

Computing COMP2 Notes

Fundamentals of Computer Systems

- **Hardware** - Is any physical component of a computer system
- **Software** - Computer programs and related data that provide the instructions for telling computer hardware what to do and how to do it
- Software runs on hardware
- Software can be classified based upon its uses, the main categories are:
 - **System Software** performs the tasks needed to operate the hardware
 - **Application Software** allows users to perform non-computer tasks such as writing a letter.



- **Operating Systems** include Linux, Mac OS and FreeBSD
 - Acts as an interface between user and hardware, provides a virtual machine, a machine much more easy to use compared to if the user manipulated the hardware directly
 - Hides the complexity of the hardware
 - Provides platform for the software to run on
 - Application software are usually written for a specific platform
- **Library Programs**
 - A collection of compiled routines that other programs can use
 - The same print routine could be used by a word processor and a spreadsheet
- **Utility programs** include disk formatter, file compressor and firewall
 - Perform a very specific task related to the working with computers
 - Often bundled with the operating system

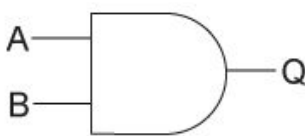
- **Programming language translators** include assembler, compiler and interpreter
 - The computer can only run machine code, when you write code in a higher level language this must be translated into machine code
 - **Assembler** translated an assembly language program into machine code, by converting each mnemonic into its binary equivalent
 - **Compiler** translates a high level language into object code
 - Looks at the entire code and optimises it before compiling
 - Object code can be run without the compiler and is faster than an interpreted program to run because compilation takes longer
 - **Interpreter** translates each line of the code at a time when running the program
 - Does not produce object code, just runs the code as it works through it line by line, each time it is run
 - Don't have to wait for the program to compile before running it
 - Good for debugging the program as works through line by line
- **General-purpose application software** include word processor, spreadsheet and database management
 - Can be used to do many different tasks
 - Usually bought off the shelf
- **Specialist-purpose application software** include web browser, payroll and tax calculator
 - Only supports one specific task
 - Usually bespoke
- **Bespoke application software** include air traffic control, BBC TV licensing service and London congestion charging scheme
 - Written and optimised for the customer's needs
 - Significantly more expensive than off-the-shelf software but can be the only way the customer can get software
- **First Generation Languages** machine code
 - This is machine code, it is made up of 1s and 0s
 - Can be written in hexadecimal
 - Each processor has its own machine code instruction set
- **Second Generation Languages** assembly language
 - Uses the same structure and instruction sets as machine code but it uses mnemonics
 - The mnemonics only have to be converted into their machine code instructions
 - Still used for fast execution programs or when a high level language could not perform the task
- **Third Generation Languages** include C/C++, COBOL and FORTRAN
 - One instruction in a third level language is converted into several machine code statements
 - Languages made to solve problems

- Use english like syntax
- **Fourth Generation Languages** include SQL and PROLOG
 - Known as declarative languages, define what is to be computed rather than how it is computed
 - Used in artificial intelligence

Fundamental Hardware Elements of Computers

- Boolean variables can either be 1 or 0
- Logic Gates:

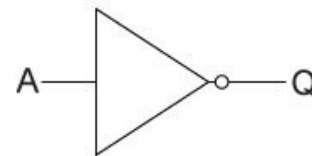
AND (.)



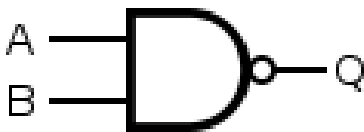
OR (+)



NOT (¯)



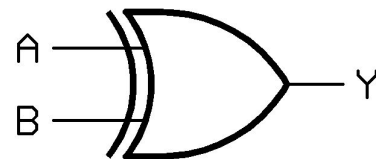
NAND



NOR



XOR (⊕)



- **De Morgan's Law**
 - $A.B = \overline{\overline{A} + \overline{B}}$ and $A + B = \overline{\overline{A}. \overline{B}}$

Hardware Devices

- **Error Checking**
 - Check digits are calculated appended to long strings of digits
 - They ensure that the code entered is valid
- **Flatbed Scanners**
 - Made up of a glass plate over a number of light sensors and a powerful light.
 - Document placed on glass plate and the light source and sensors move across the document.
 - Light is reflected by the paper and the variations of this reflection is measured by the light sensors and converted into an electrical signal.
 - Sensors can be either be a single black and white sensor or three colour sensors (RGB)
- **Retina Scanner**
 - Scanner shines low energy infrared light into the person's eyes
 - Photoelectric detectors then convert the reflected light into electrical signals, the reflected image shows the pattern of blood vessels in the person's eyes
 - This can then be queried in a database

