**Higher Computing Science**

**Computer Systems March 2018**

**a) Data Representation**

**Representing Integers**

**Positive Integers, (Whole Numbers)**

Humans Use Base 10 Computers use base 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100 |
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | Units |

2 bytes = 16 bits integers represented => 0 to 216 -1

=> 0 to 65535

n bytes = n\*8 bits integers represented => 0 to 2n\*8 -1

**Negative Integers, (Negative Whole Numbers)**

**Two’s Compliment**

Negative number represented by:- • taking positive number

• change all 1’s to 0’s and all 0’s to 1’s

• add 1

e.g. represent -5

take +5 = 0 0 0 0 0 1 0 1

invert digits = 1 1 1 1 1 0 1 0

add 1 to right most digit 1

-5 = 1 1 1 1 1 0 1 1

**TOP TIP!!!!! - Do a double check.**

Take the negative number and go through the process again, does it give you the positive number?

**You will be expected to be able to convert decimal, (denary), into binary using two’s compliment and visa versa.**

**Range of Numbers**

The range of numbers is the amount of numbers the computer can handle given a fixed number of bits.

e.g. With positive integers if we had 4 bits the range would be

Lowest number = 0 (0000)

Highest number = 15 (1111) 2n – 1 = 24 - 1 = 16 - 1

Range = 0 – 15

**With negative integers the first bit signifies the sign. - 1 = negative**

**0 = positive**

e.g.

**Lowest number** = - 128 = 10000000

= **-2n–1**  = -28–1 = 27 **= -128**

-1 to -128 = 128 numbers

**Highest number** = + 127 = 01111111

= **2n  -1** = 28 -1 = 28 -1 **= 127**

0 to +127 = 128 numbers

**RANGE =** **-2n–1 -> 2n  -1**

**Cannot represent + 128 using only 8 digits as this would give same**

**binary code for + 128 and – 128!!!!**

**Try it!!!** Need more digits.

**Representing Real Numbers, (Decimal Numbers)**

Stored as scientific notation, (floating point).

Binary version of decimal number is split into 2 separate numbers

**Mantissa:-** all the binary digits, (without any binary point)

**Exponent:-** indicates the position of the binary point

**Assumptions:-** Base 2 is being used

Binary point moved to the left hand side of the first binary digit.

e.g. 1101.1001

Mantissa = 11011001 (all the digits)

Exponent = 0100 (binary digit has moved 4 places - 4 = 0100 in binary)

**This example has a mantissa with 8 bits & an exponent of 4 bits.**

Number of bits used to represent mantissa and exponent can change.

Increasing size of mantissa = **increased accuracy**

**Number of digits for exponent must be decreased**

Increasing size of exponent = **increased range of numbers**

**Number of digits for mantissa must be decreased**

**M = Mantissa**

**A = Accuracy**

**R = Range**

**E = Exponent**

**Representing Characters**

**ASCII:-** Every character, number, symbol has a unique **8 bit** binary code.

This gives 256 different codes, more than enough for the English language

**Advantages:-** • Only requires 1 byte per character, therefore, faster to

process;

• Almost all computers understand ASCII

**Disadvantages:-** • Only has basic alphabets / limited character set.

**Unicode:-** Every character, number, symbol has a unique **16 bit** binary code.

Allows for 65,536 characters to be represented.

Allows for representation of many foreign language characters.

**Advantages:-** • Large character set;

• Allows use of many languages;

**Disadvantages:-** • Larger storage requirements – 2 bytes, therefore slower

to process.

**Representing Graphics**

**Raster Graphics:-** display stores image as a matrix of pixels.

Rasterisation required to convert vector graphics into bit map for displaying or printing.

**Bit Mapped Graphics**

**Bit Map:-** One pixel in memory is mapped onto one pixel on the screen.

2 dimensional array of pixels

**Bit Mapped Graphics:-** Graphic is split into individual pixels;

Colour of each pixel stored individually as binary digits, (Bit depth);

Can have very high file sizes;

Editing can be done at the pixel level;

When images are enlarged they can become “jagged”.

**Advantages:-** • Can be manipulated at the pixel level;

• Simple to output as long as output device has

enough memory.

**Disadvantages:-** • Can take a lot of storage space, compression can

help;

• When enlarged too much they appear “blocky”.

**File Types Supported:-** BMP, GIF, JPEG, PDF, PICT, TIFF etc.

**Bit Depth:-** Number of bits used to represent the colour of a single pixel.

i.e. Bit depth = 1 bit = 2 colours

2 bits = 4 colours

3 bits = 8 colours

: :

n bits = 2n colours

**Resolution:-** The number of pixels used to store the graphic.

**Representing Vector Graphics**

V**ector Graphics:-** Also known as Object-Orientated Graphics;

Store attributes of graphics, NOT PIXELS;

Attributes include:- Object

Start position

End position

Line thickness

Line colour

Fill colour etc.

Resolution independent, therefore can be scaled with no loss of quality;

Editing done on objects, not at pixel level;

Less storage required;

Objects can be layered over each other, retaining each object attributes.

