05.

```
1  <html>
2  <head>
3  <title> JavaScript sample</title>
4  </head>
5
6  <body>
7
8  <Script Language = "JavaScript">
9
10 document.write("data entry for students exam results" + "<BR>") ;
11 document.write("Total on three papers must be > 120" + "<BR>")
12 document.write("Each paper must be > 40") ;
13 var totalMark = 0 ;
14
15 for (loopCounter = 0 ;  loopCounter < 3 ; loopCounter ++)
16    {
17    nextMark = prompt("next paper mark  ..." ) ;
18    totalMark = totalMark + parseInt(nextMark) ;
19    }
20    if (totalMark < 120)
21       {
22       alert("A resit will be required ...") ;
23       }
24    else
25       {
26       alert("You have passed") ;
27       }
28 </Script>
29
30 </body>
31 </html>
```

Figure 2.05 Sample JavaScript code

1 What line number is the start of a count-controlled loop?

2 Explain how the syntax of the count-controlled loop works.

3 What line effectively marks the end of the loop?

4 What will be the output if the user keys in the sequence of numbers 39, 42, 38?

5 Which statement contains both the declaration and assignment of a value to a variable?

6 List the variables used in the script.

Server-side scripting

Contrast the following sequence of actions with the sequence given earlier for client-side scripting.

If the web page contains a script which is to be executed on the server:

1 The web browser requests the page.

2 The web server is aware it contains code.

3 The web server processes the code (on the server).

4 The web server renders the page content (as HTML tags and text only).

5 The web server delivers the page to the browser (as HTML tags and text only).

6 The client browser displays the page.

Figure 2.06 shows some PHP server-side code and its output in a browser. It is not really useful as the data values are hard coded within the PHP code.

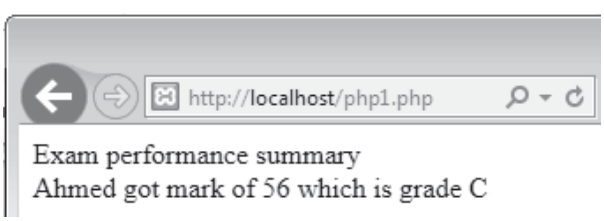
```
1  <html>
2  <head>
3  <Title> First PHP sample </title>
4  </head>
5  <body>
6  <?php
7  settype($studentName, 'string') ;
8  settype($mark, 'integer') ;
9  settype($grade, 'string') ;
10
11 $studentName = 'Ahmed' ;
12 $mark = 56 ;
13 $grade = 'C' ;
14 echo 'Exam performance summary' .'<BR>';
15 echo $studentName.' got mark of '.$mark.' which is grade '. $grade ;
16 ?>
17
18 </body>
19 </html>
```

The start of the PHP code

Variable identifiers start with $

The Echo keyword outputs to the screen

(a)



(b)

Figure 2.06 (a) PHP server-side code and (b) its output in a browser

TIP

When we access a web page with JavaScript, the web page is simply loaded or requested from the file system of the computer (Figure 2.04 shows the file path on drive C).

To display a web page which uses server-side scripting, the user's computer must retrieve the page from a web server. The usual development environment to do this is to set up a 'local server' on the computer. The author has installed the WAMPP application, which then has the Apache web server running, with a path to its root folder of 'localhost'. Note the path displayed in the address bar of the browser in Figure 2.06(b).

Progress check 2.08

1 State the essential difference between the use of JavaScript and PHP.

2 State the sequence of steps when a client web browser requests a page which contains PHP program code from a web server.

A database JOBS is created to store data for all current jobs at a company. The database has a table JobList with the structure shown in Figure 2.07.