- **Iris Scanner**
 - Uses an infrared camera to create an image of the the iris (which can be used to identify someone)
 - The scanner then using a number of algorithms will create a code of the iris (typically 512 bytes) which can be used to query a database
- **Optical Mark Reader**
 - Use photoelectric sensors to determine the presence of marks in specific areas on a form
 - A light source is passed over the page and the intensity of the reflected light is measured, pencil reflecting less than the paper
 - Registration marks (placed along the sides of the paper) are used by the scanner to identify the rows of the form, this is converted to a file
- **Optical Character Reader**
 - Scanners input images of text document, which are analysed by the system to recognise the characters used in the document
 - Some fonts work better with the systems than others
- **Magnetic Stripe Reader**
 - Magnetic stripes are stripes of plastic on placed on the back of cards containing small magnetic particles, the alignment of these are used to encode up to 2Kb of data
 - A current is caused by the magnets when the card moves through the sensor, from these the sensor can determine the data held on the card
- **Smart Card Reader**
 - Has an inbuilt microprocessor, containing small amounts of RAM, ROM and EEPROM
 - EEPROM is non-volatile that can be written and read from, but write time is 100 times slower than read times
 - Card readers provide electricity to power the microprocessor, that runs the programs in the ROM that reads from the ROM and EEPROM
 - The microprocessor can encrypt and decrypt the data
- **RFID Reader**
 - RFID readers are used to read and write data to and from RFID devices
 - RFID systems are made up of two parts, the transponder (in the card) and the RFID reader, which wirelessly exchange data using a coupling element a microwave antenna
 - The transponder is powered by the energy from the reader (via radio) or by an internal battery.
- **Touch-sensitive Screen**
 - Can work by a grid of infrared lasers cross the screen and with photoelectric sensors on the other side of the screen.
 - If a finger or another opaque object breaks one of the beams the computer can determine the coordinates of the object
- **Graphics Tablet**

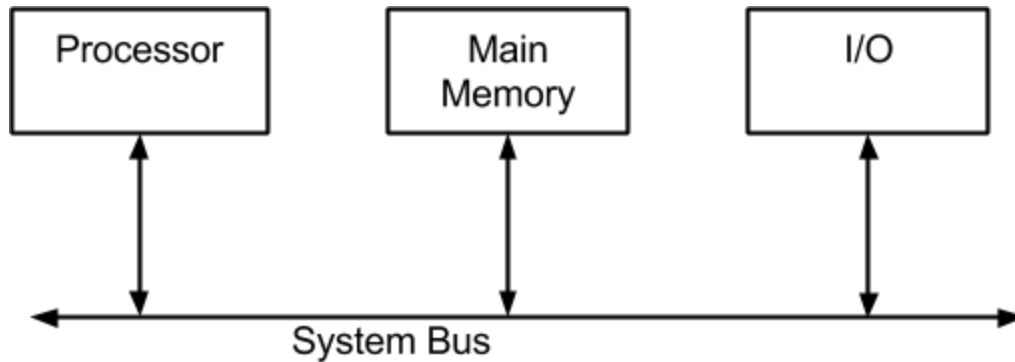
- Made up of two components, the pad (a flat pad) and the stylus
- When the stylus is pressed against the tablet it activates a microswitch in the tablet which logs the stylus position and movement
- **Voice Recognition**
 - Process using a microphone and voice recognition so that the computer can interpret the human voice and use this
- **Digital Still Camera**
 - Used to record and store photographs digitally, which are stored on a memory card
 - Focuses light onto an light sensor array, made up of either charge coupled device (CCD) or a complementary metal oxide semiconductor (CMOS).
 - CCDs transports charge across the chip to an analogy to digital converter which turns each pixel's value into a digital value which can be stored by the camera as an image.
 - CMOSs use traditional wires to move the charge, each pixel contains a transistor that converts the analogue data into digital information that can be stored.
- **Keyboard**
 - Entering characters into the computer
 - Can be difficult for those with disabilities, so modifications are sometimes made e.g.
 - On screen keyboards
 - Key guards that stop multiple keys being pressed at once
 - Keyboards with larger keys
- **Mouse**
 - Used to convert 2D motion into the motion of a pointer on the computer
 - Can be difficult for those with disabilities, so modifications are made
 - A trackpad
 - Footmouse
- **Bar Code Scanner**
 - Reads a series of white and black lines the encodes data
 - Light is shone on the barcode and the amount of reflected light is measured, white reflecting more than black
 - The light intensity is converted into digital signals by photoelectric detectors (photodiodes)
 - These signals are then analysed and decoded into character form
- **Liquid Crystal Display (LCD) Screen**
 - LCDs can change the polarisation of light when an electric current is applied to them
 - Light is shone from behind the crystals, which change the polarisation of the light, a polaroid filter sits in front of the LCs, so that by changing the light's polarisation light can be stopped
 - In colour displays each pixel has three crystals (RGB)
 - Some use **Tiny Film Transistors (TFT)**