(Rasterisation required to convert vector graphic into bit map for displaying or printing.)

**Advantages:-** • Small file sizes;

• When enlarged they do not lose quality.

**Disadvantages:-** • Cannot be manipulated at the pixel level;

• Can be difficult to output.

**File Types Supported:-** ***PDF, EPS, PSD, AI***

**b) Computer Structure**

**Basic Components:-**

• Central Processing Unit:- Control Unit;

Arithmetic & Logic Unit;

Registers;

• Main Memory;

• External Memory;

• Peripheral Devices;

• Control Bus;

• Data Bus;

• Address Bus;

**ALU:-** Data is processed and manipulated;

Involves arithmetic operations & logic comparisons, (e.g. IFs).

**Control Unit:-** Manages execution of instructions;

Sends control signals around the computer.

Has several lines which operate independently of each other:-

• Read Line:- initiates a memory read operation

• Write line:- initiates a memory write operation

• Clock:- generates a pulse to synchronise components

• Interrupt:- signal to tell processor to stop current command;

processor saves stack and returns to command

after dealing with interrupt commands.

Can be ignored by processor in certain circumstances.

• NMI:- Non-Maskable Interrupt.

An interrupt which cannot be ignored by the

processor.

• Reset Clears all registers, aborts programs and gives

control back to the operating system.

**Registers:-** Temporary storage locations inside the CPU.

**Address bus:-** Points to address in main memory;

Uni-directional (one way);

Width of address bus effects the amount of memory which can be accessed.

**Data bus:-** Carries data to and from main memory and the processor;

Bi-directional, (two way);

Width of data bus defines how much data can be carried in one fetch.

Data bus can carry:- Data

Instructions

Addresses

**Word Length:-** The number of bits which can be manipulated as a single unit by the

processor. If a word size and data bus size are the same then data transfers carried out in a single operation.

**Main Memory:-** RAM & ROM

**External Memory:-** Backing Storage devices

**Peripherals Devices:-** Any device attached to the computer.

**Addressibility:-** All memory is broken down into memory locations;

Every memory location has it’s own unique address;

The size of the address bus determines the number of addressable locations;

i.e. address bus of 8 = 28 possible addresses

16 = 216 possible addresses

24 = 224 possible addresses

: :

n = 2n possible addresses

**Maximum addressable memory** = 2address \* Data bus width

**Volatile Memory:-** Loses data when power is turned off, e.g. RAM

**RAM Static Memory:-** aka **SRAM**

Holds contents as long as there is power.

Faster access than DRAM

Cache uses SRAM

**RAM Dynamic Memory:-** aka **DRAM**

Data has to be refreshed, (every 2 microseconds).

Microsecond = 1 millionth of a second

Slower than SRAM

Main Memory uses DRAM

**ROM:-** **Non-volatile**;

Data stored onto ROM at manufacture;

The following factors affect a computer system’s performance

• ***Number of processors (cores) • Width of Data Bus***

***• Cache Memory • Clock Speed***

**• Number of Processors**

**Number of Processors:-**

Some devices have more than one processor. Eg dual core, quad core etc This means that the processor can work much faster and can work on several things at once;

i.e. Dual core – 2 things at once, (multitasking), or twice as fast

(approx) as single core.

Quad core – 4 things at once, (multitasking), or four times as

fast (approx.) as single core.

**Parallel Processing:-** This is when more than one instruction to be carried out **at the same time**.

Multi-Core processors allow this to happen.

This in turn speeds up processing.

**• Width of Data Bus**

Processors can also fetch different amounts of data at a time.

This depends on the width of the data bus, as this carries the data to and from the processor and main memory.

i.e. 32-bit cores can fetch 32 bits at one time.

64-bit cores can fetch 64 bits at one time. This reduces the amount of times the processor has to fetch data, increasing the speed.

**• Cache Memory:-**

A temporary storage facility

**Faster than Main memory as it uses SRAM rather than DRAM.**

Next instruction is read into cache in preparation of execution.

**•Clock Speed**

Processor’s speed is measure according to their clock speed.

Nowadays the clock speed are usually in the range of 4Ghz to 8GHz

The faster the clock speed the more operations can be done per second.

**Cache Advantage:-** • Faster Access time than main memory as it uses SRAM rather than DRAM

• Entire sections of code can be present in cache and therefore, cache misses won’t occur.

**Cache Disadvantages:-** • More expensive than main memory

• Can have cache misses

• More expensive than main memory

**Fetch Execute Cycle**

This is how the computer executes a machine code program.

This is how the Address bus, Data bus, Control bus, and registers take part in reading an instruction from memory and executing it.

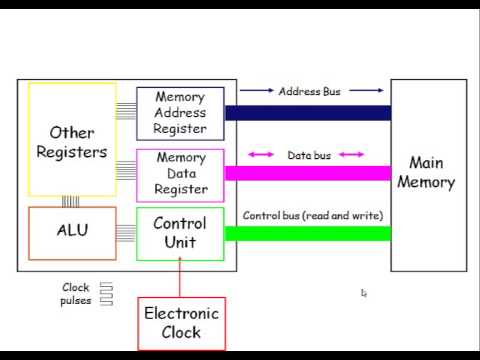
**Fetch/Execute Cycle**

• Address bus set up with the required address.