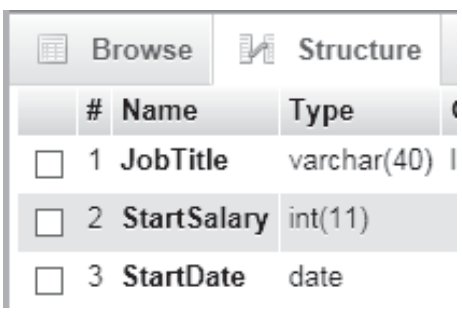


Figure 2.07 Table attributes for JobList

The user will enter data for one job into a web data collection form (HTML only with form controls) as shown in Figure 2.08. When the Submit button is clicked, the data is sent for processing (Figure 2.09) by another form.

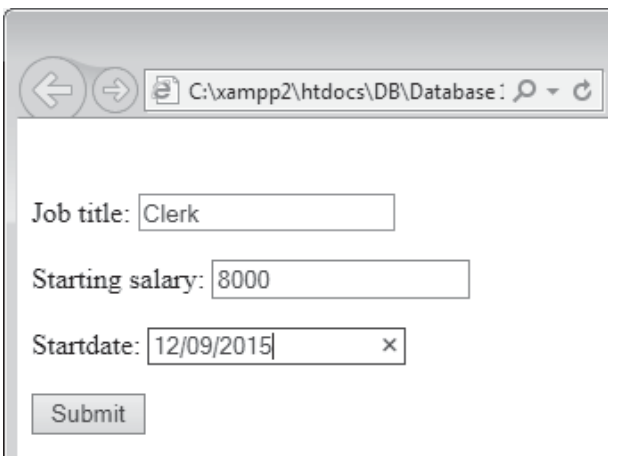


Figure 2.08 Web data collection form

The processing form (`Database 2.php`) contains a PHP script (Figure 2.10) that processes the data for the new job:

1 Data is collected from the first form and the three data items are stored in variables.

2 A connection is made to the database.

3 The server process a SQL command to insert the record to the database.

```
1  <html>
2  <head>
3    <title>Demo - Connecting to a database</title>
4  </head>
5
6  <body>
7    <p> </p>
8
9  <form name="form1" method="post" action="Database 2.php">
10   <p>Job title:
11     <input type="text" name="txtJobTitle">
12   </p>
13   <p>Starting salary:
14     <input type="text" name="txtSalary">
15   </p>
16   <p>Startdate:
17     <input type="text" name="txtStartDate">
18   </p>
19   <p>
20     <input type="submit" name="Submit" value="Submit">
21   </p>
22 </form>
23
24 </body>
25 </html>
```

Data values are posted to a second web page, `Database 2.php`

This form control is a text box – identifier `txtJobTitle`

This form control is a button – identifier `Submit`

Figure 2.09 'Posting' data from the form

```
1  <body>
2  <?php
3  $connection = mysql_connect("localhost", "root", "password")
4                                  or trigger_error(mysql_error, E_USER_ERROR) ;
5  if (!$connection)
6     echo "Sorry - Connection to the database could not be made" ;
7  else
8     {
9     $databaseSelected = myql_select_db("Jobs", $connection) ;
10    if (!$databaseSelected)
11       echo "Connection was made - but database could not be found" ;
12    else
13       {
14       $jobTitle = $_POST('txtJobTitle') ;
15       $startDate = $_POST('txtStartDate') ;
16       $startSalary = $_POST('txtSalary') ;
17
18       $myQuery - mysql_query("INSERT INTO JobList
19                      VALUES ('$jobTitle', '$startDate', '$startSalary')") ;
20       if (!myQuery)
21          {
22          echo ("new record was not added to the database") ;
23          die('Invalid query: ' . mysql_error() ) ;
24          }
25        else
26          echo "New job added to the database table" ;
27       }
28    }
29    ?>
30 </body>
```