- Each pixel has a TFT, a capacitor and liquid crystals
 - The transistor acts like a switch and the capacitor holds the current for the electric field
- **Plasma Screen**
 - Each pixel is controlled by a miniature fluorescent light
 - Controlled by changing the voltage to pixel, when voltage is applied UV is released, which strikes phosphor which emits visible light
 - Limited pixel size, minimum pixel size 0.81mm so looks pixelated up close
 - Plasma screens generate a lot of heat, that can burn people if they touch it
- **Speech Output**
 - Words can be outputted as spoken words using specialist speech synthesis, a sound card and speakers
- **Electric Paper**
 - Flexible, paper-thin displays that display images using tiny coloured beads that move and rotate in response to electric fields
 - An electrical charged pencil can be used to write on the display
 - Can be fed through a device that erases the image and writes a new page
- **Impact Printer**
 - Pins strike an ink soaked ribbon that presses against the paper and marks the paper with a dot, these form text
 - In Daisy-Wheel printer, a wheel with petals with characters on it, these strike the ribbon
 - Have been all but been replaced but still used for making carbon copies
- **Inkjet Printer**
 - The print head moves across the page in horizontal stripes spraying ink onto the page to form an image
 - Higher print quality, designed to print photographs and higher quality images
 - More expensive
- **Laser Printer**
 - A laser defines a differentially charged image on a charged drum
 - The drum collects different amounts of charged toner depending on how charged that area of the drum is
 - The toner is transferred on to the paper and heated, permanently fixing the image
- **Hard Disk**
 - Allows rapid random (direct) access to large amounts of data
 - platter made of a non-ferrous metal or plastic, rotating at 10,000 rpm beneath a R/W head that can move radially
 - Platter coated in iron or cobalt oxide particles, that act as tiny magnets (align in one direction for 1 and one for 0)
 - Terminology
 - Track - Concentric ring on a platter of a hard disk
 - Sector - a subdivision of a track

- Rewritable NAND flash memory
- Connect to the computer using a USB
- **Memory Card**
 - Solid-state flash-memory device for data storage in digital cameras
 - High capacity for re-recording, power-free storage

Computer Architecture

- **The three box model**



Machine Level Architecture

- **CPU**
 - Does the fundamental computing in the system, controlling all components
 - Performs the fetch, decode execute cycle
- **Processor**
 - Consists of
 - An ALU
 - A control unit
 - An instruction decoder
 - Registers
 - An internal clock
 - Internal busses
 - Logic gates
- **RAM**
 - Is used for memory that is readable and writable
 - It is volatile, data is lost when the power is off
- **ROM**
 - Read-only memory, can only be written to once, and is non-volatile memory
 - Used to hold fixed programs such as the bootstrap program in a PC
- **EEPROM**
 - Electrically erasable programmable read-only memory
 - Can be written to or read from, but takes over 100 times longer than reading
 - Flash memory faster at writing than over forms of EEPROM
- **System Clock**
 - Provides timing signals at fixed intervals, so that the system can run properly