• Read line (on control bus) is activated

• Instruction is fetched from memory location using the data bus and stored in the instruction register.

• Instruction in the instruction register is decoded & executed



**c) Environmental Impact**

Intelligent Systems are having a major impact on our environment

**Intelligent System:** A computer system which has sensors to react from outside data.

Programmed using Artificial Intelligence to allow it to ‘learn’ from previous experiences.

**Intelligent Heating systems**

Smart heating systems use a variety of ways to control the amount of heat required in our homes. Using activity sensors, some smart systems learn the temperatures that you prefer in certain rooms and at what times. Monitoring the activity in rooms can mean that the smart system adjusts the heating up or down depending on whether there is unusual activity in the house. The thermostat is connected to wi-fi and can be manually controlled by using an app on your phone. This allows you to turn the heating system off if you are not going home or to turn it on so that it is at the optimum temperature if you are coming home early.

e.g Hive

**Intelligent Traffic control**

Vehicles are considered one of the main contributing sources of greenhouse gas. Studies in the European Union showed that transport causes 25% of all carbon dioxide emissions. Vehicles consume greater amounts of fuel when they are constantly accelerating and braking in traffic jams. The optimum speed for low fuel consumption and low emissions is between 45 and 65 miles per hour.

Intelligent transport systems use software and hardware, along with information and communications technologies, to improve the efficiency and safety of transport networks. They use a variety of information from cameras and sensors, along with control of traffic signals, to try to keep traffic moving, reducing the amount of harmful emissions. Cars with individual navigation systems use satellite information on traffic flow to guide drivers away from traffic congestion and on to more free-flowing routes.

**Intelligent Car management systems**

A number of different car management systems are used to reduce the impact on the environment.

Start-stop systems automatically shut down the engine when the car is not moving — this reduces the amount of time the engine spends idling, reducing fuel consumption and emissions. The car automatically re-starts when the accelerator is pressed, which is most advantageous for vehicles that spend significant amounts of time waiting at traffic lights or frequently come to a stop in traffic jams.

Engine control units use sensors to ensure the engine’s air/fuel ratio can be controlled very accurately, ensuring optimum fuel consumption and a reduction of carbon dioxide emissions.

**d) Security Risks & Precautions**

**• Security Risks**

**Computer Misuse Act:-** States “hacking” is against the law, (i.e. unauthorised access to data)

3 types of hacking:

• Unauthorised access to computer material

i.e. Hacking in and looking at data

• Unauthorised access to data with intent to commit an offence

e.g. Hacking into an alarm company’s system to find out a buildings alarm codes, (e.g. a diamond shop)

• Unauthorised modification of programs or data on a computer

e.g. Hacking into a bank’s computer system to change your bank balance.

**Tracking Cookies:-** A piece of software or data which can be used to identify a user or computer.

Can record a users “entries” in the browser and report these back to the writer of the cookie.

**Problem:-** This tracking data can be passed onto third parties.

**Denial of Service**

**(DoS) Attacks:-** A DoS attach is an illegal act, with the **intent of disabling a server**.

A server responds to external requests from its network. For example a web server responds to a browser calling for a web page to be delivered from its hard drive. Each

request takes a small amount of time and some CPU resources on the server.

With a 'Denial of Service' attack, the **server is overwhelmed by millions of rogue requests** being sent it, effectively **using up all its resources** and denying normal service for legitimate users.

**Symptoms of DOS:-** • slow performance,

• inability to access network data

**Effect of DOS:-** • disruption to users & business

**Costs of DOS:-** • lost revenue,

• labour costs required to fix fault

**Type of Fault:-** • bandwidth consumption,

• resource starvation,

• Domain Name Service (DNS).

**Reason for DOS:-** • Financial - To crimple a competitor and gain their business?

• Political - To stop a company/organisation from operating that you disagree with?

• Personal - To cripple a company you just been fired from?

**• Security Precautions**

**Encryption:-**

Encryption means to **scramble a message** in such a way that **only the people who are meant to read it can** do so.

**Encryption Keys**

The method used to encode the data e.g. A=1, B=2, C=3, …… Z=26.

Basic encryption uses the same key to code and decode data.

A more secure method is public & private keys where 2 keys are used(AKA asymmetric encryption).

**• Public Key:-** Data is converted using a public key which anyone can access. They are available from many websites.

**• Private Key:-** Used to decrypt messaged encoded with public keys.

E.g. a bank would use a public key to allow user to encrypt data being sent to the bank. This would be “built in” to the bank’s website using server-side scripting e.g. a SecureID Token. The bank would have a private key to decrypt the data.

**Digital Certificates and Signatures:-**

**Certificate:-**an electronic “passport” attached to a message that allows for the secure exchange of information over the internet. Uses a Public Key Infrastructure (PKI). Company/Organisation/person wishing to use this has to apply for a digital certificate from a Certificate Authority.

**Signature:-**

A digital code which uniquely identifies the sender, attached to an electronic message.