Make a connection to the web and database server

Check for successful connection

Connect to the Jobs database

Assign data values from the data entry form to variables

Execute an SQL command to add the record to the JobsList table

Figure 2.10 Processing the PHP script

Summary

- Most network applications use the client–server model. Applications include database, email, file transfer and web servers.
- The Internet is the hardware infrastructure – consisting of routers, gateways and networks – which supports global communication. The World Wide Web is the content which is available from various web servers.
- Various communications systems support the Internet including: the Public Service Telephone Network (PSTN), dedicated lines and the cell phone network.
- Communication signals use copper and fibre-optic cabling, radio waves, microwaves and satellites.
- Bit-streaming is used to access content from servers to provide video and sound to users either on-demand or in real time.
- The packet-switching network on the Internet uses IP addressing. An IP address can be either private or public.
- Resources available on the WWW are identified using a Uniform Resource Locator (URL). The Domain Name Service has the task of mapping all URLs to an actual IP address.
- Web pages can contain program code in addition to HTML tags. This code is processed either by the client computer ('client-side scripting') or on the server ('server-side scripting'). JavaScript is used for client-side code; PHP is used for server-side code.

Exam-style questions

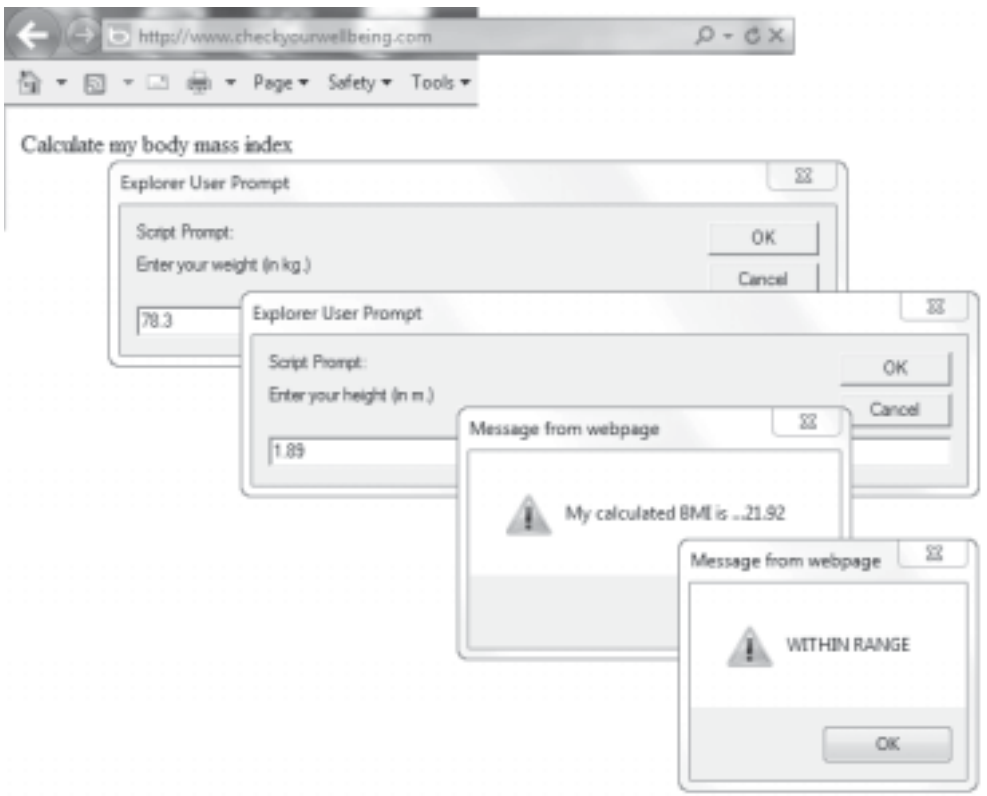
1 The website www.checkyourwellbeing.com offers help and advice about personal well-being.

The website has a link – 'Calculate my BMI' – that users can click to work out their Body Mass Index.