- From this the clock speed comes, the rate at which the processor executes instructions
- **Word Length**
 - Number of digits in a binary word
 - A **binary word** is a fixed number of binary digits, often determined by the number of bus lines in the data bus or the size of the registers
- Increasing the clock speed increases the number of instructions that can be executed in a given time, causing the computer to be faster
- Increasing the word length will increase the speed of the system as if instructions or results are larger than the word length more time must be taken to execute them, this occurs less with a larger word length
- Increasing the number of lines in the address bus increases the number of memory locations that can be addressed, the number of addressable locations is 2^n , where n is the number of buses
- Increasing the address bus width increases the speed of the system as fewer words that have to move through it twice
- **Bus**
 - Connects components
 - Can transfer a single binary word or an address
 - The system bus is split into
 - **Data Bus** - bidirectional, transfers data between the processor, main memory and I/O
 - **Address Bus** - Unidirectional, used to address memory and I/O locations
 - **Control Bus** - bidirectional bus, used to transport control signals between the processor, main memory and I/O
 - A system bus is a shared bus
- **I/O Device**
 - A hardware unit that sends, receives or stores data by communicating with the processor and main memory through an I/O controller
 - Peripherals eg. Keyboards, VDUs
 - Require an I/O controller to communicate with the processor
- **I/O Controller**
 - An electronic circuit that connects to a system bus and an I/O device, it provides the correct voltages and currents for the system bus and the I/O device
 - Is the interface between the system bus and an I/O device
 - Consists of
 - Electronics that interface with the system bus
 - A set of data, command and status registers
 - Electronics appropriate for sending control signals to the device connected to the computer
 - Contains the I/O ports a set of data, command and status registers, areas of memory that can be written to or read from
- **Secondary Storage**

- Is permanent storage memory, not directly connected to the processor, it is therefore a type of peripheral
- **Peripherals**
 - Are components that are not part of the processor or main memory
- Memory is addressed using address codes
- **The Stored Program Concept** - In order for a program to be executed it must reside in main memory

The Fetch-Execute Cycle

- Registers involved
 - **Program Counter (PC)** - Points to the next instruction to be fetched and executed
 - **Memory Address Register (MAR)** - Holds the address of the currently addressed memory
 - **Memory Buffer Register (MBR)** - Also known as the memory data register (MDR), holds the code read from the currently addressed memory location
 - **Current Instruction Register (CIR)** - Holds the most recently fetched machine code instruction
- In the fetch-execute cycle, instructions are fetched one at a time, decoded and executed
- **Fetch Phase**
 - The address of the next instruction to be executed, held in the PC, is copied to the MAR
 - The instruction held at that address is placed in the MBR
 - Simultaneously, the contents of the PC are incremented by 1 to get ready for the next instruction
 - The contents of the MBR are copied to the CIR. This frees up the MBR for the execution phase
- **Execution Phase**
 - The instruction held in the CIR is decoded
 - The instruction is executed
- **Machine Code Instructions**
 - Binary code that a machine can understand and execute
 - Consist of opcode and zero or more operands
 - Operands represent a single item of binary data or its address
- A fixed number of bits is allocated to an op-code, this limits the number instructions in the instruction set
- Hexadecimal is often used instead of binary to represent machine code, as it is easier to understand
- **Instruction Set** - The set of bit patterns or binary codes for the machine operations that a processor has been designed to perform

The Structure of the Internet

- The **internet** is a network of networks and computers that use unique IP addresses and TCP/IP
- Addresses are split into packets, which are routed independently by packet switching

- Packets consist of three parts, the source address, the Destination address and the Payload (data)
- A **gateway** connects networks that use different link layer protocols
- **The end-to-end principle**
 - The two end points of the communication are in control of the communication, the internet's role is to move the packets
 - Advantages:
 - Communications can cope with particle network failure, sending computer just resends the packets
 - Packets can be rerouted around network failures, taking alternative paths
 - The internet can easily grow as control is with the endpoints
 - No requirement for internet routers to notify each other as endpoints connections are formed and dropped, simplifying router design
 - The integrity and security of each packet sent is handled by the endpoints
 - Each endpoint only needs to be aware of the endpoints directly connected to it
- **IP address** is a unique address that identifies a computer or other electronic device on a network
 - 32-bits long
 - Split into bits to represent the network and to represent the host machine
- **Routers** are used because it would be impractical to connect each host directly
 - Routers keep a list of routers they are connected to and based on the netID of the packet will pass it towards its destination
- An **intranet** is a private network used to share information or operations within an organisation
 - Uses the same protocols as the internet
- The **World Wide Web** is a system of interlinked hypertext documents
 - Linked together via hyperlinks
 - Contains text, links, images and forms of media
 - Accessed via the internet
- **The Domain Name System (DNS)** is a hierarchical system of names and abbreviations
- **Domain Name** a name that identifies one or more IP addresses (eg. microsoft.com represents several IP addresses)
 - Registered in internet registries
- **A Fully Qualified Domain Name (FQDN)** is one that identifies a host
- The domain .uk includes all hosts that use the top-level domain name suffix 'uk'
- **DNS Servers** translates fully qualified domain names into IP addresses
- **Uniform Resource Identifier (URI)** is a string that specifies how to access a resource on the internet
- **Uniform Resource Locator (URL)** is a string that identifies a resource by its network location
 - specifies which server to access, the access method and the location of the server
 - Split into three parts