When the 'Calculate my BMI' link is clicked on the client computer, this webpage is requested:

```
<html>
<head>
<title>Body  Mass   Index</title>

</head>

<body>
Calculate my body  mass   index

<Script  Language  =  "JavaScript">

var myWeight  =  prompt("Enter  your   weight  (in kg.)", "");

var  myHeight =  prompt("Enter  your   height (in  m.)",  "");

var myBMI  =  myWeight  / (myHeight   *  myHeight);
myBMI  =  myBMI.toFixed(2)

alert("My  calculated BMI  is ..." +  myBMI)   ;

if (myBMI   <  18.5)
{
  alert("UNDERWEIGHT")  ;
}

if (myBMI   >  25)
{
  alert("OVERWEIGHT")  ;
}
if (myBMI   >=18.5  &&  myBMI<=25)
{
  alert("WITHIN  RANGE")
}

</Script>

</body>
</html>
```

Loading the webpage produced this sequence of dialogue boxes:



a Which lines in the webpage script are JavaScript code? [1]

b i Give the identifiers of **two** variables which have been used by the programmer.

1

2 [2]

ii What group of program statements are performing selection?

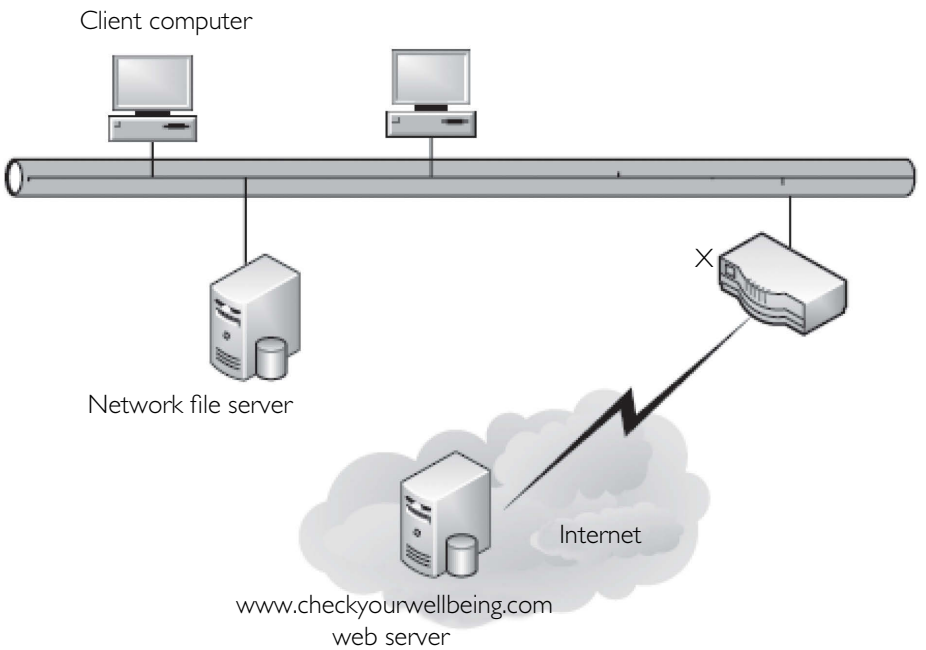
line number up to line number [1]

c By studying the web page script and its use, what is the use in JavaScript of:

i the `prompt` function? [2]

ii the `alert` function? [2]

d The diagram shows the client computer network with the connection to the Internet.



What is the hardware device labelled X? [1]

e Put **five** of these statements in the correct sequence to describe how the content of the page shown is displayed by the client computer's browser software.

Two of the statements will **not** be used.

A The client computer processes the JavaScript code.

B The page content is transmitted to the client computer.

C The page is displayed on the client computer.

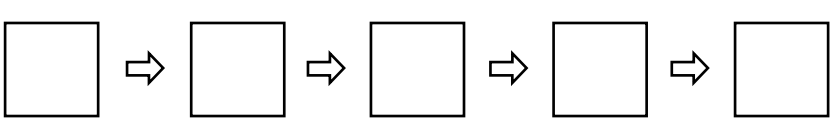
D The user clicks on the hyperlink and the web page is requested from the network file server.

E The web server processes the JavaScript code.

F The user clicks on the hyperlink and the web page is requested from the www.checkyourwellbeing.com web server.

G The server finds the web page.

The sequence is: (fill in the letters)



f How is this JavaScript code run? [1]

g The web developer tested the JavaScript code without involving the web server.

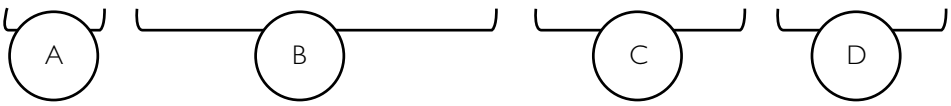
Explain how this is possible. [1]

Cambridge International AS and A Level Computer Science 9608 Specimen Paper 1, Q4 2015

2 a What does URL stand for? [1]

b Name the component parts of the URL shown:

http://www.w3schools.com/ tutorials/sql/index.htm [4]



Chapter 3

Hardware

Revision objectives

By the end of the chapter you should be able to:

- ☐ identify hardware devices used for input, output, secondary storage
- ☐ show understanding of the basic internal operation of a keyboard, a hard disk, a trackerball mouse, solid state (flash) memory, an optical mouse, optical discs, a scanner, sensors, an inkjet printer, actuators, a laser printer, speakers
- ☐ show understanding of the need for secondary (including removable) storage
- ☐ show understanding of the need for primary storage
- ☐ explain the differences between RAM and ROM memory
- ☐ explain the differences between static RAM (SRAM) and dynamic RAM (DRAM)
- ☐ understand and use these logic gates: NOT, AND, OR, NAND, NOR, XOR
- ☐ construct the truth table for each of the logic gates
- ☐ construct a logic circuit from either a problem statement or a logic expression
- ☐ construct a truth table from either a logic circuit or a logic expression
- ☐ show understanding that some circuits can be constructed with fewer gates to produce the same outputs

3.01 Input, output and storage devices

One of the fundamental diagrams (see Figure 3.01) to describe a computer system is to distinguish between the input devices, the output devices, the processing which various programs will carry out and the need for both primary and secondary storage.

On a typical PC computer, the following would be the various devices:

- Input: keyboard and mouse
- Output: the monitor
- Secondary storage: the hard disk or a solid-state drive
- Main memory: memory chips inside the box
- Processor: the microprocessor inside the box

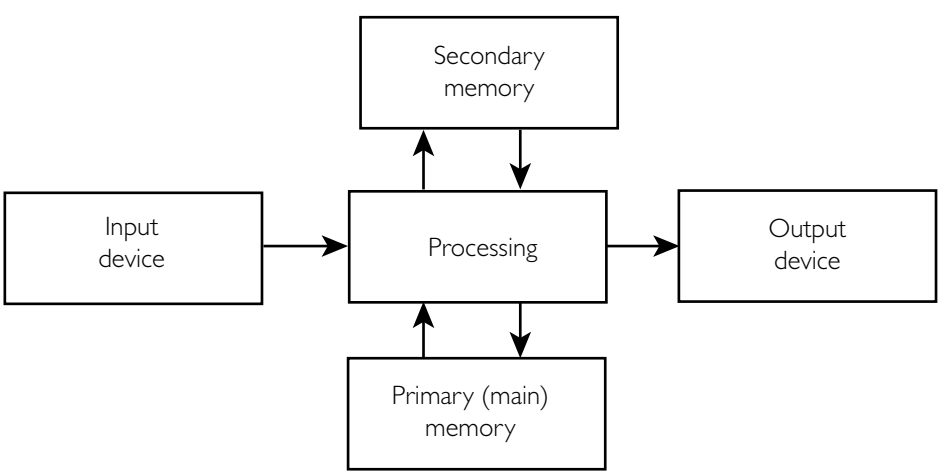


Figure 3.01 Typical computer system