- **How:** Which protocol to be used
- **Where:** Defines the host
- **What:** Specifies the name of the requested object and the complete path to it

The path on the addressed server, the **what**

<http://www.microsoft.com/index/index.html>

Protocol to be used. In this case it is Hypertext Transfer Protocol, the **How**

Address of Microsoft's World Wide Web Server, the **Where**

- **Client-Server Model** a client software process initiates a request for a service from a server software process, and the server responds to that request
- **A protocol** is a set of agreed signals, codes and rules for data exchange between systems
- **The TCP/IP Protocol Stack** consists of four layers
 - **Application Layer**
 - Handles details of particular networking applications
 - Uses different protocols for different applications
 - **Transport Layer**
 - A piece of software that ensures a reliable flow of data
 - Stops applications having to deal with connecting to hosts
 - Guarantees delivery of packet and that they will be in the correct order
 - **Network (IP layer)**
 - **Two processes depending on direction**
 - Addresses the packets with the source and destination IP address and passes to link layer
 - Removes addresses from packets and passes to transport layer
 - **Link Layer**
 - Adds the source and destination hardware (MAC) addresses to packets
 - Destination hardware address is the gateway's hardware address
- **TCP Ports** TCP/IP performs multiple processes at once, ports are addresses to the software performing the process so that TCP knows where the data is to be sent

- **A socket** is the combination of the IP address and port number, a connection between two sockets is bidirectional
- **Application Protocols**
 - **Hypertext Transfer Protocol (HTTP)**
 - Client sends request message to server, server responds with a response message
 - Response message could be HTML, images, videos or audio files
 - Process web browser does
 - Accepts URI from a user
 - Extracts FQDN and using DNS server gets IP address
 - Sends a GET request
 - Receives file returned from web server
 - Renders the file in web browser
 - Sends GET requests for resources on page
 - **File Transfer Protocol (FTP)**
 - Enables files from one host to be copied to another
 - One host is the FTP server the other is the FTP client
 - Two ports are used, one for data, one for commands
 - **Telnet**
 - Allows you to manage a remote machine, read html text from web pages and send and receive emails
 - **POP3 and Simple Mail Transfer Protocol (SMTP)**
 - SMTP to send email messages, just a text based protocol
 - Mail server listens for the message and then stores it
 - The user then accesses the mail from the server using the POP3 protocol
 - **HTTPS**
 - The data being sent is encrypted when sent and decrypted upon receipt
 - Over than this is the same a HTTP

Consequences of Uses of Computing

- **Health and Safety Regulations**
 - Employers must
 - Train employees with equipment
 - Evaluate Health and Safety
 - Ensure employees have regular breaks
 - Regular eye tests
 - Employees must
 - Use workstations correctly
 - Bring problems to the attention of their employer
 - Manufacturers must ensure that
 - Screens have clear characters and are flicker free
 - Keyboard separate from screen and are matte, stopping glare
- **Copyright, Design and Patents Act 1988**
 - Illegal to

- Copy or distribute software
 - Execute or run software for which you do not have a licence
 - Alter or edit software
 - Transmit software or send via a telecommunication link
- **Computer Misuse Act 1990**
 - Three levels of offence
 - Unauthorised access to computer material
 - Unauthorised access to computer material with criminal intent
 - Unauthorised modification of computer material
- **Data Protection Act 1998**
 - Anyone with personal information must comply with
 - Fairly and lawfully processed
 - Processed for limited purposes
 - Adequate, relevant and not excessive
 - Accurate and up to date
 - Not kept for longer than is necessary
 - Processed in line with your rights
 - Secure
 - Not transferred to other countries without adequate protection
 - Anyone can access their stored data and why they have it
 - Exemptions
 - Safeguarding national security
 - Prevention and detection of crime
- **Regulation of Investigatory Powers Act 2000**
 - An offence to intercept a message sent through a private or public telecommunications network except:
 - Law enforcement can intercept to prevent or detect crime and can demand encryption keys